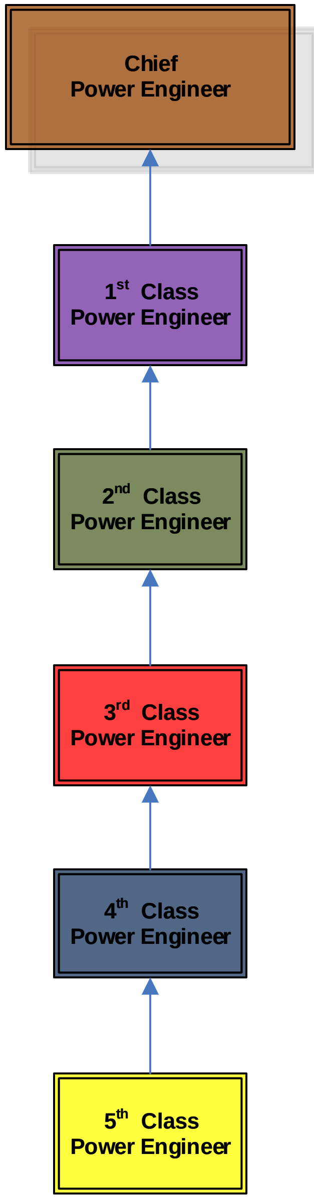
The National Institute for the Uniform Licensing of Power Engineers
Standard Progression



Quality Control Commissions

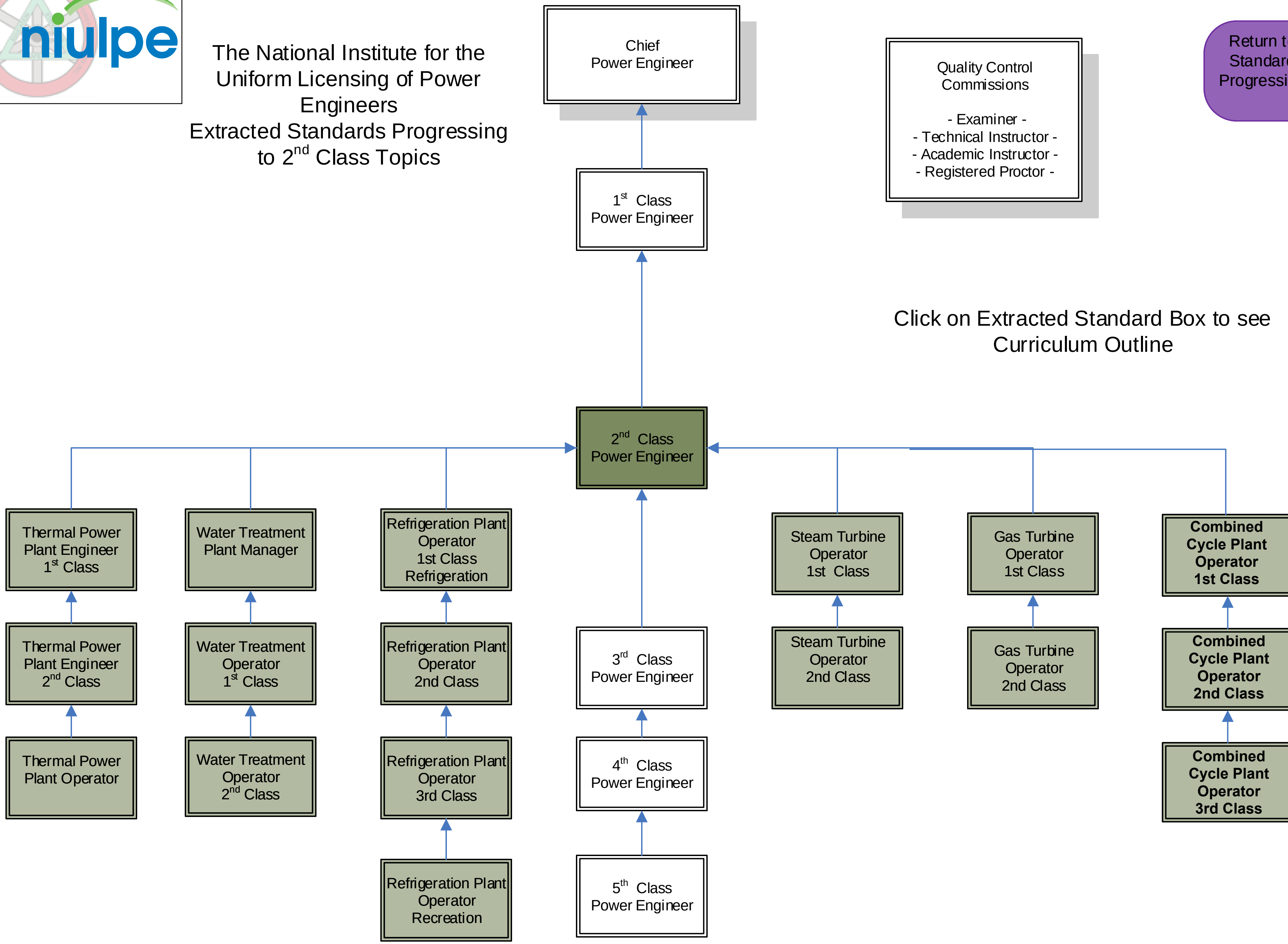
- Examiner -
- Technical Instructor -
- Academic Instructor -
- Registered Proctor -

Explore Certifications & Curriculum Outlines

Click on Class to see Extracted Standards Leading to Topics at that Level

The National Institute for the Uniform Licensing of Power Engineers

Extracted Standards Progressing to 2nd Class Topics



Click on Extracted Standard Box to see Curriculum Outline

Return to Standard Progression

The National Institute for the Uniform Licensing of Power Engineers
Extracted Standards Progressing to 3rd Class Topics

Return to Standard Progression

Chief Power Engineer

1st Class Power Engineer

2nd Class Power Engineer

Quality Control Commissions

- Examiner -
- Technical Instructor -
- Academic Instructor -
- Registered Proctor -

Click on Extracted Standard Box to see Curriculum Outline

3rd Class Power Engineer

Steam Boiler Operator 1st Class – High Pressure

Steam Boiler Operator 2nd Class – High Pressure

Steam Boiler Operator Low Pressure

Compressor Plant Operator 1st Class

Compressor Plant Operator 2nd Class

4th Class Power Engineer

5th Class Power Engineer

Diesel Plant Operator 1st Class

Diesel Plant Operator 2nd Class

Green Facility Manager

Green Facility Operator

Facility Engineer 1st Class

Facility Engineer 2nd Class

Facility Engineer 3rd Class

FOS Preparatory Math Topics

FOS Elementary Mechanics and Dynamics

The National Institute for the Uniform Licensing of Power Engineers
Extracted Standards Progressing to 4th Class Topics

Return to Standard Progression

Chief Power Engineer

1st Class Power Engineer

2nd Class Power Engineer

3rd Class Power Engineer

4th Class Power Engineer

5th Class Power Engineer

Quality Control Commissions

- Examiner -
- Technical Instructor -
- Academic Instructor -
- Registered Proctor -

Click on Extracted Standard Box to see Curriculum Outline

FOS Industrial Plant Configurations

FOS Building Systems and Control

FOS HVAC Fundamentals

FOS Industrial Communication Skills

FOS Chemical & Thermodynamic Topics

FOS Preparatory Math Topics

FOS Material Science and Welding Tech

FOS Frluid Handling Technology

FOS Plant Operations and the Environment

HVAC Plant Operator 1St Class

HVAC Plant Operator 2Nd Class

Hot Water Generation Operator 1st Class

Hot Water Generation Operator 2nd Class

FOS Introduction to Power Engineering

FOS Introduction to Plant and Fire Safety

FOS Basic Electrotechnology

FOS Basic Instrumentation and Controls

FOS Introduction to Boiler Designs

FOS Boiler Systems

FOS Boiler Safety Devices

FOS Boiler Operation and Maagement

FOS Energy Plant Maintenance

FOS Prime Movers and Heat Engines

FOS Plant Auxiliary Systems

FOS Compression and Absorption Refrigeration

FOS Lubrication and Bearings

FOS Pumps and Compressors

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

SCHEDULE “B”

NIULPE Certification Standards

Exam Number	Examination Title	Syllabus Link	Exam Number	Examination Title	Syllabus Link
1	Power Engineer (Chief)		30	HVAC Plant Operator (1^{st} Class)	
2	Power Engineer (1^{st} Class)		31	HVAC Plant Operator (2^{nd} Class)	
3	Power Engineer (2^{nd} Class)		32	Compressor Plant Operator (1^{st} Class)	
4	Power Engineer (3^{rd} Class)		33	Compressor Plant Operator (2^{nd} Class)	
5	Power Engineer (4^{th} Class)		34	Diesel Plant Operator (1^{st} Class)	
6	Power Engineer (5^{th} Class)		35	Diesel Plant Operator (2^{nd} Class)	
7	Steam Boiler Operator LP		36	International Power Engineer (1^{st} Class)	
8	Steam Boiler Operator HP (1^{st} Class)		37	International Power Engineer (2^{nd} Class)	
9	Steam Boiler Operator HP (2^{nd} Class)		38	International Power Engineer (3^{rd} Class)	
10	Water Treatment Plant Manager		39	International Power Engineer (4^{th} Class)	
11	Water Treatment Plant Operator (1^{st} Class)		40	International Power Engineer (5^{th} Class)	
12	Water Treatment Plant Operator (2^{nd} Class)		41	Green Facility Manager	
13	Combined Cycle Plant Operator (1^{st} Class)		42	Green Facility Operator	
14	Combined Cycle Plant Operator (2^{nd} Class)		43	Facility Engineer 1^{st} Class	
15	Combined Cycle Plant Operator (3^{rd} Class)		44	Facility Engineer 2^{nd} Class	
16	Refrigeration Plant Operator (1^{st} Class)		45	Facility Engineer 3^{rd} Class	
17	Refrigeration Plant Operator (2^{nd} Class)		46	Plant Management Engineer	
18	Refrigeration Plant Operator (3^{rd} Class)		47	Plant Environmental Manager	
19	Refrigeration Plant Operator – Recreation		48	Engineer (1^{st} Class) – MA Prep	
20	Facility Operator Certification Series (25)		49	Engineer (2^{nd} Class) – MA Prep	
21	Thermal Power Plant Engineer (1^{st} Class)		50	Engineer (3^{rd} Class) – MA Prep	
22	Thermal Power Plant Engineer (2^{nd} Class)		51	Fireman (1^{st} Class) – MA Prep	
23	Thermal Power Plant Operator		52	Fireman (2^{nd} Class) – MA prep	
24	Steam Turbine Operator (1^{st} Class)		53	Stationary Engineer (1^{st} Class) – MI Prep	
25	Steam Turbine Operator (2^{nd} Class)		54	Stationary Engineer (2^{nd} Class) – MI Prep	
26	Gas Turbine Operator (1^{st} Class)		55	Stationary Engineer (3^{rd} Class) – MI Prep	
27	Gas Turbine Operator (2^{nd} Class)		**56 - 80**	**Facility Operator Series – Schedule “C”**	25 Units
28	Hot Water Generation Operator (1^{st} Class)			**Non-Curriculum Focused Syllabi**	
29	Hot Water Generation Operator (2^{nd} Class)		81	Power Engineer (Technical Instructor)	
			82	Power Engineer (Examiner)	

National Institute for the Uniform Licensing of Power Engineers, Inc.
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Pittsburgh, PA 15242-0369

SCHEDULE "C"

NIULPE Facility Operator Series

Exam Number	Examination Title	Syllabus Link	Exam Number	Examination Title	Syllabus Link
56	Preparatory Math Topics E				
57	Elementary Physical, Chemical, & Thermodynamic Principles				
58	Introduction to Power Engineering and its Governance				
59	Introduction to Plant and Fire Safety				
60	Introduction to Plant Operations & the Environment				
61	Elements of Material Science& Welding Technology				
62	Introductory Fluid Handling Technology				
63	Basic Concepts in Electro Technology				
64	Energy Plant Instrumentation and Controls				
65	Fundamental Industrial Communication Skills				
66	Introduction to Boiler Designs				
67	Elements of Boiler Systems				
68	Lubrication and Bearings				
69	Pumps and Compressors				
70	Boiler Safety Devices				
71	Boiler Plant Operation and Management				
72	Energy Plant Maintenance				
73	Water Treatment				
74	Types of Prime Movers and Heat Engines				
75	Plant Auxiliary Systems				
76	Basic Concepts of Compression & Absorption Refrigeration				
77	HVAC Fundamentals for Facility Operators				
78	Building Environmental Systems and Control				
79	Typical Industrial Plant Configurations				
80	Elementary Mechanics and Dynamics				

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

REFERENCE CURRICULUM

For

Power Engineer (Chief)

National Institute for the Uniform Licensing of Power Engineers, Inc. PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the NIULPE Power Engineer (Chief) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

Reference Curriculum for Power Engineer (Chief) Examination Candidates

Major Topic: Safety, Loss, and Environmental Program Management

Topic 1 Loss Control

Learning Outcome

Describe the design, components, and implementation of a loss control program.

Learning Objectives

1. Explain the purpose, benefits, and typical components of a loss control program.
2. Explain the process of developing a comprehensive loss control program including the typical responsibilities and accountabilities of the program.
3. Describe the factors affecting insurance rates and the authority, role, and interaction of insurance inspectors with plant staff.
4. Describe the tools and techniques used to develop a positive attitude towards the components of a loss control program.
5. Describe the tools and techniques used to develop safety awareness in consumers.

Topic 2 Safety Legislation

Learning Outcome

Identify the authority and application of federal and state safety legislation to the work place.

Learning Objectives

1. Explain the ultimate responsibility and requirement, in the work place, to enforce all relevant safety legislation and regulations and to respond to regulatory directives.
2. Describe the legal and ethical obligations of managers, supervisors, and employees to personnel safety.
3. Explain the significance, components, and applications of Canada Labor Occupational Health and Safety legislation.
4. Explain the authority, significance, components, and applications of provincial safety regulations, including the role and interactions of the provincial safety inspectors with plant staff.
5. Explain the requirements for safety compliance training.
6. Explain right to refuse work legislation and its legal implications.
7. Explain the authority, significance, and applications of the Workers' Compensation Board regulations, including the role and interactions of the Board with plant staff.
8. Describe the function of, and roles and responsibilities for, a worksite health and safety committee.

Topic 3 Safe Work Programs

Learning Outcome

Describe comprehensive safe work programs.

Learning Objectives

1. Identify the components and explain the management of a comprehensive safe work program.
2. Explain the components and management of a safety training program.
3. Explain the process of hazard identification, risk assessment and mitigation.
4. Explain the significance and procedure for safe work planning.
5. Explain the significance and procedure for safe work permits, including lockouts.
6. Explain the significance and procedure for confined space entry.
7. Explain the significance and procedure for hot work.
8. Explain the significance and procedure for excavations.
9. Explain the significance and procedure for working at heights.
10. Explain the significance and components of a contractor safety program.
11. Explain the components and management of a safety audit program, including roles and responsibilities.
12. Explain the purpose, components, and procedure for a hazard and operability study.

Topic 4 Emergency Response and Incident Investigation

Learning Outcome

Describe emergency response and incident investigation programs.

Learning Objectives

1. Identify the benefits and typical stakeholders of an emergency response program.
2. Explain the typical components of an emergency response program.
3. Explain the process of developing and maintaining an emergency response program, including typical responsibilities and accountabilities.
4. Explain the procedure for emergency response testing.
5. Explain the typical components of an incident reporting and investigation program.
6. Define categories of incidents.
7. Describe roles and responsibilities for incident initial reporting, investigation, final reporting, and corrective actions.
8. Explain the significance off and steps required in incident investigation.
9. Describe a system for managing incident report data, including the communication process and its significance.
10. Apply an incident reporting and investigation procedure to a case study.

Topic 5 Environmental Legislation

Learning Outcome

Identify the authority and application of federal and provincial safety legislation and permits.

Learning Objectives

1. Explain the ultimate responsibility and requirements to enforce all relevant environmental legislation and regulations and to respond to regulatory directives.
2. Explain the authority, significance, components, and applications of provincial environmental legislation and regulations, including the role and interactions of the provincial inspectors with plant staff.
3. Explain the authority, significance, components, and applications of federal environmental legislation and regulations, including the role and interactions of the federal environmental inspectors with plant staff.
4. Explain the significance and process of identifying and working with typical stakeholders for environmental programs – the Environmental Impact Assessment (EIA) process.
5. Explain typical compliance requirements for an environmental monitoring program, including equipment calibration and uptime requirements.

Topic 6 Environmental Management

Learning Outcome

Explain environmental management programs, including reporting, clean-up, disposal, and reclamation.

Learning Objectives

1. Explain the purpose, significance and components of an Environmental Management System.
2. Describe the ISO 14000 - 14002 standards for an Environmental Management System.
3. Describe requirements for environmental routine, excursion and exceedance reporting.
4. Explain the compliance tests for Continuous Emission Monitoring Systems (CEMS) and the significance and procedures for Relative Accuracy Test Audits (RATA).
5. Explain the responsibilities and procedures for spill containment and cleanup.
6. Explain the components and development of an environmental audit program.
7. Explain the procedure for an environmental audit, including the roles and responsibilities for performing and responding to the audit.
8. Explain the significance, procedures, and regulatory requirements of waste segregation and disposal.
9. Identify waste streams that require special disposal procedures, including recognition of hazardous wastes.
10. Explain the significance and general components of Transportation of Dangerous Goods Acts.
11. Explain the significance and general requirements of hazardous waste transportation.
12. Describe the purpose, significance, requirements and general process of land reclamation.

Major Topic: Inspection, Maintenance and Repair Practices

Topic 1 Project Management

Learning Outcome

Demonstrate the application of project management practices.

Learning Objectives

1. Define a project, the role of project management and the makeup of the project stakeholders.
2. Identify the roles and responsibilities of a typical project team.
3. Explain in detail the project planning step.
4. Describe the common tools that are used for project planning and management, including Work Breakdown Structure (WBS), Critical Path Method (CPM) and Gantt charts.
5. Explain in detail the project execution step, including control processes.
6. Explain in detail the project completion step, including assessment and reporting.

Topic 2 Maintenance Management Practices

Learning Outcome

Explain management practices for typical maintenance programs.

Learning Objectives

1. Describe how equipment is managed through the concept of asset management.
2. Explain the purpose, components, and management of a maintenance program including preventive, predictive and corrective maintenance approaches.
3. Explain the concepts and importance of reliability centred maintenance (RCM) in developing a maintenance program.
4. Describe the major steps in performing an RCM analysis.
5. Provide an example of how RCM is applied.
6. Explain the purpose and process of root cause failure analysis (RCFA).
7. Describe how maintenance can be optimized.
8. Describe how a plant turnaround is planned and effectively executed.
9. Explain the concept, process, and benefits of outsourcing maintenance.
10. Explain the setting up and management of short-term maintenance contracts and long-term service agreements.
11. Explain the purpose and process of maintenance planning and scheduling.

Topic 3 Boiler Repairs

Learning Outcome

Explain quality control programs and specific boiler repair procedures.

Learning Objectives

1. Explain the National Board of Boiler Inspectors (NBBI) requirements for owner inspection and quality control programs.
2. Describe in detail the components of owner inspection and quality control programs, including roles and responsibilities, records and reporting procedures.
3. Describe the roles, responsibilities, and personnel qualifications regarding repairs to boilers.
4. Explain the detailed procedure for repairs to cracks in boiler parts, including drums and headers.
5. Explain the detailed procedure for repairs to ruptured boiler tubes.
6. Explain the management, responsibilities, and procedures for safety valve repairs.

Topic 4 Pressure Vessel and Piping Repairs

Learning Outcome

Explain specific pressure vessel and piping inspection and repair procedures.

Learning Objectives

1. Describe the management roles, responsibilities, and qualifications regarding repairs to pressure vessels and pressure piping.
2. Explain the concept for fitness for service.
3. Describe in detail a typical pressure vessel inspection, identifying typical problem areas.
4. Describe in detail a typical pressure piping inspection identifying common problem areas.
5. Explain the detailed procedure for typical repairs to cracks in pressure vessels.
6. Explain the methods and detailed procedures for typical repairs to corrosion in pressure vessels.
7. Explain the detailed procedure for typical repairs to cracks in pressure piping.
8. Explain the methods and detailed procedures for typical repairs to corrosion in pressure piping.

Topic 5 Non-Destructive Examination

Learning Outcome

Explain the methods, applications, and control of non-destructive examination.

Learning Objectives

1. Explain the significance and application of ASME Section V.
2. Describe radiographic examination.
3. Describe the process of ultrasonic examination.
4. Describe the process of dye penetrant examination.
5. Describe the process of magnetic particle examination.
6. Describe the process of eddy current examination.
7. Describe the process of acoustic emission examination.
8. Explain the selection, management, and control of a non-destructive examination contractor.

Topic 6 Rotating Equipment Maintenance

Learning Outcome

Explain specific maintenance procedures for, and typical maintenance problems of, rotating equipment.

Learning Objectives

1. Explain the typical maintenance problems of a large steam turbine.
2. Explain the procedures for inspection and overhaul of a large steam turbine.

3 Explain the typical maintenance problems of a gas turbine.

4. Explain the procedures for inspection and overhaul of a gas turbine.
5. Explain the typical maintenance problems of a large multi-stage pump.
6. Explain the procedures for inspection and overhaul of a large multi-stage pump.
7. Explain the typical maintenance problems of a large generator.
8. Explain the procedures for inspection and overhaul of a large generator.

Topic 7 Rotating Equipment Monitoring

Learning Outcome

Describe the parameters and methods of turbine monitoring and oil analysis.

Learning Objectives

1. Describe the purpose, importance and types of rotating equipment monitoring.
2. Explain the concept and significance of turbine thermal expansion, the general principles and placement of measuring devices and the procedures to control.
3. Explain the concept and significance of turbine differential expansion, the general principle and placement of measuring devices and the procedures to control.
4. Explain the concept and significance of turbine eccentricity, the general principle and placement of measuring devices and the procedures to control.
5. Explain the concept of vibration, including typical causes, effects, and locations of vibration in rotating equipment and how it is measured.
6. Explain the concept and significance of turbine critical speed.
7. Explain the concept and significance of oil whirl, oil whip, and steam whirl and the design and operational considerations to counter oil whirl.
8. Describe common oil problems and their effects on rotating equipment and a typical oil sampling and testing program.

Major Topic: Business and Workforce Management

Topic 1 Business Management

Learning Outcome

Explain general concepts in plant budgeting, finance, accounting, and inventory control.

Learning Objectives

1. Explain the concept and significance of the following accounting terms: accounting cycle, dual entry accounting, debits and credits, accrual accounting, revenue and expenses, assets and liabilities, and debt and equity.
2. Explain the concept and significance of financial statements, including Income Statement, Balance Sheet, Statement of Retained Earnings and Cash Flow Statement.
3. Explain budget development, control and reporting processes.
4. Explain typical types of budgets and their significance, including revenue, expense, capital expenditure and production budgets.
5. Explain the components of plant department budgets.
6. Explain the significance of a cost/benefit analysis.
7. Explain the "time value of money" concept and calculate the Net Present Value (NPV) and Internal Rate of Return (IRR) of a proposed investment.
8. Calculate the Return on Investment (ROI) of a proposed investment.
9. Explain depreciation, including straight-line and declining balance depreciation, and the concept and significance of Capital Cost Allowance (CCA).
10. Describe the components and use of a typical automated inventory system.
11. Explain the purpose and operation of typical inventory management systems, including fixed-point, fixed-interval, max/min, ABC, Just In Time (JIT) and Economic Order Quantity (EOQ).
12. Explain the concepts and significance of periodic and perpetual inventory systems, Last In First Out (LIFO) and First In First Out (FIFO).
13. Describe the role of a supplier and the use of strategic partnerships in an inventory management system.

Topic 2 Contract Management

Learning Outcome

Explain general concepts and management of contracts.

Learning Objectives

1. Explain the content and significance of a typical code of ethics of a professional association.
2. Explain the importance and application of ethical practices in the work place.
3. Define and explain the legal significance of contract, offer and acceptance.
4. Explain the significance of contract documentation, and the rights and obligations of a contactor and contractee.
5. Compare contract types, including: fixed price; cost plus/shared risk; fixed price/cost plus incentive; bonus/penalty; time/material; product/service/resource; and enforceable/unenforceable contracts.
6. Describe methods of discharging a contract, including: agreement, performance, impossibility, operation of law, breach, failure to perform and specific performance.
7. Explain tort and its legal significance; the three basic types of torts, including: intentional, fault-based or negligent, and strict liability; the distinction between legal and ethical liability.
8. Explain due diligence and its legal and ethical significance.
9. Explain "force majeure" and its legal significance.
10. Explain what is involved in issuing and then completing a tendering process.

Topic 3 Problem Solving and Decision Making

Learning Outcome

Explain techniques for structured problem solving and decision making.

Learning Objectives

1. Explain the importance and application of a structured decision making process.
2. Describe the eight steps in a rational decision making process.
3. Compare analytic, conceptual, directive and behavioral decision making styles.
4. Explain the advantages and disadvantages of group decision making.
5. Describe the common methods of group decision making, including brainstorming, storyboarding, Nominal Group Technique (NGT) and the Delphi technique.
6. Apply a problem solving and decision making approach to a typical plant case study.

Topic 4 Leadership

Learning Outcome

Discuss models of leadership and motivation.

Learning Objectives

1. Explain leadership responsibilities and the significance of an effective leadership style.
2. Explain the Managerial Grid and its significance.
3. Explain Situational Leadership and its significance.
4. Compare the concept and significance of traditional objective setting and Management by Objectives (MBO).
5. Compare methods of communicating goals and objectives.
6. Explain the Motivation Process
7. Compare the basic models of individual motivation, including the Hierarchy of Needs, Motivation-Hygiene Theory, Goal-Setting Theory, Reinforcement Theory, Equity Theory, and Expectancy Theory.
8. Explain the concept and significance of the Social Styles Matrix.

Topic 5 Communication and Conflict Resolution

Learning Outcome

Apply principles of communication and conflict resolution in the work place.

Learning Objectives

1. Compare linear, interactive, and transactive communications and their significance.
2. Explain the common communication shortcuts and their significance, including selectivity, assumed similarity, stereotyping, and the halo effect.
3. Explain the significance and effects of conflict in an organization.
4. Describe interpersonal and intergroup conflict.
5. Explain the lose/lose, lose/win, win/lose and win/win outcomes of conflict.
6. Explain assertiveness and cooperativeness and their significance.
7. Compare avoiding, accommodating, forcing, collaborating and compromising as conflict resolution strategies.
8. Explain the stages in assertive behavior for conflict resolution.
9. Describe the concept, significance, responsibilities and typical steps and tactics of a grievance process.
10. Explain the process of labor/management conflict resolution.
11. Describe the typical public stakeholders for an organization's business and the typical communication processes used in dealing with the public.
12. Explain the public concerns that an organization must address and the appropriate communication methods used in addressing them.

Topic 6 Labor Relations

Learning Outcome

Explain principles and models in the management of labor relations and change.

Learning Objectives

1. Explain management's right and responsibilities in the enforcement of federal and provincial labor legislation.
2. Compare management interactions between union and non-union work forces.
3. Explain the concept, preparation, and tactics of collective bargaining, including the use of a problem-solving approach.
4. Explain the concepts, significance, roles, and responsibilities during conciliation, arbitration, strike or lockout.
5. Compare the benefits and significance of permanent and contingent employees.
6. Explain the purpose and process of human resource planning and capacity planning.
7. Explain the facilitation of labor relations with a contractor's workforce.
8. Describe the types of changes that occur in the workplace, the relationship between workplace change and employee attitude, the psychological costs and benefits of change, and management's role and responsibilities.
9. Explain the concept and significance of homeostasis.
10. Describe the three types of resistance to change (logical, psychological, and sociological), the potential benefits of resistance to change, and the three basic steps to overcome resistance (unfreezing, changing, and refreezing).
11. Explain the typical strategies used to build support for change, including: use of group forces, leadership for change, participation, shared rewards, negotiation, employee security, and communication.
12. Explain the purposes and processes of benchmarking.

Topic 7 Recruitment and Employee Development

Learning Outcome

Explain principles and models in the management of employee recruitment and development.

Learning Objectives

1. Explain the purpose and components of a human resource management process.
2. Explain the legal and ethical constraints on recruitment and selection.
3. Explain the types and processes of pre-employment testing.
4. Explain the purpose, procedure, and limitations of typical interviewing techniques, including behavioral descriptive interviews.
5. Explain the significance and components of a training and development program including training standard, roles and responsibilities.
6. Explain the significance and components of an orientation process.
7. Explain the purpose and proceeds of a needs assessment and gap analysis
8. Explain the purpose and process of competency profiling.
9. Explain the significance and selections of typical training methods, and their relationship to learning styles.
10. Explain the significance and progression and cross-training methods.
11. Explain the purpose and components of a performance management program, including coaching.
12. Explain typical models of performance reviews.
13. Explain the process of corrective and progressive discipline.

Topic 8 Management Structures and Organization

Learning Outcome

Discuss principles of organizational structure and the application of work teams.

Learning Objectives

1. Compare the design and benefits of typical organizational structures, including: scalar, functional, tall/flat and matrix.
2. Explain the concept and significance of organizational culture.
3. Explain the significance of a team-based organizational structure and methods to develop and promote teamwork.
4. Compare the significance, benefits, and limitations of supervised and self-directed work teams.
5. Describe the characteristics and functioning of a successful work team.
6. Explain the concept and significance of cross-functional work teams.

REFERENCE CURRICULUM

For

Power Engineer (1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the NIULPE Power Engineer (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Power Engineer (1st Class) Examination Candidates

Major Topic: Applied Thermodynamics and Plant Cycles

Topic 1 Rankine and Brayton Cycles

Learning Outcome

Discuss the application of the Rankine and Brayton cycles to a power plant.

Learning Objectives

1. Explain heat engines and their application to a steam power plant.
2. Explain the Rankine Cycle using a steam temperature-entropy diagram.
3. Evaluate a Rankine Cycle power plant in terms of efficiency, work ratio, specific steam consumption, isentropic efficiency and efficiency ratio.
4. Explain the Rankine Cycle improvements that can be incorporated into a power plant.
5. Explain the Brayton Cycle and its application to a gas turbine.
6. Explain the Brayton Cycle using pressure-volume and temperature-entropy diagrams.
7. Evaluate a Brayton Cycle power plant in terms of temperatures, work output, and efficiency.
8. Explain the Brayton Cycle improvements that can be incorporated into a power plant.
9. Describe the design, layout, and advantages of a gas turbine / steam turbine combined cycle plant.
10. Explain the total energy concept as it applies to a power plant.

Topic 2 Thermodynamics of Steam

Learning Outcome

Perform calculations for thermodynamic cycles of steam.

Learning Objectives

1. Describe the basis for non-flow processes of vapors.
2. Explain the constant volume process for steam and calculate heat supplied, work done and internal energy.
3. Explain the constant pressure process for steam and calculate heat supplied, work done and internal energy.
4. Explain the constant temperature process for steam and calculate heat supplied and work done.
5. Calculate steam entropy given the steam conditions.
6. Explain the significance of a Temperature-Entropy diagram for steam.
7. Explain the reversible adiabatic process for steam and calculate work done and internal energy.
8. Explain the significance of a Mollier chart for steam.

Topic 3 Steady Flow Process Calculations

Learning Outcome

Perform steady flow process calculations for vapors and gases.

Learning Objectives

1. Describe the steady-flow energy equation and calculate the work done in a steady-flow process.
2. Calculate the power consumed in a steady-flow process.
3. Explain the principle of conservation of energy and supersaturation as they apply to a nozzle and calculate nozzle inlet and outlet velocities.
4. Calculate the initial dryness fraction of steam in a throttling process.
5. Determine, using a Mollier Chart, the quality, enthalpy, and entropy of steam entering a calorimeter.
6. Calculate energy transfer, work done, and power produced in a steam turbine.
7. Calculate the heat lost, surface area, required cooling water flow, and heat transfer coefficient in a steam condenser.
8. Define and calculate availability and effectiveness in the context of the steady-flow processes.

Topic 4 Thermodynamics of Perfect Gases

Learning Outcome

Perform calculations for thermodynamic cycles of perfect gases.

Learning Objectives

1. Review the behavior of perfect gases.
2. Explain Joule's law and its significance.
3. Calculate the heat added or rejected by a mass of perfect gas under changing temperature and pressure conditions.
4. Explain the isothermal cycle using a pressure-volume diagram and calculate heat rejected and work done using a perfect gas as the working fluid.
5. Explain the reversible adiabatic cycle using a pressure-volume diagram and calculate work done, final volume, and final temperature using a perfect gas as the working fluid.
6. Calculate work done in a polytropic cycle using a perfect gas as the working fluid.
7. Using the heat energy equation, calculate the efficiency of a polytropic compression process for a perfect gas.
8. Explain the Gibbs-Dalton law and calculate the work done and heat flow per kilogram when a gas mixture is expanded.

Topic 5 Expansion and Heat Transfer

Learning Outcome

Perform calculations for expansion and heat transfer.

Learning Objectives

1. Explain how thermal expansion and contraction is allowed for in boiler and piping design.
2. Calculate the linear and volumetric expansion of a header or pipe, given internal temperature conditions.
3. Calculate heat transfer by conduction.
4. Calculate the heat flow through a compound insulated wall.
5. Calculate the thickness of insulation required to maintain a given temperature gradient.

Topic 6 Refrigeration Calculations

Learning Outcome

Perform thermodynamic calculations for a refrigeration system.

Learning Objectives

1. Explain the Carnot Cycle as it applies to refrigeration using temperature-entropy and pressure-enthalpy diagrams.
2. Calculate the Carnot coefficient of performance of a refrigeration system and a heat pump system.
3. Calculate the refrigerating effect of a refrigeration system.
4. Calculate the coefficient of performance of a refrigeration system and a heat pump system.
5. Demonstrate graphically, using temperature-enthalpy diagrams, the effect on refrigeration capacity of using a throttle valve in place of an expansion machine, of superheating at the compressor inlet, of undercooling the condensed refrigerant, and of using a flash chamber.
6. Calculate the mass flow of refrigerant in a system.
7. Calculate the swept volume of a compressor cylinder, given its volumetric efficiency.
8. Calculate the power requirement of a refrigerant compressor.

Major Topic: Principles of Applied and Fluid Mechanics

Topic 1 Lifting Machines

Learning Outcome

Perform calculations for lifting machines.

Learning Objectives

1. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load for lifting machines.
2. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a differential pulley block.
3. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a worm gear and worm wheel.
4. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a worm-driven screw jack.
5. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a turnbuckle.
6. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a hydraulic jack.

Topic 2 Energy and Momentum

Learning Outcome

Perform calculations involving potential energy, kinetic energy, and momentum of bodies in linear and rotating motion.

Learning Objectives

1. Define potential and kinetic energy.
2. Calculate the potential energy of a compressed spring.
3. Describe the behavior of a spring-mass system and calculate the maximum compression of a spring caused by contact with a moving mass.
4. Describe the effect of friction losses on potential and kinetic energy.
5. Define linear momentum and calculate the coefficient of restitution.
6. Calculate the kinetic energy and velocity of an elastic head-on collision.
7. Define angular momentum and calculate the changes in momentum of rotating shafts.
8. Calculate the kinetic energy and velocity of a rotating shaft.
9. Calculate the time required to change the rotational velocity of a shaft.

Topic 3 Centripetal Force and Acceleration

Learning Outcome

Perform calculations involving centripetal and centrifugal forces.

Learning Objectives

1. Calculate the centripetal acceleration of a rotating body in uniform circular motion.
2. Calculate the centrifugal force on a rotating body in uniform circular motion.
3. Calculate the tension in an attachment cord for vertically revolving masses.
4. Calculate the speed and period of a conical pendulum.
5. Calculate the positions of balancing masses to equalize centrifugal forces.
6. Calculate the stress in a rotating flywheel rim.
7. Calculate the velocity, acceleration, and accelerating force of a reciprocating component such as a piston driving, or driven from, a crankshaft.

Topic 4 Torque and Torsion

Learning Outcome

Perform calculations involving torque and torsion.

Learning Objectives

1. Calculate angular velocity given the angular momentum of a rotating shaft.
2. Calculate strain in a solid bar under torsion load.
3. Calculate the stress at a given radius in a solid shaft.
4. Calculate torsional stress and strain in a hollow shaft.
5. Calculate modulus of rigidity and torsional resilience for a solid shaft.
6. Calculate the power consumed by torque acting on a rigid body rotating about a fixed axis.
7. Calculate maximum and mean torque for solid and hollow shafts of circular cross section.
8. Calculate the deflection of a closely coiled helical spring.

Topic 5 Stress and Strain

Learning Outcome

Perform calculations involving stress, strain, shear forces, and bending moments.

Learning Objectives

1. Explain the behavior of stress and strain in solids.
2. Calculate single and double shear stress in a solid bar subject to oblique loading.
3. Define the modulus of elasticity.
4. Calculate stress, strain, and the equivalent modulus of elasticity for a compound bar.
5. Calculate stress due to restricted thermal expansion.
6. Calculate the elastic strain energy of a solid bar.
7. Calculate the instantaneous compression and stress of a solid bar subjected to suddenly applied and shock loads.
8. Calculate stresses in pressure vessels due to internal pressure.
9. Using the fundamental bending equation, calculate bending moment, moment of inertia, modulus of elasticity, radius of curvature, maximum stress, and location of neutral axis.
10. Compare the strengths of beams using the modulus of section.
11. Calculate the deflection of a beam under load.

Topic 6 Static Fluids

Learning Outcome

Perform calculations involving fluids at rest.

Learning Objectives

1. Calculate the relative density of a liquid mixture.
2. Calculate the pressure indicated by a manometer.
3. Calculate the energy transmitted by a pressurized liquid.
4. Calculate the pressure and force on the surfaces of a tank containing non-mixing liquids.
5. Calculate the position of the centre of pressure of a tank containing non-mixing liquids.
6. Explain Archimedes' principle.
7. Calculate the relative density from the buoyant force on a submerged body and its true and apparent weights.
8. Calculate the tension and stress in the cable or wire supporting a submerged solid body.
9. Calculate the density of a floating body, given the volume of liquid that it displaces.

Topic 7 Fluids in Motion

Learning Outcome

Perform calculations involving fluids in motion.

Learning Objectives

1. Explain the equation of continuity.
2. Calculate the fluid flow through a valve, given the valve diameter and lift.
3. Calculate flow through rectangular and triangular notches.
4. Calculate the total energy of a liquid in motion.
5. Calculate the pressure in a pipe given the cross-sectional area and liquid flow rate.
6. Calculate the diameter, velocity, and flow through an orifice given the coefficient of discharge.
7. Calculate flow through horizontal and vertical venturi given the discharge coefficient.
8. Compare the resistance to flow of various liquids due to their viscosity using the velocity gradient and coefficient of viscosity.
9. Explain the significance of steady and unsteady liquid flows with regard to Reynold's number.
10. Using Poiseuille's equation, calculate liquid flow in a pipe and the pressure required for the liquid flow to overcome viscosity.
11. Calculate the theoretical head imparted to water by a centrifugal pump.
12. Calculate the manometric head and efficiency, and power consumed by a centrifugal pump.
13. Calculate the power available from a hydraulic turbine.
14. Explain the design and significance of convergent and convergent-divergent nozzles and calculate the critical pressure of a steam nozzle.

Major Topic: Applied Engineering Technologies

Topic 1 Metallurgy

Learning Outcome

Discuss the selection, properties, and stress effects of steel.

Learning Objectives

1. Describe the structure of metals.
2. Explain the nature and significance of phase changes in iron and steel due to temperature change.
3. Explain how alloying elements affect phase changes in steel and state the major alloying elements used in steel.
4. Explain the effect of temperature on the tensile strength of steel.
5. Explain the criteria for the assessment of materials.
6. Explain what creep is, and why it is important to monitor its effects on equipment.
7. Explain the methods of stress analysis.
8. Explain failure analysis.

Topic 2 Corrosion, Chemistry and Processes

Learning Outcome

Explain the chemistry and processes of corrosion mechanisms.

Learning Objectives

1. Explain how atomic and molecular structures affect corrosion.
2. Explain the anodic and cathodic processes of corrosion.
3. Explain the electromotive force series and galvanic series.
4. Explain the effect of polarization
5. Explain corrosion of single metals.
6. Explain the processes of crevice corrosion and pitting corrosion.
7. Explain the process of microbiologically influenced corrosion.
8. Explain the process of stress induced corrosion.
9. Explain the processes of erosion-corrosion.

Topic 3 Boiler Corrosion

Learning Outcome

Discuss the mechanisms of corrosion in boilers.

Learning Objectives

1. Explain the impact of corrosion
2. Explain the agents of corrosion found in water
3. Explain the mechanisms and significance of magnetite formation and magnetite depletion on boiler tube surfaces.
4. Explain the mechanisms and significance of economizer and superheater corrosion.
5. Explain the mechanism, identification, and significance of flue-gas side corrosion of boiler components.
6. Explain the mechanism, identification, and significance of low temperature corrosion of boiler components.
7. Explain the relationship between boiler water chemistry and corrosion of copper alloys in feedwater systems.
8. Explain the mechanisms and significance of deaerator cracking and corrosion.

Topic 4 Corrosion Monitoring and Prevention Techniques

Learning Outcome

Explain techniques used to monitor and prevent corrosion.

Learning Objectives

1. Describe the methods of monitoring and analyzing corrosion.
2. Explain the design, applications, and operation of cathodic protection systems.
3. Explain the use of protective coatings for corrosion control.
4. Describe the regulatory and safety requirements relating to corrosion monitoring.
5. Describe chemical control of corrosion.

Topic 5 Corrosion Prevention Programs

Learning Outcome

Explain corrosion prevention programs.

Learning Objectives

1. Explain the corrosion characteristics and susceptibility of engineering materials and their selection for various purposes.
2. Describe the chemical, mechanical, and operational factors that are considered in controlling corrosion in steels.
3. Describe the chemical, mechanical, and operational factors that are considered in controlling corrosion in copper alloys.
4. Explain the risks and required precautions involved with chemical cleaning of boiler surfaces.
5. Explain the steps taken to reduce waterside and fireside corrosion during dry and wet storage of a boiler.
6. Explain the development, components, and management of a corrosion prevention program for cooling water systems, including the selection, application and characteristics of biocides.
7. Explain the development, components and management of a corrosion prevention program for piping and pressure vessels.
8. Explain the development, components and management of a corrosion prevention program for rotating equipment.

Topic 6 Fuel Types

Learning Outcome

Discuss the characteristics and applications of coal, oil, and non-conventional gaseous and liquid fuels.

Learning Objectives

1. Explain the factors involved in the selection of primary and secondary fuel for a new installation.
2. Describe the fuel handling considerations and fuel burning characteristics for non-conventional solid fuels including municipal waste, petroleum coke and biomass.
3. Compare the fuel burning characteristics of non-conventional gaseous fuels, including refinery gas, landfill gas, digester gas, carbon monoxide, liquid petroleum gases (LPGs) and acid gases.
4. Compare the fuel burning characteristics of black liquor.
5. Compare the physical properties and fuel burning characteristics of different grades of oil.
6. Describe the considerations for coal cleaning and blending.
7. Describe the purpose and process of coal gasification.
8. Differentiate between low heating value and high heating value fuels.
9. Describe the design and operational considerations for the use of low heating value fuels.
10. Explain the economic considerations for fuel selection for multifuel burners.

Topic 7 Burner Design

Learning Outcome

Explain the criteria for burner design and selection.

Learning Objectives

1. Describe the general criteria for effective burner design.
2. Describe the classes of burner designs, based on the fuel in use.
3. Compare the design strategies for mixing fuel and air including: co-flow, cross-flow, flow stream disruption and entrainment.
4. Describe the design considerations for a duct burner.
5. Sketch a typical multi-nozzle duct burner layout.
6. Describe the relationship of burner selection to furnace design.
7. Describe the relationship between coal pulverizer selection and burner design.
8. Describe burner design methods to reduce noise.
9. Explain the principle, significance, application, and design of staged combustion burners, including staged fuel flow and staged air flow burners.

Topic 8 Combustion Optimization

Learning Outcome

Explain the considerations for obtaining optimum efficiency and operation of burners.

Learning Objectives

1. Explain the inherent assumptions and factors considered when determining combustion efficiency.
2. Explain the methods and limitations for obtaining maximum efficiency from the combustion of gaseous fuels.
3. Explain the methods and limitations for obtaining maximum efficiency from the combustion of liquid fuels.
4. Explain the methods and limitations for obtaining maximum efficiency from the combustion of solid fuels.
5. Explain the economic and efficiency factors for fuel and burner management in real time operating conditions for a multifuel system.
6. Describe the use of electronic instruments to continuously monitor combustion efficiency.
7. Explain the significance of flame shape, color and temperature.
8. Explain the effect of excess air on combustion stability and boiler efficiency.
9. Explain the symptoms, significance and corrective action for common combustion problems.

Topic 9 Combustion Safety and Emissions

Learning Outcome

Discuss safety and environmental considerations in burner operation, including strategies for NO_X control.

Learning Objectives

1. Describe the requirements for safe operation of a combustion system.
2. Compare the significance of burner safety devices for different fuel types.
3. Explain the cause and prevention of furnace explosions in boilers and fired heaters.
4. Describe the processes for dust reduction in coal handling systems.
5. Describe the procedures for dealing with coalbunker and pulverizer fires.
6. Explain the effect of excess air and combustion efficiency on emissions parameters.
7. Explain pre-treatment as a strategy for NO_X reduction (fuel switching, additives and fuel pre-treatment).
8. Explain combustion and operational modification as a strategy for NO_X reduction (low NO_X burners, staged combustion, water/steam injection, burners out of service, low excess air and air preheat and furnace temperature reduction.
9. Explain process modification as a strategy for NO_X reduction (reduced production, electrical heating, improved thermal efficiency and product switching).
10. Explain post treatment as a strategy for NO_X reduction (SCR and SNCR).
11. Explain the effect on NO_X emissions of boiler design, boiler condition and boiler loading characteristics.
12. Explain the reasons for and significance of flue gas recirculation.

Topic 10 Water Pre-Treatment

Learning Outcome

Describe the processes used to treat raw water for power plants, including detailed chemistry where applicable.

Learning Objectives

1. Describe the mechanisms of coagulation and flocculation.
2. Describe the chemical processes and reactions of oxidation of organic contaminants.
3. Describe the chemical processes and reactions of iron and manganese removal from raw water.
4. Describe the chemical processes and reactions in a lime-soda softener.
5. Describe the chemical processes and reactions in a sodium zeolite softener.
6. Describe the chemical processes and reactions in a hydrogen zeolite softener.
7. Describe the chemical processes and reactions in a demineralizer.
8. Describe the chemical processes and reactions in a dealkalizer.
9. Describe the mechanisms of membrane technology, including chemical and mechanical cleaning methods and clean-in-place design.
10. Describe the chemical processes and mechanisms of electrodialysis (ED) and electrodeionization (EDI.)
11. Describe the chemical processes and reactions of oxygen scavenging and metal passivation.
12. Describe the methods by which silica is removed from feedwater and condensate.

Topic 11 Internal Water Treatment

Learning Outcome

Describe the processes used to treat boiler water and condensate, including detailed chemistry where applicable.

Learning Objectives

1. Explain the principles, reactions and control of chelation.
2. Explain the principles, reactions and control of a coordinated phosphate program.
3. Explain the phenomenon of phosphate hideout.
4. Explain the principles, reactions and control of a congruent phosphate program.
5. Explain the principles, reactions and control of an equilibrium phosphate program.
6. Explain the principles, reactions and control of an all-volatile treatment program.
7. Explain the principles, reactions and control of a polymer treatment program.
8. Explain the principles, reactions and control of an oxygenated water treatment program.
9. Describe the mechanism of sludge conditioning.
10. Describe the mechanism of antifoam conditioning.
11. Describe the chemical processes and reactions of condensate treatment, including corrosion prevention, deaeration and polishing.

Topic 12 Water Treatment Management

Learning Outcome

Explain the monitoring, management, and maintenance of water treatment systems.

Learning Objectives

1. Explain the financial management of the costs and benefits of water treatment.
2. Apply raw water analysis to the selection of a water treatment system.
3. Explain monitoring and control of cycle chemistry.
4. Describe the troubleshooting process when a cycle chemistry parameter deviates from the acceptable range.
5. Describe the selection and maintenance of resins for zeolite, demineralizer, dealkalizer and condensate polisher service.
6. Describe the procedures and interpretation for tube deposit analyses.
7. Explain the inspection procedure for internal boiler components in relation to water treatment.
8. Describe a typical maintenance program for components of water treatment systems, including: water filters, clarifiers and lime-soda softeners, sodium zeolite softeners, demineralizers, mixed bed and condensate polishers, reverse osmosis units, microfiltration, electrodialysis and electrodeionization units and deaerators.
9. Describe the selection, responsibilities, and management of water treatment consultants.

Topic 13 Non-Boiler Water Treatment

Learning Outcome

Explain the monitoring and management of potable water and cooling water treatment systems.

Learning Objectives

1. Describe the regulatory requirements for potable water quality and monitoring.
2. Describe the parameters and interpretation of potable water analyses.
3. Describe the selection and mechanism of oxidation agents.
4. Describe the mechanism of ultraviolet sterilization.
5. Explain the components and management of a cooling water treatment program.
6. Describe the use and chemistry of biocides in cooling water.
7. Describe the use and chemistry of corrosion inhibitors in cooling water.
8. Explain the use of chelants in cooling water.
9. Explain the use of threshold scale inhibitors in cooling water.
10. Explain the use of surfactants, dispersants and biodispersants in cooling water.

Major Topic: Power Plant Operations

Topic 1 Electrical Energy Management

Learning Outcome

Discuss the concepts and techniques of electrical energy management.

Learning Objectives

1. Explain the concept of energy management and identify the operational factors that are included in an energy management program.
2. Describe the significance, components, responsibilities and procedure of an energy audit.
3. Explain the significance and application of power factor management, including the effects of: capacitor banks, synchronous motors, inductive and resistive loads, transformers, voltage regulation for synchronous generators and synchronous compensators.
4. Calculate capacitor ratings required for power factor correction.
5. Explain, using a sketch, the purpose, applications, design and operation of a static uninterruptible power supply (UPS).
6. Explain the concept and significance of distributed generation, including the design implications for electrical distribution systems.
7. Describe the benefits of UPS in a distributed generation system, including the use of UPS as a bridge between utility and internal power.
8. Explain the benefits of motor-generator sets, internal combustion engines and micro-turbines in a distributed generation system.
9. Explain the design, operating principle, and benefits of a fuel cell in a distributed generation system.
10. Explain the purpose, components, and operation of emergency power systems, including the physical interconnection between emergency power and main power.
11. Explain the concept, significance, and management of peak load reduction, including utility contract obligations and use of internal generation.
12. Explain the concept and principles of generation load dispatch including contract obligations.

Topic 2 Plant and Equipment Efficiencies

Learning Outcome

Explain and calculate power plant and equipment efficiencies.

Learning Objectives

1. Describe methods used to maximize efficiency of steam power plants and minimize energy losses.
2. Calculate boiler gross efficiency using input-output method and heat loss method.
3. Calculate turbine performance and efficiency.
4. Calculate the condensate savings and heat gained through improvements in condenser efficiency.
5. Describe the components and significant parameters of a typical computerized plant performance management system, including a program to reduce controllable losses.
6. Describe the efficiencies of a simple cycle gas turbine and various cycle improvements that can be made.
7. Describe different methods for waste heat recovery and the resultant improvement of efficiency.
8. Compare the inherent efficiencies of Once-Through Steam Generators (OTSG) with Heat Recovery Steam Generators (HRSG).
9. Calculate the steam generated and efficiency of a combined cycle plant, given system data.

Topic 3 Power Plant Construction

Learning Outcome

Explain the regulations, processes, and procedures pertaining to the design, construction, and modification of plant facilities.

Learning Objectives

1. Describe the general criteria, including economics, which must be considered in determining the need for additional facilities and in deciding between new plant construction and existing plant expansion.
2. Describe the general criteria to be considered in the design of a new plant.
3. Describe the regulatory permitting processes for a construction project, including environmental feasibility study.
4. Describe a quality assurance /quality control (QA/QC) program for pressure equipment, including the process for accepting, receiving, and approving new and used vessels.
5. Describe the major considerations and steps involved in the construction of a new plant, from design to completion.
6. Explain the role of the Chief Power Engineer and regulatory inspectors in a plant construction project.
7. Explain the components and management of a construction health and safety program.
8. Explain the process of coordinating plant expansion activities with the operation of the existing plant, including tie-in of the old and new facilities.
9. Interpret, in detail, the information provided in construction drawings.

Topic 4 Commissioning and De-Commissioning

Learning Outcome

Explain the regulations, processes, and procedures pertaining to the commissioning and de-commissioning of plant facilities.

Learning Objectives

1. Explain the sequence for commissioning a new plant.
2. Explain the detailed procedures for commissioning a boiler.
3. Explain the detailed procedures for commissioning a steam turbine.
4. Explain the detailed procedures for commissioning a gas turbine.
5. Explain the detailed procedures for commissioning a piping system.
6. Explain the detailed procedures for commissioning a large fan.
7. Describe the content and significance of a performance contract/guarantee for new equipment or a new plant.
8. Explain the specific procedures for re-commissioning a plant after a major outage.
9. Explain the obligations and liabilities of de-commissioning a plant, including regulatory requirements.
10. Explain the specific procedures for de-commissioning a plant.

Topic 5 Retrofitting

Learning Outcome

Explain the benefits, applications, and processes of retrofitting power plant equipment.

Learning Objectives

1. Explain the considerations that are used to determine whether replacement, re-powering, retrofitting or upgrading should be undertaken.
2. Explain the regulatory requirements for modifications to equipment and systems, including pressure equipment, electrical systems and environmental impact.
3. Explain the overall process and responsibilities when modifying or retrofitting plant systems.
4. Describe the benefits of control system retrofitting with smart instrumentation.
5. Describe the retrofitting methods used to improve boiler efficiency and capacity including superheater upgrades, economizer upgrades, combustion system upgrades, improved air heater seals, improved waterwall design, environmental enhancements and control upgrades.
6. Describe the retrofitting methods used to improve steam turbine efficiency including improved turbine blades and diaphragms, turbine stage additions and improved blade tip sealing.
7. Describe the retrofitting methods used to improve gas turbine efficiency including upgrading inlet guide vanes, improved seals, tighter clearances, improved combustion liners, improved turbine blades and vanes, thermal barrier coatings, compressor blade coatings, compressor stage additions and compressor supercharging.

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Major Topic: Legislation and Codes for Industrial Equipment

Topic 1 Codes, Acts and Regulations

Learning Outcome

Explain the significance and application, at the Chief Engineer level, of boiler and pressure vessel legislation and regulations.

Learning Objectives

1. Describe the typical duties of the chief engineer as set out in boiler and pressure vessel legislation.
2. Describe the legal foundation for the boiler and pressure vessel legislation.
3. Define statutory delegation of powers as they apply to the *Boiler and Pressure Vessels Act*.
4. Describe the authority that safety officers (inspectors) have within their jurisdiction.
5. Determine what the offences and penalties are under the act and the appeal process.
6. Describe the typical regulations under the *Boiler and Pressure Vessels Act*.
7. Describe the typical codes and standards referenced by the *Boiler and Pressure Vessels Act*.

Topic 2 ASME Section I

Learning Outcome

Demonstrate familiarity with the content of A.S.M.E. Section I, and perform calculations involving cylindrical components, openings, compensations, safety and safety relief valves, and stays in boilers.

Learning Objectives

1. Describe the organization of ASME Section I and its application.
2. Calculate the required thickness or maximum allowable working pressure of a cylindrical shell.
3. Calculate the required thickness or maximum allowable working pressure of a seamless, unstayed dished head, flat head, and formed head.
4. Calculate the maximum dimensions of openings, and the strength of compensation required for reinforcement of openings in cylindrical shells, headers, or heads.
5. Calculate the requirements for braced surfaces and support stays.
6. Calculate the required tubesheet thickness and maximum allowable working pressure for firetube and watertube boilers.
7. Calculate required wall thicknesses of plain circular furnaces, circular flues, Adamson ring reinforced and corrugated furnaces.
8. Calculate the required size and capacity of pressure relief valves.

NOTE: The content of this chapter, including formulae and calculations, is based on the 2007 edition of the ASME codes. While studying, students should refer to the 2007 ASME “Academic Extract” or the complete 2007 codes

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Topic 3 ASME Section VIII and IX

Learning Outcome

Demonstrate familiarity with the content of A.S.M.E. Sections VIII and IX, and perform calculations involving cylindrical components, openings, compensations, safety and safety relief valves, and stays in pressure vessels.

Learning Objectives

1. Describe the organization of ASME Section VIII Division 1 and its application
2. Calculate the required thickness or maximum allowable working pressure of a cylindrical shell in a pressure vessel.
3. Calculate the required thickness or maximum allowable working pressure of a seamless dished head, flat head and formed head in a pressure vessel.
4. Calculate the reinforcement requirements of openings in a pressure vessel.
5. Calculate the minimum required thickness of a cylinder using ligament efficiency.
6. Calculate the required dimensions and locations of staybolts and braced surfaces in a pressure vessel.
7. Calculate the required size and capacity of pressure relief valves for a pressure vessel.
8. Explain the significance of A.S.M.E. Section IX.

NOTE: The content of this chapter, including formulae and calculations, is based on the 2007 edition of the ASME codes. While studying, students should refer to the 2007 ASME "Academic Extract" or the complete 2007 codes

Topic 4 CSA B-51 and B-52

Learning Outcome

Describe the content and requirements, and interactions with C.S.A. B-51 and C.S.A. B-52.

Learning Objectives

1. Describe the content and requirements of C.S.A. B-51
2. Describe the content and requirements of C.S.A. B-52
3. Explain the role and interactions of regulatory authorities and the Chief Engineer with regard to C.S.A. B-51 and B-52.

Topic 5 Piping and API Codes

Learning Outcome

Explain the significance and application, at the A.S.M.E. B31.1, A.S.M.E. B31.3, A.P.I. 510 and A.P.I. 570.

Learning Objectives

1. Explain the significance and applications of ASME B31.1 Power Piping.
2. Describe the general content of ASME B31.1 Power Piping.
3. Explain the significance and applications of ASME B31.3 Process Piping.
4. Describe the general content of ASME B31.3 Process Piping.
5. Explain the significance and applications of API 510 Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair and Alteration.
6. Describe the general content of API 510 Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair and Alteration.
7. Explain the significance and applications of API 570 Piping Code: In-service Inspection, Rating, and Alteration of Piping Systems.
8. Describe the general content of API 570 Piping Code: In-service Inspection, Rating, and Alteration of Piping Systems.
9. Explain the role and responsibilities of the chief engineer with regard to the ASME and API Codes.

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REFERENCE CURRICULUM

For

Power Engineer (2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
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Introduction

This Curriculum is intended to assist candidates studying for the NIULPE Power Engineer (2nd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Power Engineer (2nd Class) Examination Candidates

Major Topic: Code Calculations and Legislation

Topic 1 A.S.M.E. Code Calculations - Cylindrical Components

Learning Outcome

Apply the appropriate formulae from ASME Sections I and VIII to calculations involving cylindrical components, openings, and compensations in boilers and pressure vessels.

Learning Objectives

1. Calculate the minimum required thickness or the maximum allowable working pressure of ferrous tubing, up to and including 125 mm O.D.
2. Using ASME Sections I and VIII, calculate the required minimum thickness or the maximum allowable working pressure of ferrous piping, drums, and headers.
3. Calculate the required thickness or maximum allowable working pressure of a seamless, unstayed dished head.
4. Calculate the minimum required thickness or maximum allowable working pressure of unstayed flat heads and welded covers.
5. Determine whether or not reinforcement is required for openings in a cylindrical shell, header, or head.
6. Using the ligament efficiency method, calculate the minimum required thickness of a cylindrical drum with two or more openings in the pressure boundary.

NOTE: The formulas, calculations, and code references found in this chapter are from the 2015 ASME BPVC, which is reproduced in part in the PanGlobal 2018 ASME Academic Extract Volumes 1 and 2.

Topic 2 ASME Code Calculations: Stayed Surfaces, Pressure Relief Valves and Furnaces

Learning Outcome

Apply the appropriate formulae from A.S.M.E. Sections 1 and 8 to calculations involving pressure vessel stayed surfaces, safety and safety relief valves, and firetube boilers.

Learning Objectives

1. Calculate the required thickness and maximum allowable working pressure for braced and stayed surfaces in pressure vessels.
2. Calculate the minimum required cross-sectional area of stays and staybolts in firetube boilers, including diagonal stays.
3. Calculate the required size and capacity of pressure relief valves.
4. Explain design considerations for various circular furnaces and calculate the required thickness of corrugated furnaces.

NOTE: The formulas, calculations, and code references found in this chapter are from the 2015 ASME BPVC, which is reproduced in part in the PanGlobal 2018 ASME Academic Extract Volumes 1 and 2.

Topic 3 Boiler and Pressure Vessel Legislation

Learning Outcome

Describe the components and application of boiler and pressure vessel legislation within Canadian jurisdictions.

Learning Objectives

1. Identify the types and sources of Laws and the levels and scope of the Courts.
2. Define Statutory Delegation of Powers as they apply to the Boilers and Pressure Vessels Act.
3. Describe the authority that Safety Officers (Inspectors) have within their jurisdiction.
4. Determine what are the offences and penalties under the Act and the appeal process.
5. Describe the typical Regulations under the Boilers and Pressure Vessels Act.
6. Describe the typical Codes and Standards referenced by the Boilers and Pressure Vessels Act.

Topic 4 Plant Design and Installation

Learning Outcome

Explain the codes and procedures involved in the design and construction of a new plant.

Learning Objectives

1. State the codes and standards that must be followed when designing and building a new plant.
2. Describe the steps involved in developing specifications and contracts for new installations and modifications.
3. Explain the major steps involved in the design and construction of a new plant.
4. Explain the roles and responsibilities in the design and construction of a new plant.
5. Explain how the design and construction of a new plant are administered and controlled.

Topic 5 Management and Supervision

Learning Outcome

Describe the roles and basic competencies of a supervisor and manager.

Learning Objectives

1. Define management and explain the general functions of management.
2. Explain how management goals and objectives are developed through planning.
3. Describe how business decisions are made.
4. Describe methods of selecting new employees.
5. Explain how employees are trained.
6. Explain how to provide leadership and motivate employees.
7. Explain how to manage employee performance and behaviors.
8. Describe proper communication skills by writing a formal report.

Topic 6 Plant Maintenance

Learning Outcome

Describe plant maintenance management systems.

Learning Objectives

1. Describe the major aspects of managing maintenance activities including management of maintenance, maintenance program development, planning, scheduling, performing maintenance, assessment and improvement.
2. Describe the different approaches to maintenance including preventive and corrective.
3. Describe how routine maintenance activities are planned, scheduled, and controlled.
4. Describe the use of Gantt and PERT charts and the critical path method to schedule major maintenance activities.
5. Describe the steps involved in preparing for and conducting a pressure vessel inspection.
6. Describe the use of computerized systems in managing maintenance, including a work order system.
7. Describe various methods of monitoring equipment, including log sheets and trending.
8. Describe the steps involved in developing a plant budget and controlling maintenance costs.

Topic 7 Safety

Learning Outcome

Explain the components and application of safety programs, safety audits, and safety training.

Learning Objectives

1. Describe the elements of a comprehensive safety program for a power plant.
2. Explain the purpose of and the process used for safety checklists, inspections, audits and reviews.
3. Explain the purpose of and the process used for safety orientation, education, and training.

Topic 8 Linear Motion

Learning Outcome

Apply the theory of applied mechanics to bodies at rest and in linear motion.

Learning Objectives

1. Calculate the displacement, velocity, and acceleration of bodies moving in a straight line.
2. Calculate the displacements and flight times of projectiles.
3. Describe the relationship between mass, force, acceleration and weight.
4. Explain inertia, momentum, and conservation of momentum and perform related calculations.
5. Demonstrate graphically the relationship between work, force, and distance.
6. Define and calculate the kinetic energy of moving objects.
7. Define and calculate the potential energy of stationary objects.
8. Explain the Law of Conservation of Energy.
9. Define and calculate indicated power and power cylinder dimensions.

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Topic 9 Angular Motion

Learning Outcome

Apply the theory of applied mechanics to bodies in angular motion.

Learning Objectives

1. Define and calculate angular displacement, angular velocity, and angular acceleration.
2. Define and calculate moment of inertia, radius of gyration and torque.
3. Define and calculate the kinetic energy of rotating masses, including flywheels.
4. Define rotational work and power. Calculate brake power and mechanical efficiency of a reciprocating engine.
5. Calculate the power transmitted by a belt drive.
6. Define centrifugal and centripetal force, centripetal acceleration, and perform calculations involving them.
7. Calculate the distance of movement of a governor due to centrifugal force.
8. Explain the balancing of masses about a center of rotation and perform simple balancing calculations for single and multiple masses.

Topic 10 Friction

Learning Outcome

Perform calculations related to frictional force.

Learning Objectives

1. Describe the concept, types, and laws of friction.
2. Define and calculate the coefficient of friction and applied forces for objects moved on a horizontal surface by forces parallel to the surface.
3. Define and calculate the applied forces for objects moved on a horizontal surface by forces not parallel to the surface.
4. Define and calculate the applied forces for objects moved on an inclined plane.
5. Define and calculate the frictional forces on a screw jack.
6. Define and calculate maximum torque on a belt drive.

Topic 11 Static and Dynamic Forces

Learning Outcome

Perform calculations related to static and dynamic forces acting on a body.

Learning Objectives

1. Define and evaluate forces in terms of moments and couples.
2. Define and calculate centroids and first and second moments of areas.
3. Define and calculate the different types of stress.
4. Define strain, modulus of elasticity, Poisson's ratio and perform calculations.

5 Define the thermal expansion of bars, including reactions, under conditions of restricted expansion and reactions of bars composed of dissimilar metals.

6. Define and calculate shear forces and bending moments for simply supported beams and cantilevers.
7. Perform calculations involving the fundamental torsion equation and explain the relationship between torque and stress.
8. Explain the relationship between torque and power, and calculate maximum and mean torque for solid shafts of circular cross section.
9. Calculate stress in coupling bolts due to torque.

Topic 12 Fluid Mechanics

Learning Outcome

Perform calculations related to fluid flows and pressure.

Learning Objectives

1. Describe the basics of fluid mechanics.
2. Perform calculations related to pressure in a fluid, including center of pressure.
3. Explain buoyancy and perform calculations involving buoyancy principles.
4. Define and calculate thermal expansion of a vessel and its liquid contents.
5. Describe flow in open channels and calculate fluid flow through a weir.
6. Describe liquid flow in a pipe using the continuity equation.
7. Apply the law of conservation of energy to fluid flow and define Bernoulli's equation.
8. Calculate fluid flow from a vessel orifice.
9. Calculate flow using a venturi meter.

Major Topic: Thermodynamics and Metallurgy

Topic 1 Heat, Expansion of Solids, and Heat Transfer

Learning Outcome

Perform calculations to determine the thermal expansion of solids and basic heat transfer properties.

Learning Objectives

1. Perform heat calculations on solids, liquids, and vapors.
2. Explain the theory of thermal expansion and solve problems using the formula for linear thermal expansion.
3. Calculate the change in the area of an object, including holes, due to a temperature change.
4. Describe the principle of volumetric expansion and perform calculations involving the change in volume of solids, due to a change in temperature.
5. Describe the three basic modes of heat transfer (convection, conduction, and radiation) and perform simple calculations.
6. Perform calculations involving heat transfer at a surface.

Topic 2 Thermodynamics of Gases

Learning Outcome

Perform calculations related to expansion and compression of perfect gases.

Learning Objectives

1. Explain the behaviors of a perfect gas and the laws that govern gas behavior, including Boyle's Law, Gay-Lussac's Law, Charles Law, the General Gas Law, and the Ideal Gas Law.
2. Explain Dalton's Law of Partial Pressures.
3. Define and calculate specific heats under constant volume and constant pressure conditions.
4. Explain the relationship between work and heat as expressed in the First and Second Laws of Thermodynamics.
5. Calculate the work done during expansion and compression under constant pressure and isothermal conditions.
6. Calculate the work done during adiabatic expansion and compression.
7. Calculate the work done during polytropic expansion and compression.

Topic 3 Thermodynamics of Steam

Learning Outcome

Perform calculations related to properties of steam.

Learning Objectives

1. Describe the basic properties of water and steam.
2. Perform calculations involving specific enthalpy, dryness fraction, specific heat, and specific volume using steam tables.
3. Explain the principles and use of calorimeters to measure the dryness fraction of wet steam.
4. Calculate the dryness fraction of steam based on calorimeter data.
5. Calculate the internal energy of steam under given conditions.
6. Explain entropy and calculate the change in entropy for a particular water/steam process.
7. Determine steam properties using a Mollier Chart.
8. Calculate boiler thermal efficiency using test data.

Topic 4 Practical Thermodynamic Cycles

Learning Outcome

Explain the concepts and use of common thermodynamic cycles, using pressure-volume and temperature- entropy diagrams.

Learning Objectives

1. Explain the concept of a heat engine and describe the different types of heat engines.
2. Describe the Carnot cycle and calculate Carnot cycle efficiency.
3. Explain the Rankine cycle using pressure-volume and temperature-entropy diagrams and calculate Rankine cycle efficiency.
4. Explain the Otto cycle using pressure-volume and temperature-entropy diagrams and calculate Otto cycle efficiency.
5. Explain the Diesel cycle using pressure-volume and temperature-entropy diagrams and calculate Diesel cycle efficiency.
6. Explain the Brayton cycle using pressure-volume and temperature-entropy diagrams and calculate Brayton cycle efficiency.
7. Calculate the heat balance at different points in a Rankine cycle system using test data provided.

Topic 5 Metallurgy

Learning Outcome

Discuss the uses and structure of common metals.

Learning Objectives

1. Explain the study of metallurgy and the atomic and crystalline structure of metals.
2. Explain the significance of the iron-carbon equilibrium diagram.
3. Explain the purposes of, and processes used, in the heat treatment of steels.
4. Explain how to interpret metal specifications.
5. Explain typical selection of metals for process plant applications (what is selected and why).
6. Describe the composition, physical properties, and uses of copper, lead, and tin.
7. Describe the composition, physical properties, and uses of aluminum and aluminum alloys.

Topic 6 Testing of Metals

Learning Outcome

Discuss the common procedures and parameters for testing of metals.

Learning Objectives

1. Differentiate between destructive and non-destructive testing and explain the procedures and interpretation of tensile, hardness, and impact tests.
2. Explain the purpose and procedure of a Proof (Hydrostatic Deformation) Test.
3. Explain the causes and significances of welding discontinuities.
4. Explain Non-Destructive Examination, along with its applications and benefits.
5. Explain visual inspection and the procedures used.
6. Explain magnetic particle inspection and the procedures used.
7. Explain liquid penetrant testing and the procedures used.
8. Explain ultrasonic testing and the procedures used.
9. Explain radiographic testing, including interpretation of results.
10. Explain acoustic emission testing and the procedures used.
11. Explain leak and pressure testing.
12. Explain how to monitor and test metals for creep, fatigue, and corrosion.

Topic 7 Corrosion of Metals

Learning Outcome

Discuss corrosion mechanisms and corrosion prevention methods.

Learning Objectives

1. Define corrosion and explain the electrochemical principles involved.
2. Explain how the environment can affect corrosion.
3. Explain the most common corrosion mechanisms.
4. Describe the predominant corrosion mechanisms that potentially affect various power plant systems and equipment.
5. Explain methods used to monitor and test for corrosion during plant operation.
6. Explain the methods used to control and prevent corrosion at the design stages and during operation.
7. Explain the main components of a corrosion failure analysis and a typical corrosion failure report.

Topic 8 Introduction to Welding Symbols

Learning Outcome

Describe how weld joints are constructed, using standard weld symbol terminology.

Learning Objectives

1. Explain the purpose of welding symbols.
2. Describe the common weld joints and weld types, including groove, fillet, plug and slot welds, with related weld terminology.
3. Recognize and describe symbols that identify weld types.
4. Identify and explain the meaning of the reference line, the arrow, and the tail in a welding symbol.
5. Identify and explain the meaning of supplemental welding symbols, not specific to the weld itself.
6. For groove and fillet welds, identify and explain welding symbols that relate to the weld configuration and joint preparation.

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Major Topic: Boilers and Water Treatment

Topic 1 Boiler and Steam Generator Components and Design

Learning Outcome

Discuss the components and design considerations of a steam generator.

Learning Objectives

1. Explain how the ratings of boilers and steam generators are calculated.
2. Explain the factors to be considered in designing a steam generator.
3. Contrast the influence of solid fuel, liquid fuel, and gas fuel on steam generator design.
4. Explain the principles of natural water circulation in a steam generator. Explain why forced circulation is used in a steam generator and how it is attained.
5. Explain the design, placement, and installation considerations for water walls, superheaters, desuperheaters, reheaters, economizers, and air heaters.
6. Explain the purpose and placement of screen tubes, division walls, water-cooled stringer tubes in superheaters, and wall-mounted radiant superheaters.
7. Describe top and bottom support systems for a steam generator.
8. Describe furnace casing design considerations.
9. Describe the purpose and use of specialized steam generator duct arrangements, including air heater bypass, economizer bypass, and air heater recirculation.
10. Describe the methods used to insulate different parts of a steam generator.
11. Explain the general steps used to construct a steam generator.

Topic 2 Specialized Boiler Designs

Learning Outcome

Identify and discuss common specialized boiler designs.

Learning Objectives

1. Describe typical designs, components, and operating strategies for once-through steam-flood boilers.
2. Describe typical designs, components, and operating strategies for fluidized bed boilers (bubbling bed and recirculating bed types).
3. Describe typical designs, components, and operating strategies for heat recovery steam generators.
4. Compare different designs of heat recovery steam generators (HRSG): natural circulation, controlled circulation and once-through (OTSG).
5. Describe typical designs, components, and operating strategies for supercritical steam generators.
6. Describe typical designs, components, and operating strategies for black liquor recovery boilers.
7. Describe typical designs, components, and operating strategies for refuse boilers used in waste disposal.
8. Describe typical designs, components, and operating strategies for biomass boilers.
9. Describe typical designs, components, and operating strategies for waste-heat boilers (firetube and watertube types).

Topic 3 Boiler and Steam Generator Operation

Learning Outcome

Describe in detail the typical procedures for operation of a large steam generator.

Learning Objectives

1. Describe the detailed hot and cold startup procedures for a steam generator including safety precautions.
2. Describe the detailed shutdown procedure for a steam generator including safety precautions.
3. Describe the detailed lay-up procedures for a steam generator including safety precautions.
4. Describe the detailed refractory dry out procedure for a new steam generator including safety precautions.
5. Describe the detailed boil out procedure for a new steam generator including safety precautions.

Topic 4 Boiler and Steam Generator Maintenance and Inspection

Learning Outcome

Describe in detail the typical procedures for boiler maintenance and inspection.

Learning Objectives

1. Describe the mechanical cleaning procedures for a boiler including safety precautions.
2. Describe the detailed chemical cleaning procedures for a watertube boiler including safety precautions.
3. Describe the detailed hydrostatic testing procedure for a boiler including safety precautions.
4. Describe standard shutdown activities and preventive maintenance procedures required for a boiler.
5. Describe the detailed procedure for complete inspection of a boiler including waterside, fireside, and auxiliary equipment.
6. Describe boiler inspection techniques and equipment.
7 Describe the required inspection records and reporting procedures.
8. Describe the roles and responsibilities for an inspection including engineering staff, operators, and boiler inspector.
9. Describe the safety requirements during a boiler inspection.

Topic 5 Pumps

Learning Outcome

Discuss the application of large centrifugal pumps.

Learning Objectives

1. Explain selection criteria for pump applications.
2. Interpret pump operating characteristics and performance curves.
3. Describe the procedure for the installation of a large multi-stage centrifugal pump.
4. Describe the typical repairs and preventive maintenance procedures required for a multi-stage centrifugal pump.
5. Describe the methods of control for a multi-stage centrifugal pump including recirculation control.
6. Describe the selection criteria for seal types and materials in a centrifugal pump.
7. Describe the methods of counteracting thrust in a large centrifugal pump.

Topic 6 Water Chemistry and Analysis

Learning Outcome

Discuss the significance of common water impurities, and the application of water analyses.

Learning Objectives

1. Describe the sources of the impurities found in raw water.
2. Describe the effect of the listed water impurities on power plant equipment and processes.
3. Explain the significance and importance of standard methods of water analysis.
4. Describe which analyses are appropriate at given sampling points including the significance of the sampling point locations.
5. Interpret the results of a comprehensive standardized water analysis including the relationship of the various parameters.
6. Explain the purposes and principles of testing instruments, including embrittlement detector, total solids meter, and pH meter.
7. Explain the purpose of steam purity measurement and process of steam sampling.

Topic 7 Water Pre-Treatment I

Learning Outcome

Describe water pre-treatment processes for removal of suspended solids, oil, and gases.

Learning Objectives

1. Explain the purpose, equipment, operation, and limitations of sedimentation.
2. Explain the purpose, equipment, operation, and limitations of coagulation and flocculation.
3. Explain the purpose, equipment, operation, and limitations of filtration.
4. Explain the purpose, principles, equipment, operation, and limitations of microfiltration.
5. Describe how oil is removed from water.
6. Explain the purpose, equipment, operation, and limitations of mechanical deaeration.
7. Explain the purpose, equipment, operation, and limitations of evaporation.

Topic 8 Water Pre-Treatment II

Learning Outcome

Describe water pre-treatment processes for ion removal.

Learning Objectives

1. Explain the purpose, equipment, and operation of lime-soda softening.
2. Explain the purpose, equipment, operation, and limitations of hot process phosphate softening.
3. Explain the purpose, equipment, operation, and limitations of sodium zeolite softening.
4. Explain the purpose, equipment, and operation of hydrogen zeolite softening.
5. Describe how silica is removed from water.
6. Explain the purpose, equipment, and operation, of demineralization, including condensate polishing.
7. Explain the purpose, equipment, and operation of electrodialysis (ED) and electrodeionization (EDI).
8. Explain the purpose, equipment and operation of reverse osmosis (RO).

Topic 9 Internal Water Treatment

Learning Outcome

Describe boiler internal water treatment processes.

Learning Objectives

1. Explain the causes, effects, and control of scale.
2. Explain the causes, effects, and control of foam in boiler water.
3. Explain the causes, effects, and control of caustic embrittlement.
4. Explain the causes, effects, and control of return line corrosion.
5. Explain the use of chelating agents in boiler water.
6. Explain the use of sludge conditioning in boiler water.
7. Explain the use of pH control in boiler water.
8. Explain the use of chemical deaeration in boiler water.
9. Explain the causes, effects, and control of carryover of boiler water.
10. Explain the use of blowdown from boiler water.
11. Explain the use and control of chemical feed systems for boiler water.
12. Explain the control of silica to avoid turbine blade deposits.

Topic 10 Non-Boiler Water Treatment

Learning Outcome

Discuss water treatment applications for cooling water, wastewater, and potable water.

Learning Objectives

1. List the water impurities of concern in a cooling water system and the effects caused by each one.
2. Describe control methods for a cooling water system for control of corrosion, fouling, and microbiological attack including chloride corrosion, and delignification.
3. Describe the potential effects of wastewater discharge.
4. Compare and contrast mechanical, chemical, and biological methods of wastewater treatment including the advantages and disadvantages of each.
5. Specify an appropriate method of wastewater treatment for a particular case study.
6. Describe the methods used for potable water treatment and analysis.

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Major Topic: Prime Movers

Topic 1 Steam Turbine Theory and Construction

Learning Outcome

Explain the design and components of a large steam turbine, and perform nozzle and steam velocity calculations.

Learning Objectives

1. Explain selection criteria for a turbine application.
2. Describe the design and components of steam turbine casings and casing drains.
3. Describe the design and components of steam turbine rotors, blading, and diaphragms.
4. Describe shaft seal designs, including stuffing boxes, carbon rings, labyrinth, and water seals.
5. Describe the design and components of steam turbine bearings.
6. Describe the ways in which steam turbines are designed to counteract thrust.
7. Describe the purpose and design of expansion and anchoring components.
8. Explain the principles of steam turbine nozzle design.
9. Explain a steam turbine blade velocity diagram.
10. Calculate the steam velocity and angle of entry for impulse and reaction turbine blading.
11. Calculate the work done on steam turbine blades and the resulting power developed.
12. Calculate steam turbine Rankine cycle thermal efficiency.

Topic 2 Steam Turbine Auxiliaries and Control

Learning Outcome

Explain the purpose and design of steam turbine auxiliaries, control, and monitoring equipment.

Learning Objectives

1. Describe the purpose, design and components of a turning gear.
2. Describe the purpose, design and components of an adjusting gear.
3. Explain critical speed.
4. Describe the design and components of lubricating oil and jacking oil systems.
5. Describe the design of speed reducing gears.
6. Describe the design and components of flexible couplings.
7. Describe the purpose and design of steam turbine governors and governor systems.
8. Describe the purpose and design of steam turbine stop valves and control valves.
9. Describe the purpose and design of steam turbine grid type extraction valves.
10. Describe the purpose and design of steam turbine casing pressure relief systems including rupture diaphragms.
11. Describe the purpose and design of steam turbine overspeed trips.
12. Describe the purpose and design of steam turbine supervisory equipment.

Topic 3 Steam Turbine Operation and Maintenance

Learning Outcome

Discuss procedures for operation and maintenance of a large steam turbine.

Learning Objectives

1. Describe the detailed hot and cold start-up procedures for a large steam turbine, including safety precautions.
2. Describe the detailed shutdown procedure for a large steam turbine including safety precautions.
3. Explain what checks are performed on a large steam turbine during normal operation.
4. Sketch the flow of steam and condensate through a condensing steam turbine and a non-condensing steam turbine.
5. Explain the preventive maintenance requirements for a large steam turbine. Include shaft alignment, bearings, clearances for thrust, blades, shaft seals, correction of blade fouling, erosion and cleaning.
6. Describe the purpose of and procedure for static and dynamic balancing.

Topic 4 Steam Condensers

Learning Outcome

Discuss condenser principles, performance, operation and auxiliaries.

Learning Objectives

1. Describe the principles and design of jet, air cooled, and surface condensers.
2. Describe the purpose, principle and design of surface condenser support and expansion systems.
3. Explain the significant parameters in condenser performance.
4. Calculate condenser thermal efficiency from the test data.
5. Explain the procedures used to troubleshoot condenser performance.
6. Explain the procedures used to backwash and clean a condenser.
7. Describe the purpose, principle and design of air ejectors and vacuum pumps.
8. Describe the purpose and flow of cooling water systems.
9. Describe the purpose, principle and design of cooling water intake screens, circulating pumps, cooling towers, and cooling ponds.
10. Describe the purpose, principle and design of condenser atmospheric exhaust (relief) valves.
11. Describe the purpose, principle and design of condensate pumps.

Topic 5 Internal Combustion Engines: Components and Auxiliaries

Learning Outcome

Explain the design, selection, and components of internal combustion engine installations, including auxiliaries.

Learning Objectives

1. Explain design, applications, and selection criteria for the different types of reciprocating internal combustion engines.
2. Explain fuels and combustion processes used by internal combustion engines.
3. Describe the design of internal combustion engine scavenging and supercharging arrangements.
4. Describe the design and components of internal combustion engine fuel conditioning systems, injection systems, and ignition systems.
5. Describe the design and components of internal combustion engine cooling systems and cooling water conditioning systems.
6. Describe the purpose, design and components of internal combustion engine lubricating oil systems.
7. State the purpose and describe the control of a typical internal combustion engine including the operation of safety devices.

Topic 6 Internal Combustion Engines: Operation and Maintenance

Learning Outcome

Describe general maintenance requirements, and detailed operating and troubleshooting procedures for internal combustion engines.

Learning Objectives

1. Describe the detailed startup procedures for an internal combustion engine.
2. Describe the detailed shutdown procedures for an internal combustion engine.
3. Explain the routine maintenance and monitoring requirements for an internal combustion engine.
4. Explain the major maintenance and overhaul requirements for an internal combustion engine.
5. Explain the troubleshooting of combustion and engine problems.

Topic 7 Gas Turbine Design and Auxiliaries

Learning Outcome

Explain the design and components of a large gas turbine and related auxiliaries.

Learning Objectives

1. Explain applications and selection criteria for the different types of gas turbine engines.
2. Describe the principles and design of open and closed cycle gas turbine systems.
3. Describe the principles and design of combined cycle and cogeneration systems using gas turbines.
4. Describe the principles and design of gas turbine regeneration, intercooling, and reheating.
5. Describe the principles and design of gas turbine shaft arrangements.
6. Describe the design and components of gas turbine compressors, combustors (combustion chambers) and turbines.
7. Describe the design and operation of gas turbine air intake and exhaust systems.
8. Describe the design and operation of a gas turbine lubricating oil system.
9. Describe the design and operation of a gas turbine fuel system.
10. Describe the design and operation of a gas turbine steam or water injection system and a dry low NO_X system.

Topic 8 Gas Turbine Operation and Control

Learning Outcome

Discuss operating procedures, and control and monitoring components of a large gas turbine.

Learning Objectives

1. Describe the components and operation of gas turbine supervisory and control systems.
2. Describe the principles and design of gas turbine protection devices.
3. Describe the detailed hot and cold startup procedures for a gas turbine, including safety precautions.
4. Describe the detailed shutdown procedure for a gas turbine, including safety precautions.
5. Explain the routine maintenance and monitoring requirements for a gas turbine.
6. Describe the major maintenance and overhaul requirements for a gas turbine.
7. Explain the troubleshooting of gas turbine problems.

Topic 9 Lubrication

Learning Outcome

Explain the components of a lubrication application and maintenance program.

Learning Objectives

1. Describe the methods of manufacture and the different classifications of lubricants.
2. Describe the significance and measurement of lubricating oil characteristics, including viscosity, relative density, API (American Petroleum Institute) gravity, pour point, and dielectric strength.
3. Explain the typical causes of lubricating oil deterioration.
4. Describe the types of lubrication additives.
5. Describe a typical power plant lubrication program, including a lubrication survey.
6. Explain the different types of lubricating/governing/seal oil systems.
7. Describe the components and operation of a typical lubricating oil purification system.
8. Describe the various applications of ball-and-roller bearings and their lubrication, including bearing seals.

Topic 10 Piping

Learning Outcome

Explain piping system design, inspection, and maintenance.

Learning Objectives

1. Explain selection criteria for piping materials.
2. Calculate the required thickness and the internal design pressure of piping.
3. Describe typical inspection procedures for piping installations and repairs.
4. Describe a typical routine inspection procedure and schedule for high-energy piping.
5. Explain the effects of high temperature on piping strength.
6. Describe the design and installation criteria for a piping system layout.
7. Explain the theory and effects of water hammer.

Topic 11 Mechanical Drawing

Learning Outcome

Interpret construction and process drawings.

Learning Objectives

1. Interpret the information provided in orthographic, isometric, and oblique projections.
2. Interpret the information provided in construction drawings with sectioning and dimensioning.
3. Interpret the information provided in Process Flow Diagrams.
4. Interpret the information provided in Piping and Instrumentation Diagrams (P&IDs).
5. Explain the use of isometric piping system and spool drawings in piping systems.

Major Topic: Combustion and Plant Systems

Topic 1 Power Plant Fuel Systems

Learning Outcome

Describe the design and operation of typical power plant systems.

Learning Objectives

1. Describe, using a sketch, the design and operation of fuel oil supply systems.
2. Describe, using a sketch, the design and operation of fuel gas supply systems.
3. Describe, using a sketch, the design and operation of solid fuel supply systems.

Topic 2 Power Plant Water and Steam Systems

Learning Outcome

Describe the design and operation of power plant systems.

Learning Objectives

1. Describe, using a sketch, the design and operation of feedwater systems.
2. Describe, using a sketch, the design and operation of steam distribution systems.
3. Describe, using a sketch, the design and operation of condensate systems.
4. Describe, using a sketch, the design and operation of cooling water systems.
5. Describe, using a sketch, the design and operation of waste handling systems.
6. Explain how different power plant water systems interconnect and what parameters are significant to each.

Topic 3 Measurement and Control Components

Learning Outcome

Explain the design and application of measuring devices and final control elements.

Learning Objectives

1. Describe the design, use, and placement of electrical and electronic pressure measuring devices.
2. Describe the design, use, and placement of electrical and electronic temperature measuring devices.
3. Describe the design, use, and placement of Venturi tubes, orifice plates, flow nozzles, and Pitot tubes.
4. Describe the design and use of: manometers, ring balance, force balance, and electric flow indicating mechanisms.
5. Describe the design, use, and placement of the following liquid level measurement devices: ball-float, displacement-type, hydrostatic head, electric and pneumatic level transmission, electric and magnetic type level-limit devices, and remote water-level indicators.
6. Describe the types, construction, and flow characteristics of control valves.
7. Describe the design, operation, and application of the following valve operators: solenoid, pneumatic-diaphragm, power cylinder, and electric motor.

Topic 4 Control Instrumentation Systems

Learning Outcome

Explain and apply the theory of automatic boiler, distributed control, and programmable logic control systems.

Learning Objectives

1. Describe the principle, design, application, and limitations of the following automatic control methods: proportional, proportional-plus-reset, and proportional-plus-reset-plus-rate.
2. Describe the principle, design, application, and limitations of single, two, and three-element boiler feedwater control systems.
3. Describe the principle, design, application, and limitations of superheated and reheated steam temperature control systems.
4. Describe the principle, design, components, application, and limitations of Distributed Control Systems (DCS).
5. Describe the principle, design, application, and limitations of Programmable Logic Controllers (PLC).

Topic 5 Fuels and Combustion Calculations

Learning Outcome

Perform combustion and furnace draft calculations and explain flue gas analysis.

Learning Objectives

1. Describe the nature of combustion and the different types of fuels.
2. Calculate the mass and volumetric analysis of a fuel.
3. Describe proximate and ultimate analysis and calculate the heating value of fuel.
4. Given the results of a bomb calorimeter test, calculate the heating value of a fuel.
5. Calculate the amount of air and excess air required for combustion of fuel.
6. Explain flue gas analysis parameters and their significance.
7. Calculate theoretical draft, flue gas velocity, and stack diameter.
8. Calculate draft fan power and efficiency.

Topic 6 Firing and Draf t Equipment

Learning Outcome

Explain the design, components, and auxiliary equipment of steam generator furnaces.

Learning Objectives

1. Describe steam generator furnace designs including cyclone furnaces and divided furnaces. Explain the purpose and placement of furnace arches.
2. Explain the purpose and design of separately fired superheat and reheat furnaces.
3. Explain the purpose, types, characteristics, and placement of refractory in a furnace.
4. Describe the principle, design, and application of oil, gas, and coal burners.
5. Describe the principle, design, and application of pulverizers.
6. Describe the principle, design, and application of ash and slag disposal systems.
7. Explain the significance, monitoring, and control of ash fusion temperature.
8. Describe the designs and applications of forced and induced draft fans.
9. Explain the methods which control furnace draft.

Topic 7 Combustion Control and Safeguards

Learning Outcome

Explain combustion control methods and safeguard components.

Learning Objectives

1. Describe, using a sketch, the combustion control arrangements in a steam generator.
2. Explain series, parallel, and series/parallel combustion control.
3. Explain turbine-following, boiler-following, and integrated combustion control systems.
4. Describe the operation of purge, fan failure, and flame failure interlock systems.
5. Describe the operation of flame detectors.
6. Describe, using a sketch, a typical programming sequence for a packaged boiler control system.
7. Describe the typical limiting devices and alarms for a packaged boiler combustion system.

Topic 8 Environmental Monitoring

Learning Outcome

Explain the significance of environmental parameters and methods of monitoring.

Learning Objectives

1. Explain the significance of the following air quality parameters: particulates, stack opacity, SO_2 concentration, SO_2 mass flow, NO_X concentration, NO_X mass flow, mercury, O_2, CO_2, and hydrocarbons.
2. Explain the basic principles of operation for Continuous Emissions Monitoring System (CEMS) measurement instruments.
3. Explain the general requirements for Continuous Emissions Monitoring Systems (CEMS).
4. Explain the significance of the following water quality parameters: iron, phosphorous, biochemical oxygen demand (BOD), chemical oxygen demand (COD), hydrocarbons, temperature, flow, pH, and nitrogen.
5. Explain the general requirements for wastewater monitoring.
6. Explain how data received from environmental monitoring equipment is interpreted.
7. Explain the significance of environmental monitoring equipment failure.
8. Describe the procedures used for troubleshooting environmental monitoring equipment.

Topic 9 Environmental Control Methods

Learning Outcome

Explain the methods used to remove SO_2, NO_X, CO_2 and particulates from boiler flue gases.

Learning Objectives

1. Describe the purpose, design, operation, and application of Flue Gas Desulfurization (FGD) systems.
2. Describe the purpose, design, operation, and application of Selective Catalytic Reduction (SCR) systems.
3. Explain the significance of NO_X reduction in a power plant, and the procedures and equipment used to reduce NO_X emission from a boiler and from a gas turbine.
4. Explain the purpose, effects, and application of flue gas chemical conditioning in a power plant.
5. Explain the significance, procedures, and equipment for reduction of CO_2 emission from a boiler.
6. Describe the purpose, design, operation, and application of a baghouse.
7. Describe the purpose, design, operation, and application of an electrostatic precipitator.

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Major Topic: Electricity and Refrigeration

Topic 1 Alternating Current Theory

Learning Outcome

Explain characteristics and perform calculations involving AC circuits.

Learning Objectives

1. Explain the vector relationships between AC voltage and current.
2. Explain the significance of root mean square values for AC sine waves. Calculate root mean square and peak-to-peak values for AC sine waves.
3. Explain voltage/current relationships and calculate power in purely resistive circuits.
4. Explain voltage/current relationships in purely inductive circuits.
5. Explain voltage/current relationships in purely capacitive circuits.
6. Explain voltage and current relationships in circuits having resistance/inductance and resistance/capacitance combinations.
7. Calculate impedance, reactance, true and apparent power, and power factor in AC circuits.
8. Explain the significance of power factor and how it can be improved in AC circuits.
9. Explain the principle and significance of three-phase AC circuits, star, and delta connections in alternators, transformers and AC motors.
10. Calculate phase voltage, phase current and apparent and true power in a three-phase AC circuit.

Topic 2 Direct Current Machines

Learning Outcome

Explain the construction and operating principles of DC generators and motors.

Learning Objectives

1. Describe the construction and operating principles of a DC generator.
2. Explain the principle and application of compensating windings, interpoles, and lap and wave armature windings.
3. Explain the principles, applications, and load/voltage characteristics of generators.
4. Describe the parallel operation and voltage regulation of DC generators.
5. Review the principle of DC motor operation, including torque development and back EMF.
6. Calculate torque and speed of a DC motor.
7. Explain the principle and application of shunt, series, and compound-wound DC motors including speed control.
8. Explain the principle and application of counter-E, current limit and time limit DC motor automatic starters.
9. Explain the principle and application of dynamic and regenerative braking.
10. Calculate efficiency and discuss the reasons for power losses in a DC motor and generator.

Topic 3 Alternating Current Generators

Learning Outcome

Explain the construction and operating principles of AC generators.

Learning Objectives

1. Explain the operating principles, design and construction of alternators with salient-pole and cylindrical rotors.
2. Explain the relationship between alternator speed, frequency, and number of pole pairs.
3. Describe the purpose and construction of an exciter.
4. Describe the purpose and design of alternator voltage regulators.
5. Describe alternator cooling systems, including circulating air cooling, hydrogen cooling, and stator winding cooling water systems.
6. Describe shaft sealing arrangements for an alternator.
7. Explain the theory and significance of alternator synchronization and parallel operation including the impact on power factor.
8. Explain efficiency and power losses in an AC generator.

Topic 4 Alternating Current Motors

Learning Outcome

Explain the construction and operating principles of AC motors.

Learning Objectives

1. Describe the principle of a pulsating magnetic field for single-phase AC motors and rotating magnetic field for three-phase AC motors. Describe general rotor and stator construction.
2. Describe the torque/speed characteristics of induction motors and the relationship between torque, slip and rotor speed.
3. Define full-load amps, locked rotor amps and service factor amps.
4. Describe the principles, applications, and operation of wound rotor motors.
5. Describe the principles, applications, and operation of single-phase AC motors. Include universal, shaded-pole, split-phase, capacitance-start, repulsion-start, and reluctance-start.
6. Describe the principles, applications, starting methods and operation of a synchronous motor.

Topic 5 Transformers

Learning Outcome

Explain the construction and operating principles of transformers.

Learning Objectives

1. Describe the construction of core type and shell type transformers.
2. Explain the factors that affect transformer rating.
3. Calculate load, power, iron and copper losses, and efficiency in a transformer.
4. Explain the purpose and procedures for transformer short and open circuit tests.
5. Describe the methods of cooling a transformer.
6. Describe the methods of connecting a transformer, including delta-delta, star-star, delta-star, and star-delta.
7. Explain the theory and significance of transformer paralleling.
8. Describe the applications of instrument transformers.
9. Describe the protective measures and devices used on transformers.

Topic 6 Electrical System Protection

Learning Outcome

Describe the protective devices used on alternators, motors, and electrical circuits.

Learning Objectives

1. Describe the significance of fuses and circuit breakers for circuit protection including continuous rating, interrupting capacity, and inverse time principle.
2. Describe the purpose and designs of different types of fuses.
3. Describe the operation of circuit breakers used for different voltages, including moulded-case, oil-immersed, airblast, air-break, vacuum, and SF_6 switchgear.
4. Describe the operation of switches and contactors used for different voltages.
5. Explain the purpose, and significance of protection relaying as it applies to a large alternator.
6. Explain the purpose and significance of the protection devices for a large electric motor.

Topic 7 Air and Gas Compression

Learning Outcome

Explain the construction and operation of large air compressors and compressed air systems.

Learning Objectives

1. Describe the design and application of compressors, including prime mover selection.
2. Describe reciprocating compressor designs.
3. Describe rotary compressor designs.
4. Describe centrifugal and axial compressor designs.
5. Describe the types and operation of coolers and air dryers, including desiccant types.
6. Describe the installation of a compressed air system, including all ancillary equipment and typical instrumentation.
7. Describe the regulation and control of compressors.
8. Describe the monitoring and protection devices for a compressed air system.
9. Explain the effects of altitude, air temperature, and humidity on air compressor performance.
10. Describe the monitoring, troubleshooting, and typical preventive maintenance for a compressed air system.

Topic 8 Refrigeration Systems and Equipment

Learning Outcome

Explain the construction and operation of refrigeration systems.

Learning Objectives

1. Describe the types of refrigerants.
2. Describe the principles and operation of vapor compression refrigeration systems.
3. Describe the principles and operation of absorption refrigeration systems.
4. Describe the principles and operation of multi-stage and cascade refrigeration systems.
5. Describe the principles, applications, and operation of heat pump and thermoelectric systems.
6. Describe the design of hermetic refrigeration systems.
7. Describe the design and operation of refrigeration compressors.
8. Describe the design and operation of evaporators, condensers, receivers, scale traps and dehydrators.
9. Describe the design and operation of absorbers.
10. Describe the design and operation of valves and fittings.

Topic 9 Refrigeration Safety, Control, and Operation

Learning Outcome

Explain the procedures, standards, instrumentation, and controls for a refrigeration system.

Learning Objectives

1. Describe the codes and standards which apply to the design, installation, and operation of a refrigeration plant.
2. Describe the purpose and operation of the various operating, actuating, limiting and safety controls used in refrigeration systems.
3. Explain refrigeration metering devices.
4. Explain evaporator and compressor capacity controls.
5. Describe the detailed startup and shutdown procedures for a refrigeration system.
6. Explain absorption system startup and shutdown.
7. Explain leak testing, charging, purging, and compressor lubrication.
8. Describe the common operating problems and troubleshooting procedures for a refrigeration system.

Topic 10 Refrigeration Calculations

Learning Outcome

Perform refrigeration system calculations.

Learning Objectives

1. Describe the general refrigeration cycle and the application of the Carnot cycle.
2. Describe the relationship between enthalpy and pressure for a refrigeration cycle.
3. Define and calculate the refrigerating effect and the mass of refrigerant circulated.
4. Calculate the coefficient of performance for a refrigeration system.
5. Calculate the capacity of a refrigeration machine.
6. Calculate the theoretical power of a refrigeration compressor.
7. Calculate the theoretical bore and stroke of a refrigeration compressor.

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REFERENCE CURRICULUM

For

Power Engineer (3rd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the NIULPE Power Engineer (3rd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Power Engineer (3rd Class) Examination Candidates

Major Topic: Applied Mechanics, Thermodynamics, and Chemistry

Topic 1 Forces and Friction

Learning Outcome

Explain concepts and solve problems involving vectors, force systems and friction.

Learning Objectives

1. Define concurrent, coplanar vectors and draw space diagrams for forces and displacements.
2. Draw a vector diagram and use it to graphically determine the resultant and equilibrant of a force system.
3. Use trigonometry to resolve forces into components and to calculate the resultant and equilibrant of a force system.
4. Given a coplanar, concurrent force system, calculate any unknown forces.
5. Define static and sliding friction, coefficient of friction, and use the coefficient formula to calculate the coefficient, force, or mass in a simple friction problem.
6. Explain friction angle and perform friction calculations for forces applied parallel to the horizontal plane.
7. Calculate the coefficient of friction, object mass, and applied forces for objects moved on a horizontal surface by forces that are NOT parallel to the plane.

Topic 2 Work, Power, Energy: Linear and Angular Motion

Learning Outcome

Explain concepts and solve problems involving velocity and acceleration, the Laws of Motion and work, power and energy.

Learning Objectives

1. Define force, force due to gravity, and work. Calculate the work done in moving objects horizontally and vertically.
2. Define power and mechanical efficiency. Calculate the power expended when work is done, plus the power developed and mechanical efficiency of a reciprocating engine.
3. Define potential and kinetic energy. Calculate the energies of stationary and moving objects.
4. Define, and show the relationships between, distance, displacement, speed, linear velocity, and linear acceleration.
5. Using linear motion relationships, calculate the displacements, velocities and accelerations of bodies moving in a straight line.
6. Define and calculate angular displacement, angular velocity and angular acceleration.

Topic 3 Heat, State Change, Calorimetry

Learning Outcome

Explain terminology regarding heat and perform calculations regarding heat during changes of state and calorimeter tests.

Learning Objectives

1. Define and explain internal energy, heat, specific heat, heat units, temperature and explain the relationship between the different temperature scales.
2. Define sensible heat and use the sensible heat equation to calculate the amount of heat required to change the temperature of a substance, the mass of the substance, and the temperature change, if no change of state occurs.
3. Explain the changes of state and define latent heat, latent heat of fusion, and latent heat of evaporation.
4. Given start and end conditions, calculate the heat required to change the states of water and other substances.
5. Determine the final temperatures and the original masses for mixtures of ice, water, steam, and other substances.
6. Explain the working principle of a simple calorimeter and use the calorimeter equation to determine specific heat and final temperature.
7. Explain water equivalent and perform calculations involving calorimetry and water equivalents.

Topic 4 Thermal Expansion and Heat Transfer

Learning Outcome

Explain concepts and perform calculations involving the thermal expansions of solids and liquids and heat transfer by conduction.

Learning Objectives

1. Explain the thermal conditions that cause expansion of solids and liquids and describe the relationship between linear, superficial (area) and volumetric expansion.
2. Given known conditions, calculate linear expansion or contraction, temperatures, and/or expansion coefficients for solids.
3. Given known conditions, calculate superficial expansion or contraction, temperatures, and/or expansion coefficients for solids.
4. Given known conditions, calculate volumetric expansion or contraction, temperatures, and/or expansion coefficients for solids or liquids.
5. Calculate the stress produced in a pipe or its supports when thermal expansion is restricted.
6. Explain the methods of heat transfer: conduction, convection, and radiation.
7. Define thermal conductivity and calculate the quantity of heat conducted, the temperature difference, or the material thickness when heat is transferred through flat walls and plates.

Topic 5 Steam Properties and Calculations

Learning Outcome

Define properties of saturated and superheated steam and, using information from the steam tables, calculate the heat required to produce steam at various conditions; determine the equivalent and factor of evaporation for steam boilers.

Learning Objectives

1. Define and explain the following terms: saturation temperature, saturated steam, dry saturated steam, wet saturated steam, dryness fraction, superheated steam, enthalpy.
2. Identify, from the pressure-based and temperature-based steam tables, the properties of saturated steam at specified conditions.
3. Identify, from the superheated steam tables, the properties of superheated steam at specified conditions.
4. Calculate the heat required to produce dry saturated or superheated steam at given conditions, from feedwater at given conditions.
5. Calculate the dryness fraction of wet steam and/or the heat required to produce wet steam at a given dryness fraction.
6. Explain the properties of steam on a temperature-enthalpy diagram.
7. Define and calculate heat rate, equivalent evaporation and factor of evaporation for a boiler.

Topic 6 Gas Laws and Calculations

Learning Outcome

Explain the laws of perfect gases and perform calculations involving the expansion and compression of gases.

Learning Objectives

1. Explain Boyle's Law, Charles' Law, Gay-Lussac's Law, and the General Gas Law and use these to calculate pressure, temperature and/or volume changes for perfect gases.
2. Explain the Characteristic Gas Constant and use the Characteristic Gas Equation to determine the mass, the conditions, and the constant for a gas.
3. Explain isothermal, adiabatic, and polytropic processes (expansion and compression) for a gas, state the formula for each process, and compare the processes on a pressure/volume diagram.
4. Calculate unknown pressures, volumes and temperatures for gases during isothermal adiabatic, and polytropic processes.
5. Explain and calculate the work done in a cylinder under constant pressure.
6. Explain and calculate the work done in a cylinder during an isothermal expansion or compression.
7. Explain and calculate the work done in a cylinder during an adiabatic expansion or compression.
8. Explain and calculate the work done in a cylinder during a polytropic expansion or compression.

Topic 7 Chemistry Fundamentals

Learning Outcome

Explain the fundamental principles in the structure, formation and interaction of chemical compounds and the importance of chemistry in industrial operations.

Learning Objectives

1. Define each term and explain the relationship between atoms, ions, elements, molecules, compounds, and mixtures.
2. Using the Periodic Table of the Elements, determine the atomic numbers and the atomic masses of elements.
3. Explain electronegativity and the bonding of ions.
4. Explain the formation of chemical compounds, explain typical reactions and apply fundamental principles to the balancing of simple chemical reactions.
5. Calculate the amount of reactants required or products produced in a chemical reaction.
6. Define acids, bases, and salts and explain their properties.
7. Define organic chemistry and explain, in general terms, the structure and applications of hydrocarbons and hydrocarbon derivatives.
8. Explain typical applications of chemistry in industry, including water treatment and testing, corrosion, combustion, hydrocarbon processing, petrochemical and pulp and paper processes.

Topic 8 Metallurgy and Materials

Learning Outcome

Explain the production, properties and applications of metallic and non-metallic materials.

Learning Objectives

1. Define and explain the importance and application of mechanical properties of materials, including brittleness, hardness, ductility, malleability, plasticity, elasticity, and toughness.
2. Describe material testing, including tension test, Brinell and Rockwell hardness tests, Charpy and Izod impact tests.
3. Describe the blast furnace and cupola furnace methods for iron production and compare the characteristics of gray, white, malleable, and ductile cast iron.
4. Define steel and explain the compositions and characteristics of low carbon, medium carbon and high carbon steels.
5. Define alloy steels, and explain the benefits of alloying elements, including nickel, chromium, molybdenum, vanadium, copper, lead, manganese and tungsten.
6. Explain the purposes of hot working, cold working and heat treating of metals.
7. Describe the production of carbon and alloy steel, using the open hearth, basic oxygen and electric-arc furnace processes.
8. Describe the properties and applications of non-ferrous metals and alloys.
9. Explain the basic structure, properties and applications of polymers, ceramics and composites.

Topic 9 Corrosion Principles

Learning Outcome

Explain the mechanisms that cause corrosion and the methods used to monitor and control corrosion.

Learning Objectives

1. Define corrosion terms and explain the causes and characteristics of corrosion types, including galvanic, atmospheric, stray current, biological, stress cracking, hydrogen induced, sulphide stress cracking and chloride stress cracking.
2. Explain specifically the nature and sources of corrosion on the water side of boilers, including caustic corrosion, hydrogen damage, and pitting.
3. Explain the environmental factors that affect corrosion.
4. Explain the principles of corrosion inhibitor mechanisms, including adsorbed films, passivation, cathodic precipitates, and neutralization.
5. Describe the principles and applications of cathodic protection devices or systems, including sacrificial anodes, galvanic anodes, impressed current, and groundbeds.
6. Describe the principles and applications of corrosion monitoring devices, including coupons, electrical resistance probes, galvanic probes, and hydrogen probes.
7. Describe corrosion inspection procedures, including ultrasonics and radiography.

Major Topic: Boiler Codes, Electrical and Instrumentation Theory

Topic 1 Legislation and Codes for Power Engineers

Learning Outcome

Explain the purpose of, general content of, and interaction with the legislation and codes that pertain to the design and operation of boilers and related equipment.

Learning Objectives

1. Explain Codes and Standards.
2. Explain the purpose and scope of the National Board of Boiler Inspectors (NBBI).
3. Explain the scope of the ASME and state the purpose and general content of the following sections of the the ASME Codes: Section I, II, IV, V, VI, VII, VIII, IX.

Topic 2 Code Calculations - ASME Section I

Learning Outcome

Using the ASME Code - Section I, and ASME Section II D. Table 1A, calculate the design thickness and pressure of boiler tubes, drums, and piping, and calculate the capacities of pressure relief valves.

Learning Objectives

1. Given the tube material specification numbers, and other necessary parameters, use the formulae in PG-27.2.1 to calculate either the minimum required wall thickness or the maximum allowable working pressure for a boiler tube.
2. Given the material specification, construction method, and other necessary parameters, use the formulae in PG-27.2.2 to determine the minimum required thickness and or maximum allowable working pressure for boiler drums, headers, or piping.
3. Given the required specifications and operating conditions, use formula PG-29.1 to calculate the minimum required thickness of a seamless, unstayed dished head.
4. Given the required specifications and operating conditions, use formulae in paragraphs PG-29.11 and PG-29.12 to calculate the minimum required thickness of an unstayed, full-hemispherical head.
5. Using ASME Section I, Paragraphs PG-67 to PG-73, identify code information with respect to pressure relief valves and, using Table A-44, calculate the required pressure relief valve capacity for a given boiler.

Topic 3 Fuels, Combustion, and Flue Gas Analysis

Learning Outcome

Explain the properties and combustion of common fuels and the analysis of combustion flue gas.

Learning Objectives

1. Explain/define complete combustion, incomplete combustion, combustion products, and write balanced combustion equations.
2. Explain the purpose and benefits of excess air and calculate the theoretical and excess air required for the complete combustion of a given fuel.
3. Explain proximate analysis, ultimate analysis, and heating value of a fuel and describe the use of calorimetry to determine heating value. Explain higher and lower heating values.
4. Given the ultimate analysis of a fuel, use Dulong's Formula to calculate the heating value of the fuel.
5. Describe the properties, classifications and combustion characteristics of coal.
6. Describe the properties, classifications and combustion characteristics of fuel oil.
7. Describe the properties and combustion characteristics of natural gas.
8. Explain the use and combustion characteristics of alternatives to traditional fossil fuels, including biomass, coke and oil emulsions.
9. Explain the analysis of flue gas for the measurement of O_2, CO, and CO_2 in relation to combustion efficiency. Describe typical, automatic flue gas analyzers.
10. Explain the formation, monitoring and control of nitrogen oxides (NO_X), sulfur dioxide, and particulates.

Topic 4 Piping Design, Connections, Support

Learning Outcome

Discuss the codes, designs, specifications, and connections for ferrous, non-ferrous and non-metallic piping and explain expansion and support devices common to piping systems.

Learning Objectives

1. Identify and explain the general scope of the ASME, ANSI, ASTM codes and standards with respect to piping and pipe fittings. Differentiate between power piping (Code B31.1) and pressure piping (Code B31.3).
2. Explain methods of pipe manufacture; size specifications and service ratings, and the material specifications and applications for ferrous pipe.
3. Using pipe specifications and the ASME code Sections I and II you will be able to identify the size of pipe required for a particular installation, process or operating condition.
4. Explain the materials, code specifications and applications of common, non-ferrous metal piping and cast iron.
5. Describe screwed, welded, and flanged methods of pipe connection and identify the fittings used for each method.
6. Describe the construction, designs, and materials of flange gaskets and explain the confined, semi-confined, and unconfined flange styles.
7. Explain the materials, construction and approved applications of common, non-metallic pipe.
8. Explain the effects of temperature on piping; explain the mechanisms and the dangers of expansion in piping systems, including attached equipment.
9. State the purpose and explain the designs, locations and applications of simple and offset U-bend expansion bends.
10. Describe designs, locations, care and maintenance of slip, corrugated, bellows, hinged, universal, pressure-balanced, and externally pressurized expansion joints.
11. Describe design, location, operation of pipe support components, including hangers, roller stands, variable spring hangers, constant load hangers, anchors, and guides.

Topic 5 Steam Traps, Water Hammer, Insulation

Learning Outcome

Explain the designs and operation of steam trap systems, the causes and prevention of water hammer, and the designs and applications of pipe insulation.

Learning Objectives

1. Explain the dynamics, design, and components of steam/condensate return systems for steam lines and condensing vessels. Explain roles and locations of separators and traps.
2. Describe the design, operation and application of ball float, inverted bucket, thermostatic, bi-metallic, impulse, controlled disc, and liquid expansion steam traps.
3. Explain the selection, sizing and capacity of steam traps and explain the factors that determine efficient trap operation.
4. Explain the procedures for commissioning, testing, and maintenance of steam traps.
5. Explain and compare condensate-induced and flow-induced water hammer in steam and condensate lines. Explain the typical velocities, pressures and damage that can be created in steam/condensate lines due to water hammer.
6. Describe specific trap and condensate return arrangements that are designed to prevent water hammer in steam and condensate lines.
7. State precautions that must be observed to prevent water hammer and describe a typical steam system start-up procedure that will prevent water hammer.
8. State the purposes of insulation and explain the properties required for a good insulating material. Explain thermal conductivity, K-Factor and R-Value.
9. Identify the most common industrial insulating materials, describe the composition and characteristics of each, and explain in what service each would be used.
10. Describe common methods for applying insulation to piping and equipment, including wrap and clad, blanket, insulated covers and boxes. Explain the care of insulation and cladding and the importance of maintaining good condition.

Topic 6 Valves and Actuators

Learning Outcome

Describe the designs, configurations and operation of the common valve designs that are used in power and process piping.

Learning Objectives

1. Explain the factors that determine the suitability and applications of the major valve styles; gate, globe, ball, plug, butterfly and needle.
2. Explain the factors that determine the selection of valve materials, and describe examples of typical valve body and trim materials. How are common control valves identified?
3. Describe the configurations and applications for gate valves, including gate designs (solid, split, flexible, sliding), stem configurations (rising, non-rising, outside screw-and-yoke, inside screw), and bonnet designs (flanged, screwed, welded).
4. Describe the designs and applications of globe valves, including conventional disc, composition disc, plug-type disc, and angle valves. Describe high-pressure plug-type control valves.
5. Describe the designs, application and operation of single-seated and double-seated balance valves. Explain caged trim for balanced control valves.
6. Describe the designs and applications of typical plug valves, including tapered and cylindrical plug, four-way, eccentric, and jacketed.
7. Describe the designs and configurations for mixing and diverter valves.
8. Describe the designs and operation of diaphragm valves.
9. Describe designs and operation of butterfly valves, including vertical, horizontal, swing-through, lined, and high-performance.
10. Describe the design, application, and operation of gear, motor, air-diaphragm, and air-piston actuators for valves.

Topic 7 AC Theory and Machines

Learning Outcome

Explain formation and characteristics of AC power, and describe the design, construction and operating principles of AC generators, motors and transformers.

Learning Objectives

1. Explain the creation of single phase and three-phase alternating power; define cycle, frequency and phase relationships (voltage/current) for AC sine waves.
2. Define the following terms and explain their relationships in an ac circuit: capacitance, inductance, reactance, impedance, power factor, alternator ratings (kVA and kW).
3. Describe the stator and rotor designs, operation, and applications for salient pole and cylindrical rotor alternators
4. Describe water, air and hydrogen cooling systems for large generators.
5. Explain parallel operation of alternators and state the requirements for synchronization. Describe manual and automatic synchronization.
6. Describe the design, applications and operating principles for large three-phase squirrel cage and wound rotor induction motors.
7. Describe the design and operating principle of synchronous motors.
8. Explain variable speed control, variable speed starting, and step starting for large induction motors.
9. Explain the principles and applications of power transformation. Perform transformer calculations.
10. Describe the designs and components of typical core and shell type transformers, including cooling components.

Topic 8 AC Systems, Switchgear, Safety

Learning Outcome

Identify the components of typical AC systems and switchgear and discuss safety around electrical systems and equipment.

Learning Objectives

1. Using a one-line electrical drawing, identify the layout of a typical industrial AC power system with multiple generators, and explain the interaction of the major components.
2. Explain the function of the typical gages, meters, and switches on an AC generator panel.
3. Explain the purpose and function of the circuit protective and switching equipment associated with an AC generator: fuses, safety switches, circuit breakers, circuit protection relays, automatic bus switchover, grounding and lightning arrestors.
4. Explain the components and operation of a typical Uninterruptible Power Supply (UPS) system.
5. Explain safety procedures and precautions that must be exercised when working around and operating electrical system components. Explain grounding.

Topic 9 Electrical Calculations

Learning Outcome

Define terms and perform simple calculations involving DC and AC power circuits.

Learning Objectives

1. Use Ohm's Law and Kirchhoff's Laws to calculate current, resistance or voltage drop in series or parallel multi-resistor circuits.
2. Calculate unknown resistances using a Wheatstone Bridge circuit.
3. Explain and perform calculations involving electrical power, work and energy.
4. Calculate the frequency, period and phase angle for an AC sine wave.
5. Define terms and calculate the peak-to-peak, root mean square, and maximum values for AC voltage and current.
6. Given required parameters, calculate the inductive reactance, capacitive reactance, total reactance, and impedance for an AC circuit, plus circuit frequency and current flow.
7. Calculate real power, imaginary power and power factor for an AC circuit.
8. Given the load, voltage and power factor of a 3-phase generator, calculate the kVA and kW ratings of the generator.

Topic 10 Control Loops and Strategies

Learning Outcome

Explain the operation and components of pneumatic, electronic and digital control loops, and discuss control modes and strategies.

Learning Objectives

1. Describe the operation, components and terminologies for a typical control loop.
2. Describe the operation and components of a purely pneumatic control loop. Explain the function of each component.
3. Describe the operation and components of an analog/electronic control loop. Explain the function of each component.
4. Describe the operation and components of a digital control loop. Explain the function of each component.
5. Explain the purpose, operation, and give examples of on-off, proportional, proportional-plus-reset, and proportional-plus-reset-plus-derivative control. Define proportional band and gain.
6. Describe and give typical examples of feed forward, feed back, cascade, ratio, split-range, and select control.
7. Explain, with examples, the purpose and incorporation of alarms and shutdowns into a control loop/system.
8. Explain the interactions that occur and the interfaces that exist between an operator and the various components of a control loop/system, including the components of a controller interface.

Major Topic: Pumps and Boilers

Topic 1 Watertube Boiler Designs Learning

Outcome

Describe common designs, configurations and circulation patterns for modern bent-tube watertube boilers and steam generators and explain how boilers are rated.

Learning Objectives

1. Explain the difference between packaged, shop assembled, and field-erected watertube boilers. Explain how boilers are rated.
2. Explain the process of water circulation in a watertube boiler and the factors that influence circulation.
3. Identify examples of and describe the A, O, and D design configurations and explain the water and gas circulation patterns for each. Define integral furnace.
4. Define a steam-generating unit, identify oil and gas-fired units, and explain the components, heating surfaces, and flow patterns through a typical unit. State typical temperatures throughout the unit.
5. Differentiate between critical and super-critical boilers.
6. Explain the purpose and advantage of forced circulation and describe the flow through a typical controlled circulation boiler.
7. Explain the purpose and design of a once-through boiler.

Topic 2 Special Boiler Designs

Learning Outcome

Describe the designs, components, firing methods, and operating considerations for some special boilers used in industry.

Learning Objectives

1. Describe typical designs, components and operating strategies for once-through, steam flood boilers.
2. Describe typical designs, components and operating strategies for Fluidized Bed boilers.
3. Describe typical designs, components and operating strategies for Heat Recovery Steam Generators.
4. Describe typical designs, components and operating strategies for Black Liquor Recovery boilers used in pulp mills.
5. Describe typical designs, components and operating strategies for Refuse boilers used in waste disposal.
6. Describe typical designs, components and operating strategies for waste heat, biomass boilers.

Topic 3 Boiler Construction

Learning Outcome

Explain Code requirements, in general terms, and describe construction and assembly methods for the major components of a large boiler.

Learning Objectives

1. Explain top and bottom support and describe the support techniques for various components of a large boiler, including lateral supports for furnace walls. Explain allowances for expansion.
2. Explain the purpose, design, locations and installation methods for boiler casing insulation, refractory, and cladding.
3. Describe the methods used to fabricate boiler tubes.
4. Describe the preparation, fabrication, and testing of boiler drums.
5. Describe methods of attaching tubes to drums and headers, including expanding and welding, and explain where each method would be used.
6. Explain code requirements/sizes for, and describe the designs and installation of, manholes and handholes, including welded handholes. Explain procedures for removing and installing covers.
7. Describe the field assembly of a large boiler or steam generating unit.

Topic 4 Boiler Heat Transfer Components

Learning Outcome

Explain the purpose, location, design and operating conditions for the major heat transfer components of a large watertube boiler or steam generator.

Learning Objectives

1. Describe baffle designs and locations and explain their significance to boiler heat transfer.
2. Describe the designs of integral furnace sidewall and header arrangements, including tube-and-tile, tangent tube, and membrane.
3. Define primary, secondary, convection, radiation, platen, and pendant as they apply to superheaters. Describe the locations of superheaters within a steam generator and state the operating characteristics of convection and radiant superheaters.
4. Explain the purpose and design of a separately-fired superheater.
5. Explain the purpose and describe the locations of reheaters. Explain the position of and flow through the reheater in relation to the superheaters.
6. Describe designs and locations for integral and separate economizers.
7. Describe the designs, operation, and location of plate, tubular, and rotary regenerative air heaters.
8. Explain operating care and considerations that must be given to the various heat transfer sections of the boiler.
9. Explain a typical water and gas temperature profile through a large steam generating unit.

Topic 5 High Pressure Boiler Fittings

Learning Outcome

Describe the design and operation of common external and internal fittings attached to the pressure side of a high-pressure boiler.

Learning Objectives

1. Describe the design, installation, operation, and setting of a high-pressure pressure relief valve. Explain the Code requirements for size, capacity and locations of the pressure relief valves on a boiler.
2. Describe the code requirements for boiler pressure gages, including attachment and locations.
3. Describe common designs, connections and components of high-pressure water columns and flat gage glasses, including illumination and quick shut-off devices and bulls-eye glasses. Explain testing and maintenance of a high-pressure gage glass.
4. Describe the float and probe designs for low-water fuel cutoffs and explain how these are tested.
5. Describe boiler steam outlet arrangements and fittings including gate, angle, and globe stop valves and globe, Y, angle, and spring-cushioned non-return valves.
6. Describe manual blowoff piping arrangements. Describe the design and operation of sliding disc, seatless sliding plunger, seat and disc, and combination valves. Explain manual blowoff procedures. Describe the requirements for a blowoff tank.
7. Explain the components of the steam drum internals of a watertube boiler. Describe the design and operation of various steam separation devices, including baffles, primary and secondary separators, and scrubbers.

Topic 6 Burner Designs and Supply Systems

Learning Outcome

Describe the typical components of fuel supply systems and describe common burner/furnace designs for gas, oil, and coal-fired boilers.

Learning Objectives

1. Describe a complete fuel gas supply system from fuel gas header to burner and explain the function of each component, including control and shut-off valves, auto-vents, and instruments. State the typical operating pressures.
2. Describe the design and operation of spud and ring burners, and explain high-efficiency, low NO_X designs.
3. Describe a complete fuel oil supply system from storage tanks to burners and explain the function of each system component.
4. Describe the design and operation of air, steam, and mechanical atomizing burners.
5. Describe a coal supply system from stockpiles to burners for a typical pulverized coal furnace.
6. Describe the design and operation of a pulverized coal burner and explain turbulent vertical, tangential, and cyclone furnaces.
7. Describe the design and operation of ball, impact, ball-race, and bowl mill pulverizers.
8. Describe the designs and operation of underfeed, overfeed, and crossfeed stokers for furnaces burning solid fuels.

Topic 7 Boiler Draf t and Flue Gas Equipment

Learning Outcome

Explain boiler draft systems and fans and describe the equipment used to remove ash from flue gas.

Learning Objectives

1. Define and explain the applications and designs of natural, forced, induced and balanced draft.
2. Explain how draft is measured, monitored, and controlled in a large, balanced draft boiler. Explain the position of control dampers.
3. Describe typical draft fan designs, single and double inlet arrangements, and explain methods used to control fan output.
4. Explain the start-up and running checks that must be made on draft fans.
5. Describe typical windbox and air louver arrangements and distinguish between primary and secondary air.
6. Describe the design and operation of flue gas particulate clean-up equipment, including mechanical and electrostatic precipitators and baghouse filters.
7. Describe the design and operation of ash handling systems, including hydro and air systems, bottom ash systems, and scraper conveyor systems.
8. Describe the designs and operation of SO_2 recovery systems, including lime and wet gas scrubbing.

Topic 8 Boiler Control Systems

Learning Outcome

Explain the components and operation of automatic control systems for boiler water level, combustion, steam temperature, and start-up.

Learning Objectives

1. Describe on-off and single element control of boiler feedwater.
2. Explain swell and shrinkage in a boiler. Describe the components and operation of a two-element feedwater control system, explaining the interaction of the controllers.
3. Describe the components and operation of a three-element feedwater control system.
4. Describe the components and operation of a direct combustion control system.
5. Describe the components and operation of a ‘steam flow – airflow’ combustion control system.
6. Describe the components and operation of a ‘fuel flow – airflow’ combustion control system.
7. Describe the components and operation of an ‘airflow – fuel flow’ combustion control system.
8. Describe the components and operation of a multi-element combustion control system.
9. Describe steam temperature control methods and equipment, including attemperation (desuperheating), gas recirculation, gas bypass, and tilting burners.
10. Describe the automatic, programmed start-up sequence for a gas-fired boiler.

Topic 9 Boiler Procedures

Learning Outcome

Describe common procedures in the operation and maintenance of high pressure boilers.

Learning Objectives

1. Explain the steps involved in the commissioning of a new boiler or before starting a boiler after major repairs, including:
    a) hydrostatic test
    b) external and internal inspections
    c) drying out refractory
    d) boiling out
    e) testing shutdowns and safety devices
2. Describe the wet and dry methods when laying up a boiler for an extended time, including nitrogen blanketing.
3. Describe the proper shut down and preparation of a boiler for internal inspection.
4. Describe a thorough inspection of the water and furnace sides of a boiler.
5. Describe typical equipment and procedures for cleaning the water side of a boiler:
    a) mechanically
    b) chemically
6. Explain routine tasks and visual monitoring that the operator must perform on a large operating boiler.
7. Explain the procedures and precautions that an operator must exercise to avoid furnace and pressure-side explosions.
8. Describe sootblowing systems and describe the procedures for operating sootblowers.

Topic 10 Internal Water Treatment for Boilers

Learning Outcome

Discuss internal water treatment methods and systems for the control of scale, corrosion, and carryover and explain testing and monitoring strategies.

Learning Objectives

1. Explain the causes and effects of boiler scale; explain the most common internal methods of scale control, including phosphate treatment, chelate treatment, sludge conditioning and dispersion.
2. Explain the causes and effects of boiler and condensate return line corrosion; explain treatment methods for acidic, caustic, oxygen, and carbon dioxide corrosion, including sulphite, hydrazine, and amine treatment.
3. Explain the mechanical and chemical causes, effects and types of carryover; explain methods of carryover control, including the use of antifoam and blowdown.
4. Describe the design and explain the operation of simple blowdown, heat recovery, and automatic blowdown systems.
5. Explain, in general terms, the sampling and testing strategies for boiler internal conditions; describe typical sampling and automatic monitoring equipment.
6. Describe typical chemical feed systems, including pot feeders, continuous feed with day tanks, and continuous feed with pump tanks.

Topic 11 Boiler Water Pretreatment

Learning Outcome

Explain the purpose, principles, equipment, and monitoring of boiler water pretreatment processes.

Learning Objectives

1. Describe the design and explain the terms, purpose and operation of a clarifier, using coagulation, flocculation, and subsidence.
2. Describe the design and explain the terms, purpose and operation of gravity and pressure filters.
3. Describe the design and explain the terms, purpose and operation, including chemical reactions for a cold lime softener.
4. Describe the design and explain the terms, purpose and operation of a hot lime softener.
5. Explain the principles of ion exchange softening in general, identifying the common anions and cations in untreated water.
6. Describe the design, components, and operation of a sodium zeolite softening system including chemical reactions.
7. Describe the design, components, and operation of a hydrogen zeolite softening system including chemical reactions.
8. Describe the design, components, and operation of a dealkalization system including chemical reactions.
9. Describe the design, components, and operation of a demineralizer system, including mixed bed and degasification.
10. Explain the principle and operation of a reverse osmosis system.
11. Describe the design, principle, and operation controls of a typical deaerator.

Topic 12 Pressure Vessels

Learning Outcome

Explain pressure vessel design, stresses, and operating considerations.

Learning Objectives

1. Define “pressure vessel” and explain, in general terms, how pressure vessels are regulated in design, construction and repair (including purpose of Section VIII, ASME).
2. Explain the stamping/nameplate requirements for pressure vessels and identify terms and specifications on a typical nameplate.
3. Describe the weld locations on a typical pressure vessel and identify head designs, including ellipsoidal, torispherical, hemispherical, conical, and toriconical.
4. Describe acceptable nozzle attachment methods, including reinforcements; describe inspection openings.
5. Explain the loads that contribute to stresses in pressure vessels, including pressure, thermal, attachments, static, wind, seismic, and cyclic loads.
6. Explain the components and fittings of a typical pressure vessel.
7. Explain operating and maintenance considerations for the safe operation of pressure vessels, including the appropriate use of hydrostatic and pneumatic testing.

Major Topic: Prime Movers and Refrigeration

Topic 1 Steam Turbine Auxiliaries and Operation

Learning Outcome

Describe auxiliary support and control systems for steam turbines and explain start-up and shutdown procedures.

Learning Objectives

1. Describe typical lube oil systems for small and large steam turbines.
2. Explain the purpose and describe the design and operation of barring gear and jacking oil systems on a large turbine.
3. Describe a condensing turbine circuit and explain typical operating parameters.
4. Explain and state the applications, where applicable, of the following governor types: speed-sensitive, pressure-sensitive, nozzle, throttle, and bypass. Explain governor droop and isochronous control.
5. Explain the operation and the major components of the three main speed-sensitive governor systems: mechanical, mechanical-hydraulic, and electronic-hydraulic.
6. Explain the operation and describe the components of typical mechanical and electronic overspeed trip systems.
7. Explain the sequence followed for the cold start-up and the shutdown of a non-condensing steam turbine.
8. Explain the sequence followed for the cold start-up and the shutdown of a condensing and extracting steam turbine.

Topic 2 Turbine Condenser Systems

Learning Outcome

Explain typical designs, components and operating principles of steam turbine condensers.

Learning Objectives

1. Explain the purposes of a turbine condenser in a steam plant cycle and describe a typical condensing circuit, with operating temperatures and pressures.
2. Explain the design, operation and applications of the jet condenser, including the ejector type.
3. Explain the design, operation and applications of the surface condenser, including air cooled and water-cooled, down flow and central flow.
4. Describe construction details for surface condensers, including shells, tube attachment, supports, and allowances for expansion.
5. Explain the effects of air in a condenser and describe the design and operation of single and two-stage air ejectors. Explain the detection of condenser air leaks. Explain vacuum pumps.
6. Explain the devices and operating considerations used to protect a condenser against high backpressure, high condensate level, and cooling water contamination. Describe a cooling water leak test.
7. Describe the operating conditions and corresponding design considerations for condensate extraction pumps and cooling water pumps.
8. Describe a feed water heater system in conjunction with a steam condenser and explain the designs of low-pressure and high-pressure feed water heaters.

Topic 3 Gas Turbine Principles and Designs

Learning Outcome

Explain common designs, major components, operating principles, and arrangements for industrial gas turbines.

Learning Objectives

1. Explain gas turbine advantages and disadvantages, background and industrial applications. Identify the types of gas turbines, their major components and describe the operating principles of a simple gas turbine.
2. Explain single and dual shaft arrangements for gas turbines. Describe open cycle and closed cycle operation.
3. Describe a typical open cycle gas turbine installation, including buildings or enclosures, intake and exhaust systems, auxiliary systems, and reducing gear.
4. Explain the efficiency and rating of gas turbines and describe the purpose and applications of gas turbine cycle improvements, including intercooling, regenerating, reheating and combined cycle.
5. Describe various aspects of compressor design and centrifugal and axial types of compressors.
6. Describe the types, operation, components and arrangements of combustors.
7. Describe turbine section design and operation especially with respect to blading and materials.
8. Explain the types and functions of the control systems and instrumentation needed for gas turbine operation.
9. Explain the typical operating parameters of a gas turbine; describe the effects of compressor inlet temperature, compressor discharge pressure, and turbine inlet temperature on gas turbine performance.

Topic 4 Gas Turbine Auxiliaries and Operation

Learning Outcome

Describe the support auxiliaries for a gas turbine and explain common operational, control and maintenance procedures.

Learning Objectives

1. Describe the types of bearings used in a gas turbine and explain the components, operation, protective devices and routine maintenance of a typical lube oil system.
2. Describe and explain the operation and routine maintenance of a typical fuel gas supply system for a gas turbine.
3. Describe and explain the operation and routine maintenance of a typical fuel oil supply system for a gas turbine.
4. Explain the control of NO_X from a gas turbine and describe the purpose and operation of water/steam injection and dry low NO_X systems.
5. Explain the purpose, location and operation of the gas turbine starting motor and turning gear.
6. Describe the compressor intake and the turbine exhaust components.
7. Describe the preparation and complete start-up sequence for a gas turbine.
8. Describe the shutdown sequence and procedure for a gas turbine.
9. Explain the purpose and describe typical on-line and off-line waterwash procedures for gas turbine blades.

Topic 5 Cogeneration Systems and Operation

Learning Outcome

Explain cogeneration and describe common configurations, components and applications.

Learning Objectives

1. Define cogeneration and explain its purpose, advantages, and applications.
2. Explain the components and operation of simple-cycle cogeneration systems.
3. Explain the components and operation of combined-cycle, gas/steam turbine cogeneration systems.
4. Explain the components and operation of a fully fired, combined-cycle cogeneration system.
5. Explain single-shaft and dual-shaft combined-cycle power plants.
6. Explain the general control strategies and components, for both power and steam production, including diverter and duct burner operation.
7. Describe the various designs of heat recovery steam generators (HRSGs) and explain their industrial applications.
8. Explain the environmental considerations and techniques in the operation of a cogeneration system.
9. Describe typical cogeneration systems that use internal combustion engines (gas or diesel) and heat recovery water heaters (HRWHs).
10. Explain a typical start-up procedure for a combined cycle cogeneration system.

Topic 6 Compressor Theory and Designs

Learning Outcome

Explain the classification, designs, and operating principles of industrial air and gas compressors.

Learning Objectives

1. Explain compressor terminologies, including compression ratio, capacity, staging, intercooling and aftercooling. Explain the effects of moisture in compressed gases. Explain the effects of altitude on the compression process.
2. Describe the operation and common arrangements of reciprocating compressors, including single-acting, double-acting, and tandem arrangements.
3. Identify the components of a reciprocating compressor and describe the operation of plate and channel valves.
4. Describe internal and external lubrication systems for reciprocating compressors.
5. Describe the design and explain the operating principles of rotary compressors, including sliding vane, rotary lobe, and rotary screw.
6. Identify the components and controls for a packaged industrial screw compressor.
7. Describe designs and principles of centrifugal compressors/blowers, including single and multi-stage designs.
8. Describe designs and principles of axial compressors/blowers.

Topic 7 Compressor Auxiliaries and Operation

Learning Outcome

Explain the controls and system auxiliaries for a typical instrument air system and explain startup procedures for air compressors.

Learning Objectives

1. Describe the control devices and strategies for air compressors, including start-and-stop, variable speed, constant speed; describe pilot and unloader devices.
2. Explain the design and operation of an anti-surge system for a dynamic compressor.
3. Describe the designs of water and air-cooled aftercoolers and intercoolers, with separators.
4. Describe the components, arrangement, and parameters of a typical, complete instrument air system, including wet and dry receivers, dryers.
5. Describe the components and operating principles and sequences of instrument air dryers. Explain dewpoint monitoring of air systems.
6. Describe the design, fittings, and operating consideration for air receivers.
7. Explain the start-up procedure for a positive displacement compressor.
8. Explain the start-up procedure for a dynamic compressor/blower.

Topic 8 Refrigeration Principles and Systems

Learning Outcome

Explain the classification and properties of refrigerants and describe the operating principles and components of compression and absorption systems.

Learning Objectives

1. Explain the required properties of a refrigerant and describe the six group classifications for refrigerants. Identify the properties of common refrigerants.
2. Explain the ammonia compression refrigeration cycle, explaining the purpose of each major component and stating typical pressures and temperatures in the system.
3. Explain direct and indirect refrigeration. Describe a centrifugal compression system, using chilled water.
4. Describe and explain the operation of a two-stage, duplex compressor system with a brine cooler.
5. Describe and explain the operation of a two-stage refrigeration system with a rotary booster compressor.
6. Describe and explain the operation of a low-temperature multi-stage refrigeration system.
7. Explain the components and operating principle of an ammonia absorption system.

Topic 9 Refrigeration Auxiliaries and Operation

Learning Outcome

Explain control and safety devices on a compression refrigeration system and explain procedures and equipment to control oil, non-condensables, moisture, refrigerant, and brine.

Learning Objectives

1. Explain the purpose, design and operation of the following controls on a compression refrigeration system: expansion valve, low-side float, high-side float, compressor controls (temperature and pressure-actuated), and condenser cooling water control.
2. Explain the purpose of the following refrigeration system safety devices: high-pressure cutout, oil pressure cutout and pressure relief devices.
3. Explain the effects of oil in ammonia and Freon systems and describe the location and operation of an oil separator and oil still. Explain how oil is manually drained from these systems.
4. Explain the effects and location of non-condensable gases. Describe the operation of manual and automatic purge devices.
5. Explain the effects of moisture in a refrigeration system and describe its removal.
6. Explain leak testing of a system and describe the procedure for adding refrigerant.
7. Explain the principles of brine control in an indirect system and explain the procedures for charging and controlling brine strength.
8. Explain refrigeration safety and environmental issues.

Topic 10 Heat Exchangers and Cooling Towers

Learning Outcome

Describe the design, operation, and applications of various types of industrial heat exchangers.

Learning Objectives

1. Describe double pipe heat exchangers, including jacketed pipe, U-tube, and concentric pipe designs.
2. Describe shell-and-tube heat exchangers including fixed straight tube and U-tube designs. Describe common front and rear head designs, shell flow configurations, and explain the purpose of baffles.
3. Explain the operation and the typical fittings/equipment on the steam/condensate side of a reboiler and a feed water heater.
4. Describe the design and operation of a plate-and-frame exchanger.
5. Describe the design and components of overhead, aerial coolers, including fan and cooler arrangements. Explain cooler control
6. Describe the design and components, including controls, of an overhead, aerial condenser. Explain condenser operation, control and precautions when used to condense excess steam.
7. Describe the design and explain the operation of natural draft cooling towers, including atmospheric and hyperbolic styles
8 Describe the design and operation of mechanical draft cooling towers, including forced draft, induced draft counterflow, and induced draft crossflow.

Topic 11 Fired Heaters

Learning Outcome

Describe the design, components, operation, and applications of direct-fired and indirect-fired natural draft process heaters.

Learning Objectives

1. Describe the common process applications for direct-fired heaters. Explain direct-fired heater designs and classifications.
2. Describe the design, identify the tube banks and explain the fluid and combustion gas flows through a multi-burner, vertical fired heater.
3. Describe typical burner designs and configurations, identifying burner components, including air registers, pilots, and flame scanners. Describe burner operation.
4. Describe the fuel gas supply system to the burners and explain the purpose of the major fittings.
5. Describe the monitoring, control, and shutdown devices on a typical heater.
6. Explain heater start-up procedure, including the lighting of additional burners once flame is established. Explain heater shutdown procedure.
7. Describe the design, components and operation of a typical horizontal, indirect-fired heater such as a salt bath heater.
8. Explain start-up and shutdown procedures for an indirect-fired heater.

Topic 12 Wastewater Treatment

Learning Outcome

Explain the purpose, designs, processes and control of industrial wastewater treatment.

Learning Objectives

1. State the purpose of wastewater treatment, list typical waste liquids, and explain the legislation and permitting, including parameters, for the disposal of wastewater.
2. Sketch an industrial wastewater treatment system and describe the processes that occur at each stage of treatment.
3. Describe the equipment and process involved in the removal of suspended solids from wastewater, including screening, flotation, and sedimentation.
4. Describe the equipment and process involved in the removal of colloidal solids from wastewater, including chemical coagulation, flocculation, and clarification.
5. Describe the equipment and process involved in the biological removal of solids from wastewater, including activated sludge, rotating biological contactors, and trickling filters.
6. Describe the control strategy for a wastewater treatment system. Define and explain the control of and sampling points for the main control parameters, including nutrients, BOD, COD, pH, and settle ability.

Topic 13 Plant Maintenance and Administration

Learning Outcome

Explain typical components of maintenance and administration programs for utilities and process facilities.

Learning Objectives

1. Explain typical communication and accountability structures within a large facility, including the responsibilities for external communication.
2. Describe the typical components and responsibilities of scheduled and preventive maintenance management programs.
3. Explain the importance and extent of record keeping and describe the quality and content requirements for operating logbooks and records.
4. Using a complete boiler turnaround and inspection as an example, describe project management using two methods, Gantt Chart and critical path.
5. Explain the importance of procedures in the operation of a facility and describe the application of well-written procedures to personnel training and daily operation.
6. Explain typical environmental monitoring and management programs for operating facilities.

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REFERENCE CURRICULUM

For

Power Engineer (4th Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
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Introduction

This Curriculum is intended to assist candidates studying for the Power Engineer (4th Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Power Engineer (4th Class) Examination Candidates

Major Topic: Preparatory Math Topics for Power Engineering

Topic 1 Numerical Unit Systems

Learning Outcome

Perform simple calculations involving SI units.

Learning Objectives

1. Describe basic SI and USCS units, matching associated symbols for unit prefixes.
2. Perform conversions both within and between SI and USCS units.

Topic 2 Basic Arithmetic Operations

Learning Outcome

Perform basic arithmetic operations without the use of a calculator.

Learning Objectives

1. Add and subtract integers.
2. Multiply and divide whole and decimal numbers.
3. Perform arithmetic operations involving combinations of addition, subtraction, multiplication, division, and powers in the proper order of operation.

Topic 3 Fractions, Decimals, and Percentages

Learning Outcome

Perform basic arithmetic operations involving fractions, decimals, and percentages.

Learning Objectives

1. Identify proper and improper fractions and mixed numbers.
2. Add, subtract, and multiply fractions, and reduce them to lowest terms.
3. Convert fractions to decimal numbers and decimal numbers to fractions.
4. Analyze percentage problems.

Topic 4 Ratio and Proportion

Learning Outcome

Describe the concepts of ratio and proportion.

Learning Objectives

1. Convert ratios of one quantity to another quantity.
2. Solve word problems involving ratios and proportions.

Topic 5 Equations and Transposition

Learning Outcome

Transpose equations in order to find values for different variables in a formula.

Learning Objectives

1. Solve equations and word problems.

Topic 6 Length, Lines, and Simple Plane Figures

Learning Outcome

Describe measurement of length, types of lines and angles, and calculate perimeters and areas of simple plane figures.

Learning Objectives

1. Describe linear measurement systems and convert measurement units from one system to another.
2. Define parallel and perpendicular lines and types of angles.
3. Describe types of simple plane figures, including triangles and quadrilaterals.
4. Describe the components of a circle, circumference, area, and diameter.

Topic 7 Length, Lines, and Simple Plane Figures

Learning Outcome

Calculate the volumes of rectangular objects, cylinders, and spheres and the surface areas of cylinders and spheres.

Learning Objectives

1. Convert between commonly used volume units.
2. Calculate the volume of a rectangular prism.
3. Calculate the surface area and volume of a cylinder.
4. Calculate the surface area and volume of a sphere.

Major Topic: Elementary Physical, Chemical, and Thermodynamic Principles

Topic 1 Introduction to Matter and Chemistry

Learning Outcome

Identify basic types of matter, their properties, and the associated chemical principles.

Learning Objectives

1. Differentiate among the physical states of matter.
2. Differentiate between chemical and physical changes in matter.
3. Classify matter as either a type of mixture or a pure substance.
4. Describe the purpose and uses of the periodic table using the parts of an atom.
5. Describe the three main ways atoms bond together: covalent, ionic, and metallic bonding.
6. Discuss chemical equations and their purpose.
7. Perform simple stoichiometric calculations.
8. Demonstrate how unstable compounds are combined to make stable compounds.

Topic 2 Introduction to Thermodynamics

Learning Outcome

Explain the principles and laws of thermodynamics.

Learning Objectives

1. Define the first two laws of thermodynamics.
2. Define heat and specific heat, and perform sensible heat calculations.
3. Describe the expansion of solids and liquids.

Topic 3 Introduction to Heat Transfer and Heat Exchangers

Learning Outcome

Explain the modes of heat transfer and the theory of heat exchanger operation.

Learning Objectives

1. Describe the three modes of heat transfer with reference to heat exchangers.
2. Discuss the general design and construction of typical heat exchangers.
3. Describe heat transfer fluids and how they affect the operation of a heat exchanger, including fouling, leakage, and vapor locking.
4. Describe heat exchanger inspection, maintenance, and operation, including placing them in service and removing them from service.

Topic 4 Thermodynamics of Steam

Learning Outcome

Apply the thermodynamics principles through practical applications using the steam tables and the temperature-enthalpy chart.

Learning Objectives

1. Describe heat as it relates to steam, water, and ice.
2. Explain the various columns of the steam tables.
3. Explain the thermodynamic principles of steam, using the steam tables.

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Major Topic: Introduction to Plant and Fire Safety

Topic 1 Introduction to Plant Safety

Learning Outcome

Describe general plant safety as it related to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may be in an energy plant, and the basic Personal Protective Equipment that may be required.
3. Define, give examples of, and describe common power house hazards.
4. Describe Industrial health and safety management system.
5. Describe Hazard Assessment and Control programs.

Topic 2 Plant Safety Programs

Learning Outcome

Describe common safety programs generally applied in plants.

Learning Objectives

1. Describe common occupational health and safety (OH&S) programs found in most plants.
2. Describe industrial safety programs in which Power Engineers may require additional training.
3. Discuss safe work permits.
4. Describe methods of equipment isolation and lock out.

Topic 3 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous materials.

Learning Objectives

1. Discuss the WHMIS system.
2. Discuss the essential components required in the WHMIS systems.
3. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
4. Discuss the safe handling of Hydrocarbons.

Topic 4 Plant Fire Safety

Learning Outcome

Explain fire safety in an industrial plant.

Learning Objectives

1. Discuss the theory, terminology, and the life safety issues associated with fires.
2. Explain the five classes of fires, and describe the types of fire extinguishing media and how they act on these fires.
3. Explain fire prevention.
4. Discuss fire prevention methods for the five types of fires.

Topic 5 Fire Extinguishing Methods and Equipment

Learning Outcome

Describe typical fire extinguishing equipment and its operation in plant environments.

Learning Objectives

1. Describe the construction and operation of various types of portable fire extinguishers.
2. Discuss the inspection and maintenance requirements of portable fire extinguishers.
3. Describe the types, layout, and operation of standpipe and sprinkler systems.
4. Discuss the maintenance requirements of standpipe and sprinkler system components.
5. Describe the purpose, operation, and maintenance of fire pumps.

Major Topic: Introductory Fluid Handling Technology

Topic 1 Introduction to Energy Plant Piping Systems

Learning Outcome

Discuss the basic types of piping, piping connections, supports, and drainage devices used in industry.

Learning Objectives

1. State the applications for the most common materials and identify the sizes of commercial pipe.
2. Describe methods of connection for screwed, flanged, and welded pipe; identify fittings and their markings.
3. Describe methods and devices used to allow for pipe expansion and support.
4. Explain the methods used to promote good drainage of steam pipes, including the installation and maintenance of steam traps, to reduce the effects of water hammer.
5. Explain the requirements, materials, and methods for insulating pipe.

Topic 2 Introduction to Energy Plant Valves

Learning Outcome

Discuss the design and uses of the valve designs most commonly used in industry and on boilers.

Learning Objectives

1. Describe standard valve designs.
2. Describe design and operation of specialized boiler valves.
3. Describe a typical steam pressure reducing station, and the design and operation of steam system pressure-reducing valves.
4. Discuss valve details, including materials of construction and identification markings.
5. Describe typical valve maintenance requirements.

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Major Topic: Basic Concepts in Electrotechnology

Topic 1 Basic Electricity

Learning Outcome

Apply the concepts of basic electricity while performing simple calculations using voltage, current, resistance, and power.

Learning Objectives

1. Describe the atomic structure of matter and its relationship to electricity.
2. Describe basic electrical circuits.
3. State Ohm's Law and apply it to single-resistor circuits.
4. Apply Ohm's Law to series resistance circuits.
5. Apply Ohm's Law to parallel resistance circuits.
6. Explain electrical conductors and insulators using examples.
7. Explain the factors that affect resistance mathematically.
8. Calculate the power developed in an electrical circuit.

Topic 2 Magnetism and Electromagnetism

Learning Outcome

Describe the basic principles of magnetism.

Learning Objectives

1. Describe magnetism and the relationship between magnetism and electricity.
2. Describe the relationship between electricity and magnetism in an electrical generator.
3. Describe the relationship between electricity and magnetism in an electric motor.

Topic 3 Electrical Metering Devices

Learning Outcome

Describe the design and application of electrical metering devices.

Learning Objectives

1. Describe electrical meters and their uses.
2. Describe how voltage, current, and resistance are measured in an electric circuit.
3. Describe the construction and operation of a kilowatt hour meter.

Topic 4 Motors and Generators

Learning Outcome

Describe the operating principles of the various types of AC and DC motors and generators.

Learning Objectives

1. Describe the construction and operation of DC generators and motors.
2. Describe the construction and operation of AC generators (alternators) and motors.
3. Interpret the information on a motor nameplate.
4. Perform basic calculations relating to power factor and power factor correction.

Topic 5 Transformers

Learning Outcome

Describe the operating principles of electrical transformers.

Learning Objectives

1. Describe the principle of operation of transformers.
2. Perform basic transformer calculations as they relate to the construction and operation of single-phase transformers.
3. Describe the construction and operation of three-phase transformers.
4. Discuss special transformer types and their applications.
5. Discuss transformer cooling, safety, and maintenance.

Topic 6 Electrical Distribution Circuits

Learning Outcome

Describe an electrical distribution system.

Learning Objectives

1. List and describe the standard types of electrical voltage systems.
2. Interpret electrical single-line diagrams and circuit symbols.
3. Describe the major components of an electrical distribution system.
4. Describe the function and operation of fuses and circuit breakers.
5. Describe the function and operation of alternate power supply system equipment.

Major Topic: Energy Plant Instrumentation and Controls Topic 1

Introduction to Energy Plant Controls and Instrumentation Learning Outcome

Describe the overall purpose and function of plant instrumentation systems.

Learning Objectives

1. Describe the concept and basic components of a control loop.
2. Describe the various means by which control signals are transmitted, and the function of transducers.
3. List and describe the types of instruments that are not control loop components.

Topic 2 Introduction to Process Measurement

Learning Outcome

Describe the construction and operation of common devices used to measure pressure, level, flow, temperature, humidity, and composition.

Learning Objectives

1. Describe the types of pressure sensing and measuring devices.
2. Describe the types of level sensing and measuring devices.
3. Describe the types of flow sensing and measuring devices.
4. Describe the types of temperature sensing and measuring devices.
5. Describe the types of humidity sensing and measuring devices.
6. Describe the types of gas sensing and measuring devices.

Topic 3 Basic Control and Instrumentation Components

Learning Outcome

Describe the basic types and functions of transmitters, recorders, controllers, and control actuators.

Learning Objectives

1. Describe the construction and operational principles of instrumentation transmitters.
2. Describe the construction and operational principles of instrumentation indicators and recorders.
3. Describe the construction and operational principles of instrumentation controllers.
4. Describe the construction and operational principles of final control elements.

Topic 4 Introduction to Programmable Controllers

Learning Outcome

Describe the operation of programming controls for boilers, including applicable testing and maintenance procedures.

Learning Objectives

1. Discuss how programmable controllers work and how they act as sequencers for equipment.
2. Describe applications of programmable controllers.
3. Explain the HMI (human machine interface) and purpose of touchscreen displays, functions, and alarm handling.

Topic 5 Electronic Control Systems and Computer Applications

Learning Outcome

Describe the design and operation of electronic control systems.

Learning Objectives

1. Discuss electronic process control systems.
2. Describe computers and how they operate within control systems.
3. Describe the applications of computerized control systems and plant computers.

Topic 6 Electrical Control Systems

Learning Outcome

Describe the design and operation of electrical control systems.

Learning Objectives

1. Describe the basic construction and operation of various electric control system components.
2. Describe the function of control devices in electric control systems.
3. Explain the operating sequence of basic electric control circuits.

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Major Topic: Introduction to Boiler Designs

Topic 1 Introduction to Boilers

Learning Outcome

Describe the historical development of boilers, boiler design, components, and configuration.

Learning Objectives

1. Describe the history of boiler applications, boiler design, and modern boiler improvements.
2. Describe packaged boilers.
3. Describe the construction of shop-assembled and field-erected boilers.
4. Describe components and design aspects common to all boiler vessels.

Topic 2 Firetube Boilers

Learning Outcome

Describe the design, components, and characteristics of firetube boilers.

Learning Objectives

1. Differentiate the Scotch Boiler from the other firetube boilers, and describe its development history.
2. Describe circulation patterns in firetube boilers.
3. Discuss construction details of firetube boilers.

Topic 3 Watertube Boilers

Learning Outcome

Describe the design, components, and characteristics of watertube boilers.

Learning Objectives

1. Describe the design and operating principles of watertube boilers.
2. Describe watertube boiler components.
3. Explain the design and application of packaged watertube boilers.
4. Describe the design, construction, and components of large-scale steam generating units.

Topic 4 Electric Boilers

Learning Outcome

Explain the general design and application of electric boilers.

Learning Objectives

1. Discuss the advantages and disadvantages of electric boilers.
2. Describe the construction and operating principle of electric boilers.

Topic 5 Special Boiler Designs for Heating Plants

Learning Outcome

Describe the special design considerations of boilers used in heating plants.

Learning Objectives

1. Describe the design of watertube and coil tube heating boilers.
2. Describe cast iron boilers and vertical firetube boilers.
3. Describe the construction and application of firetube heating boiler designs.

Topic 6 Differences between Power and Heating Boilers

Learning Outcome

Differentiate between ASME Section I and ASME Section IV boilers.

Learning Objectives

1. Discuss the differences between power boiler and heating boiler design and installation.
2. Discuss the differences between power boiler and heating boiler operation.

Major Topic: Elements of Boiler Systems

Topic 1 Combustion

Learning Outcome

Discuss the basic theory of combustion, and the equipment used to provide proper combustion conditions within a boiler.

Learning Objectives

1. Discuss combustion, combustion equations, and the relationship between theoretical and excess air.
2. Discuss the characteristics of solid, liquid, and gaseous fuels.
3. Explain the effects of fuels and combustion on refractory materials.

Topic 2 Fuel Delivery and Firing Systems

Learning Outcome

Describe common fuel systems found in boiler systems.

Learning Objectives

1. Describe solid fuel delivery systems.
2. Describe the main types of solid fuel firing systems.
3. Describe gaseous fuel delivery systems.
4. Describe the main types of gaseous fuel firing systems.
5. Describe liquid fuel delivery systems.
6. Describe the main types liquid fuel firing systems.
7. Describe flue gas analysis and how it relates to boiler efficiency.

Topic 3 Draft

Learning Outcome

Describe basic concepts and equipment used to supply combustion air to boiler furnaces.

Learning Objectives

1. Describe the various air streams that deliver combustion air to a furnace.
2. Relate differential pressure to the creation of draft.
3. Describe forced, induced, and balanced mechanical draft.
4. Discuss common methods of controlling combustion airflow.
5. Discuss common methods of measuring furnace pressures.

Topic 4 Feedwater Systems

Learning Outcome

Describe feedwater systems used with boilers.

Learning Objectives

1. Describe the overall layout of feedwater, condensate, and make-up water systems.
2. Describe the valves used in feedwater systems.
3. Describe the control strategies for single-element, two-element, and three-element boiler feedwater systems.
4. Describe methods of supplying feedwater to steam heating boilers.
5. Explain the operation of condensate receiver make-up water controls.
6. Describe the return of condensate, and the supply of feedwater to high-pressure boilers.

Topic 5 Blowof f and Blowdown Systems

Learning Outcome

Describe the equipment, operation, and purpose of boiler blowoff and blowdown systems.

Learning Objectives

1. Describe blowoff, blowoff equipment and blowoff procedures.
2. Describe continuous blowdown, blowdown equipment, and blowdown procedures.
3. Describe the maintenance and repair of blowoff systems.

Topic 6 Boiler Fireside Cleaning Systems

Learning Outcome

Describe types of boiler fireside cleaning equipment, their purpose, and their operation.

Learning Objectives

1. Describe common options for in-service fireside cleaning.
2. Describe the construction and operation of retractable soot blowers.
3. Describe the construction and operation of stationary soot blowers.
4. Describe falling shot cleaning methods.

Major Topic: Lubrication and Bearings

Topic 1 Lubrication Principles

Learning Outcome

Describe the importance of lubrication and the principles concerned with lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and application.
3. List the properties of lubricating oils, the additives used, and their selection criteria.

Topic 2 Types of Bearings and Lubrication

Learning Outcome

Describe bearing types, methods for care and maintenance of bearings, and bearing lubrication systems.

Learning Objectives

1. Define boundary and full fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of antifriction and thrust bearings.
4. Describe how to clean and replace roller and ball type bearings.
5. Explain the causes of bearing failure.

Major Topic: Pumps and Compressors

Topic 1 Types of Pumps

Learning Outcome

Describe the construction and operating principles of various types of pumps used in plants.

Learning Objectives

1. List common pump applications.
2. Define the terms associated with pump performance.
3. Describe the common pumps found in plants.

Topic 2 Pump Operation and Maintenance

Learning Outcome

Describe the major considerations and procedures for pump operation and maintenance.

Learning Objectives

1. Discuss the components of a driver and pump assembly.
2. Discuss pump shaft sealing, compression packing, and the replacement of compression packing.
3. Describe the standard types of mechanical seals.
4. Describe pump bearings, shaft alignment procedures, and the equipment used to align shafts.
5. Describe centrifugal pump startup and priming procedures.
6. Describe positive displacement pump operating characteristics, priming, startup, and routine checks.

Topic 3 Introduction to Compressors

Learning Outcome

Describe the operating principles of the different types of compressors.

Learning Objectives

1. Describe the main classifications and types of compressors.
2. Describe gaseous compression systems.

Topic 4 Compressor Operation and Maintenance

Learning Outcome

Describe the major considerations and general procedures for compressor operation and maintenance.

Learning Objectives

1. Describe compressor parts and auxiliary equipment.
2. Describe the construction and operation of seals for compressors.
3. Describe the capacity control of compressors.
4. Describe preventative maintenance and routine procedures for compressors.

Major Topic: Boiler Safety Devices

Topic 1 Pressure Relief Valves

Learning Outcome

Explain the code requirements, design, and operation of pressure relief valves for power boilers, heating boilers, and pressure vessels.

Learning Objectives

1. Discuss the code requirements, construction, and operation of ASME Section I Pressure Relief Valves and Devices.
2. Discuss the code requirements, construction, and operation of ASME Section IV Pressure Relief Valves and Devices.
3. Describe the testing and repair of pressure relief valves.
4. Describe the construction and operation of temperature and pressure relief valves.

Topic 2 Combustion Safety

Learning Outcome

Explain the design and operation of combustion safety controls on burners and boilers.

Learning Objectives

1. Describe the operation of control and safety devices found on boiler fuel supplies.
2. Describe the construction and operation of flame detectors.
3. Describe the combustion safety controls for boilers and burner systems.
4. Describe burner management systems.
5. Interpret burner operating sequence charts, and provide a typical sequence of startup and shutdown events.

Topic 3 Water Level Safety Controls

Learning Outcome

Describe feedwater devices, and control methods used on boilers.

Learning Objectives

1. Describe the construction and operation of boiler low water level fuel cut-off equipment.
2. List the CSA and ASME code requirements regarding low water fuel cut-off devices.
3. Describe direct and indirect type boiler water level indicators.

Topic 4 Boiler Fittings

Learning Outcome

Relate the code, operation, and required fittings to the operating principles of fittings found on boilers.

Learning Objectives

1. Explain the code references for boiler fittings.
2. Describe the code requirements for pressure gauges on steam boilers.
3. Describe the code requirements for the boiler connections and valves on steam boilers.
4. Describe the code requirements for fittings on hot water heating boilers.
5. Describe the non-code fittings used on boilers.

Topic 5 Firing Rate Controls

Learning Outcome

Describe the operating and safety controls found on boilers.

Learning Objectives

1. Describe basic boiler firing rate controls.
2. Discuss various operating controls for steam and hot water boilers.

Major Topic: Boiler Plant Operation and Management

Topic 1 Boiler Plant Startup

Learning Outcome

Describe the operational procedures related to starting up auxiliary equipment in a boiler plant.

Learning Objectives

1. Describe the basic auxiliaries that need to be checked, prepared, or placed in service before starting a boiler plant.
2. Describe the general procedures for starting a plant for the first time, or restarting after an outage or turnaround.
3. Discuss basic operating practices for starting pumps and fans.
4. Describe the general preparation for a hot water boiler startup.
5. Describe the general preparation for a steam boiler startup.
6. Describe the safety and housekeeping preparation requirements for boiler plant startup.

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Topic 2 Boiler Startup

Learning Outcome

Describe procedures for safely starting boiler systems.

Learning Objectives

1. Describe operating considerations when warming a cold boiler.
2. Describe how to start and cut-in a hot water boiler.
3. Describe how to start a single boiler steam plant.
4. Describe how to cut-in a steam boiler in a multiple boiler plant.
5. Describe semi-automatic burner ignition systems.
6. Discuss the post startup inspection for boilers returning to service after a major outage.

Topic 3 Boiler Operation

Learning Outcome

Describe operational procedures related to operating boilers.

Learning Objectives

1. Describe the operation of a hot water heating boiler under routine conditions.
2. Describe routine steam boiler operating duties.
3. Describe emergency conditions in boiler plants and the required responses.
4. Describe basic boiler troubleshooting activities.

Topic 4 Operational Checks

Learning Outcome

Describe operational checks for operating boiler plants.

Learning Objectives

1. Describe the shift based operator responsibilities for boiler plants.
2. Describe the safety device operational checks carried out on boilers.
3. Describe routine maintenance activities for boiler plant operation.
4. Describe the use of Standard Operating Procedures (SOPs).
5. Describe the need for boiler operating and maintenance logs, and the type of information that should be recorded.

Topic 5 Shutdown Procedures

Learning Outcome

Describe generic shutdown and layup procedures for different boiler types.

Learning Objectives

1. Describe hot water boiler shutdown procedures.
2. Describe steam boiler shutdown and lockout procedures.
3. Describe extended period layup requirements for steam boilers.

Topic 6 Boiler Plant Monitoring and Reporting

Learning Outcome

Describe the points and readings that need to be monitored and recorded in a plant.

Learning Objectives

1. Discuss recording requirements for operating and performance conditions.
2. Discuss the various systems required to conduct equipment repairs, and to manage the related maintenance records.
3. Describe the operational causes, consequences, and prevention of water hammer.
4. Describe the consequences and actions required for various equipment failures.
5. Describe the consequences, and actions required, in the event of boiler accidents.

Major Topic: Energy Plant Maintenance

Topic 1 Energy Plant Maintenance I

Learning Outcome

Describe the safe use of common hand tools in the powerhouse.

Learning Objectives

1. Describe the types and proper use of hacksaws, files, chisels, hammers, screwdrivers, and wrenches.
2. Describe the types and proper use of hand threading tools.
3. Describe the types and proper use of measuring tools.
4. Describe the proper layout of work and the use of layout tools.
5. Describe the types and proper use of portable and fixed grinders, hand drills, drill presses, and the care of drill bits.

Topic 2 Energy Plant Maintenance II

Learning Outcome

Discuss and describe the safe and proper setup of equipment for hoisting and working above ground.

Learning Objectives

1. Describe the requirements for setting up work platforms in general and ladders and scaffolding in particular.
2. Describe the general safety precautions and calculations used when rigging equipment.
3. Describe the general safety precautions used when hoisting equipment.
4. Discuss the correct use and limitations of wire cable and rope, including cable attachments and rope knots.
5. List and describe common types of metal fasteners, such as screws, bolts, studs, nuts, and washers.

Topic 3 Boiler Maintenance

Learning Outcome

Describe the service and maintenance required for boilers.

Learning Objectives

1. Describe the general maintenance and service of packaged firetube and cast iron sectional boilers.
2. Identify the operational procedures for wet and dry boiler layups.
3. Describe ways of detecting firetube and tubesheet leaks.
4. Describe the general procedure for the removal and replacement of defective firetubes.

Topic 4 Boiler Cleaning

Learning Outcome

Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical and chemical boiler cleaning methods.

Learning Objectives

1. List the steps and precautions to prepare a boiler for inspection.
2. Describe the internal inspection of a boiler.
3. Describe the methods and tools used to mechanically clean boilers.
4. Describe two methods used to chemically clean boilers.

Major Topic: Water Treatment

Topic 1 External Boiler Water Treatment

Learning Outcome

Describe the general principle, methods, and equipment used in preparing raw feedwater for steam production.

Learning Objectives

1. Describe typical impurities and their effects on plant and boiler water pre-treatment systems, and their treatment process.
2. Describe the equipment requirements for pre-treatment of plant water systems.
3. Describe water filtration and the removal of suspended solids.
4. Describe the purpose, processes, and equipment used in water softening.
5. Describe the theory, process, and equipment used in deaeration.

Topic 2 Internal Boiler Water Treatment

Learning Outcome

Describe the general principles, methods, and equipment used for internal boiler water treatment.

Learning Objectives

1. Describe the types of problems, and associated treatments, related to internal boiler water contamination.
2. Describe internal boiler feedwater chemical feed systems.
3. Describe standard boiler water testing.

Topic 3 Condensate Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condensate.

Learning Objectives

1. Describe condensate treatment and the effects of non-treatment.
2. Describe the tests conducted on condensate.

Topic 4 Cooling Tower and Condenser Water Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condenser water, and their effects on the cooling tower.

Learning Objectives

1. Describe the effects of water on condensers and cooling tower materials.
2. Describe condenser and cooling tower water treatment.
3. Describe cooling tower and condenser water tests for common treatment methods.

Topic 5 Recirculating System Water Treatment

Learning Outcome

Describe recirculating water systems, their effects, treatment, and tests.

Learning Objectives

1. Describe recirculating water system corrosion and deposition.
2. Describe the use of sacrificial anodes, and measurement techniques to determine corrosion.
3. Describe glycol system testing requirements.
4. Discuss the monitoring tools, procedures, and tests used in recirculating water systems.

Major Topic: Types of Prime Movers and Heat Engines

Topic 1 Heat Engines and Prime Movers

Learning Outcome

Discuss the historical conversion of heat energy into mechanical energy.

Learning Objectives

1. Differentiate between the terms "heat engine" and "prime mover."
2. Discuss the history of the steam engine and the expansive power of steam.

Topic 2 Steam Turbines

Learning Outcome

Describe the construction and operation of steam turbines.

Learning Objectives

1. Describe the principle of operation and major components of a steam turbine.
2. Describe the lubrication and sealing of steam turbine shafts.
3. Describe how the rotational speed of a steam turbine is governed and controlled.
4. List the steps to follow in a typical steam turbine start-up and shut-down.

Topic 3 Condensers and Cooling Towers

Learning Outcome

Describe the operation and maintenance of condensers and cooling towers.

Learning Objectives

1. Explain the construction and operation of condensers, and how they relate to the operation of cooling towers.
2. Explain the principle of operation, the purpose, and the major components of cooling towers.
3. Describe the construction and operation of natural draft cooling towers.
4. Describe the construction and operation of mechanical draft cooling towers.
5. Discuss cold climate operation for cooling towers.
6. Explain typical problems and resolutions required within the operation of cooling towers.

Topic 4 Gas Turbines

Learning Outcome

Describe the application, startup, operation, and maintenance required for gas turbines.

Learning Objectives

1. Describe the principle of construction and operation of gas turbines.
2. Identify the operational characteristics of gas turbines.
3. Describe regeneration and combined steam-gas turbine operating cycles.
4. Describe the key elements of gas turbine startup, operation, and auxiliaries.

Topic 5 Internal Combustion Engines

Learning Outcome

Describe the application, construction, and operation of internal combustion engines.

Learning Objectives

1. Discuss the fuels used in internal combustion engines.
2. Describe the working cycles of the 4-stroke and 2-stroke spark ignition engines.
3. Describe the working cycle of the 4-stroke compression ignition (diesel) cycle.
4. Describe the construction of basic spark and compression engines.
5. Explain the basic operating considerations for diesel engines.

Major Topic: Basic Concepts of Compression and Absorption Refrigeration

Topic 1 Refrigeration Basics

Learning Outcome

Explain the basic concept of refrigeration and refrigerants.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the cycle of operations in a vapor compression refrigeration system.
3. Explain how the operating temperatures and pressures are selected and related for a vapor compression refrigeration system.
4. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.
5. Describe how refrigerants are classified.
6. Describe the thermodynamic properties of refrigerants.
7. Describe the properties of refrigerants relating to miscibility, leakage tendency, odor, moisture reaction, toxicity, and flammability.

Topic 2 Compression Refrigeration Systems

Learning Outcome

Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Distinguish between direct and indirect refrigeration systems.
3. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizer.
4. Describe the special types of refrigeration compressors, and how they are similar to and different from air compressors.
5. Describe the special designs of refrigeration system evaporators and condensers.

Topic 3 Refrigeration System Control and Operation

Learning Outcome

Describe the purposes and operating principles of refrigeration system operational and safety controls.

Learning Objectives

1. Describe refrigeration system controls.
2. List the safety shutdown devices specific to centrifugal compressor water chillers.
3. Describe typical refrigeration system safety shutdown devices.
4. Describe the construction and operation of refrigerant metering devices.
5. Describe the different methods used to control evaporator capacity.
6. Describe the different methods used to control the capacity of refrigeration compressors.

Topic 4 Refrigeration System Operation and Maintenance

Learning Outcome

Describe the operating principles and maintenance of refrigeration systems.

Learning Objectives

1. Discuss refrigeration auxiliaries.
2. Describe refrigeration system leak test procedures.
3. Describe how a refrigeration system is dried and charged prior to start-up.
4. List the steps for adding oil to an in-service refrigeration compressor.
5. Describe the start-up and shut-down procedure for a compression refrigeration system.
6. Describe operational log sheets and preventative maintenance procedures for refrigeration systems.
7. Describe how a refrigeration system is purged of noncondensable gases.
8. Discuss refrigeration condenser operation and maintenance requirements.
9. Explain typical problems and resolutions related to refrigeration systems.

Topic 5 Absorption Refrigeration Systems

Learning Outcome

Describe the operating principle, maintenance, and operation of absorption refrigeration systems.

Learning Objectives

1. Describe the basic absorption system, comparing the differences to the compression system.
2. Describe the theory and operation of an ammonia absorption refrigeration system.
3. Describe the theory and operation of a lithium bromide absorption refrigeration system.
4. Explain the operation of absorption refrigeration systems with respect to crystallization and dilution.
5. Describe the major parts and systems of an absorption system, including: heat exchanger bypass system, pump motor lubrication and cooling system, and purging system.
6. Describe the startup and shutdown procedures for an absorption refrigeration system.
7. Describe the preventive maintenance that should be performed on an absorption refrigeration system.
8. Explain typical problems and resolutions related to an absorption refrigeration system.

Topic 6 Refrigeration Plant Safety

Learning Outcome

Outline the potential hazards inherent to refrigeration plants, the CSA requirements intended to mitigate hazards, and typical responses taken in the case of a significant leak.

Learning Objectives

1. Identify and provide a basic explanation of the CSA B52 Code requirements for refrigeration plant machinery rooms.
2. Identify safe practices for refrigeration plant operation and maintenance.
3. Describe the appropriate emergency response to a significant refrigerant leak.
4. Describe the Canadian Environmental Emergency Regulations and how they relate to refrigeration plants.

Major Topic: HVAC Fundamentals for Facility Operators

Topic 1 Conditioning the Air

Learning Outcome

Explain the methods and techniques for conditioning air in plants and buildings.

Learning Objectives

1. Discuss the process to condition air for human comfort and health.
2. List the categories and functions of HVAC systems.
3. Describe the operation of air-handling units.
4. Define the terms humidity, relative humidity, and dewpoint.
5. Define the terms dry-bulb temperature, wet-bulb temperature, wet-bulb depression, and how they relate to relative humidity.

Topic 2 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and warm air types of humidifiers.
3. Describe industrial and commercial types of humidifiers.

Topic 3 Fans for Air Distribution Systems

Learning Outcome

Describe the airflow behavior and movement of air through distribution systems.

Learning Objectives

1. Discuss the theory of airflow and pressure conversions.
2. Describe the major types of air handling fans, their construction, and operation.
3. Interpret fan performance curves.
4. Describe fan motors, drives, and belt guards.
5. Describe fan volume controls.

Topic 4 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems, including various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the various contaminants found in air.
3. Describe the types of air cleaning devices used in industrial/commercial buildings.

Topic 5 HVAC Duct Systems

Learning Outcome

Describe the designs and components of duct systems used in HVAC applications.

Learning Objectives

1. Explain how air duct systems are classified.
2. Describe air duct materials, system layout, fabrication, and installation.
3. Describe air duct leakage.
4. List and describe the types of liners, dampers, and louvres used in air duct systems.
5. Discuss terminal air distribution devices, and the principles of diffusion, induction, entrainment, and aspiration.

Topic 6 Types of Coils and Operation

Learning Outcome

Describe the various types and operation of coils used in HVAC systems.

Learning Objectives

1. Explain how steam, hot water, and glycol coils are sized, configured, and operated to reduce the chance of freezing.
2. Describe the installation recommendations for coils, piping, steam traps, control valves, air vents, and vacuum relief devices.

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Major Topic: Building Environmental Systems and Control

Topic 1 Steam Heating

Learning Outcome

Describe the components, operating principles, and maintenance procedures of steam heating systems.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. Describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.
3. Describe standard types of piping and equipment layout for steam heating systems.
4. Describe the general operation and maintenance of steam heating systems.
5. Apply a steam heating system troubleshooting guide.

Topic 2 Hot Water Heating

Learning Outcome

Describe the various designs, equipment, and operation of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe various types of special hot water heating systems.
4. Describe the purpose and function of standard hot water heating system accessories.
5. Explain how the location of the hot water circulating pump and the expansion tank are determined.
6. Describe the routine operation of hot water heating systems, including cleaning, filling, starting, and use of glycol/antifreeze.
7. Apply a hot water heating troubleshooting guide.

Topic 3 Other Heating Systems

Learning Outcome

Describe common heating systems encountered by Power Engineers.

Learning Objectives

1. Describe natural gas fueled warm air heating systems.
2. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
3. Discuss the concept and application of infrared heating.
4. Describe the different methods of electric heating, and their advantages and disadvantages as compared to other types of systems.

Topic 4 Cooling Systems and Combination Systems

Learning Outcome

Describe central, unitary and combined HVAC systems.

Learning Objectives

1. Describe the general layout and operation of unitary air conditioning systems.
2. Describe the general layout and operation of central air conditioning systems.
3. Describe the general layout and operation of combined air conditioning systems.
4. Discuss how HVAC systems should be operated under different situations.

Topic 5 Heat Gains and Losses, and Heat Recovery Methods

Learning Outcome

Describe heat gains and losses, and common methods for energy recovery.

Learning Objectives

1. Define heat transmission terminology.
2. Describe heat gain and heat loss analysis in a building or plant.
3. Describe the general principles of HVAC heat recovery.

Topic 6 HVAC Control Strategy

Learning Outcome

Describe the control systems strategies used in HVAC systems.

Learning Objectives

1. Describe a basic ventilation control strategy for HVAC systems.
2. Describe heating control strategies for HVAC systems.
3. Describe humidification, dehumidification, and cooling control strategies for HVAC systems.
4. Describe volume control with static pressure regulation for HVAC systems.

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REFERENCE CURRICULUM

For

Power Engineer (5th Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Power Engineer (5th Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Power Engineer (5th Class) Examination Candidates

Major Topic: Basic Physical Science, Safety, and Regulation for Facility Operations

Topic 1 Introduction to Thermodynamics

Learning Outcome

Explain the principles of thermodynamics and the modes of heat transfer.

Learning Objectives

1. Describe the three states of matter.
2. Describe the expansion of solids and liquids.
3. Explain the different temperature scales used in thermodynamics (Celsius and Fahrenheit).
4. Explain sensible and latent heat, and the thermodynamic transformation of ice to steam.
5. Describe the three modes of heat transfer.
6. Explain the energy in the expansion of water to steam.

Topic 2 Fire Safety and Site Hazards

Learning Outcome

Discuss acceptable methods of extinguishing various classifications of fire. Briefly describe site hazards awareness.

Learning Objectives

1. Explain the overall need for and the intent of fire protection standards, laws, and regulations.
2. Explain the different fire classifications and describe the extinguishing methods for each.
3. Explain the application and operation of standpipes, hoses, and sprinklers in buildings.
4. Explain the various types of fire and smoke detectors.
5. Describe the operation, placement, and maintenance of the common types of portable extinguishers.
6. Discuss the need for and use of a fire pump.
7. Briefly describe safety aspects of common site hazards.
8. Explain how to perform a pre-job hazard assessment.

Topic 3 Building Safety

Learning Outcome

Describe how the building operator can prevent accidental situations to protect the occupants of their facility.

Learning Objectives

1. Explain the personal safety responsibilities and precautions that must be applied by the building operator.
2. Describe the general safety precautions required in the maintenance and operation of buildings.
3. Identify common scenarios where the building operator can prevent accidents, and explain the importance of first aid and CPR training.

Topic 4 Confined Space Entry

Learning Outcome

Describe procedures needed to enter into, or work safely in confined spaces.

Learning Objectives

1. Define confined space, list some confined spaces, and describe the hazards of being in a confined space.
2. Refer to local jurisdictional regulations and describe procedures to be followed when performing a confined space entry, including completion of an entry checklist.

Topic 5 Introduction to Occupational Health and Safety Legislation

Learning Outcome

Discuss the provincial legislation addressing occupational health and safety.

Learning Objectives

1. Explain the general intent of occupational health and safety standards.
2. Discuss some of the responsibilities, according to the Act, of workers, employers, and others in relation to health and safety.
3. Describe the conditions that must exist before a worker can refuse to work.
4. Identify jurisdictional regulations related to health and safety.
5. List the two different types of logs kept in boiler plants and the importance of each.

Topic 6 Introduction to Heating Plant Safety

Learning Outcome

Describe general plant safety as it relates to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may exist in an energy plant, and the basic personal protective equipment that may be required.
3. Define, give examples of, and describe common workplace hazards. (Note that additional training will be required beyond this course material.)
4. Describe equipment isolation and lockout procedures.

Topic 7 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous goods and materials.

Learning Objectives

1. Discuss the WHMIS.
2. Describe the Safety Data Sheets (SDS) and Material Safety Data Sheets (MSDS) required in the WHMIS.
3. Identify the labels required in the WHMIS.
4. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
5. Discuss the safe handling of hydrocarbons.

Topic 8 Introduction to Electricity

Learning Outcome

Discuss the design and accessories of an electrical circuit; describe the design and troubleshooting of lighting systems and electric motors.

Learning Objectives

1. Explain electricity, electric circuits, and voltage drop.
2. Calculate current and power in an electric circuit, estimate the cost of electrical power for a facility, and describe how to read a power meter.
3. Describe circuit accessories, including switches, fuses, breakers, and receptacles. Explain the danger of electric shock.
4. Explain what constitutes a good lighting system. Explain maintenance of a lighting system and troubleshooting of incandescent and fluorescent systems.
5. Describe simple electrical system problems, including short circuits, grounds, and bad connections. Describe static electricity.
6. Describe transformers and electric motors. Explain motor types, bearing care, and troubleshooting of motors.
7. Explain the CSA approval and markings for electrical appliances.

Major Topic: Low Pressure Boiler Components and Operation

Topic 1 Watertube Boilers (Heating, Power, and Tubular)

Learning Outcome

Describe the various types of watertube boilers used in small industrial and heating systems.

Learning Objectives

1. Describe the construction of watertube and copper-tubular boilers.
2. Describe the water circulation in a longitudinal drum straight tube boiler.
3. Describe two-drum bent tube boilers, and the advantages of a bent tube boiler compared to a straight tube boiler.
4. Describe the construction of the "A" type, "D" type, and "O" type and the advantages of packaged watertube boilers.

Topic 2 Cast-Iron Sectional and Modular Boilers

Learning Outcome

Describe and explain the uses of cast-iron boilers.

Learning Objectives

1. Describe the general construction of cast-iron sectional boilers.
2. List the advantages of cast-iron sectional boilers over watertube and firetube boilers.
3. Describe the arrangement of equipment in a multiple cast-iron sectional boiler heating plant.
4. Describe the construction and operation of cast-iron modular boilers.

Topic 3 Firetube Boilers (Heating and Power)

Learning Outcome

Describe the various types of firetube boilers used in power and heating systems.

Learning Objectives

1. Explain the difference between power and heating boilers.
2. Describe the historical significance, the construction, and application of the early types of firetube boilers: the HRT, or horizontal return tubular, locomotive, and firebox boilers.
3. Describe the construction and application of wetback and dryback Scotch boilers.
4. Describe the construction and application of vertical firetube boilers and tubeless boilers used in heating plant service.
5. Describe the construction of packaged firetube boilers.

Topic 4 Electric Boilers

Learning Outcome

Describe electric boilers with regard to their use and general design.

Learning Objectives

1. Compare electric boilers to fuel-fired boilers.
2. Describe the construction and operating principle of electrode-type electric boilers.
3. Describe the construction and operating principle of immersion-type electric boilers.

Topic 5 Basic Fittings for Steam Boilers

Learning Outcome

Name, identify, and explain the operating principles and the differences, if any, between the following low and high pressure boiler fittings: pressure gauges, gauge siphons, safety valves, gauge glasses and water columns, safety shutoff valves, quick opening valves, stop valves, check valves, and vent valves.

Learning Objectives

1. Describe the construction, purpose, and operation of pressure gauges and gauge siphons (pigtails).
2. Describe the testing of pressure gauges.
3. Describe the construction, operation, installation, and testing of low-pressure (safety relief) and high-pressure (safety or pop) valves.
4. Describe the purpose, function, and testing of gauge glasses and water columns.
5. Explain how to change a gauge glass.
6. Describe the construction, operation, and purpose of the following valves: gauge glass safety shutoff valves, gauge glass quick closing valves, stop valves, check valves, blowoff (blowdown) valves, and vent valves.

Topic 6 Basic Fittings for Hot Water Boilers

Learning Outcome

Name, identify and explain the operating principles of the following hot water boiler fittings and equipment: pressure, altitude or combination gauges, thermometers, safety relief valves, temperature relief devices, stop valves or drain valves, backflow preventers, and expansion tanks.

Learning Objectives

1. Identify the required instruments, fittings, and controls on a hot water boiler system.
2. Explain how to change a gauge glass on an expansion tank.
3. Describe the construction and operation of the "auto fill valve."
4. List the usual devices and fittings that are used in hot water heating boiler systems.

Topic 7 Low Water Fuel Cut-Offs and Feedwater Controls

Learning Outcome

Discuss the design, operation and testing of low-water fuel cutoffs and describe feedwater control methods and devices used on low-pressure boilers.

Learning Objectives

1. Describe the construction and operation of float and electrode low water level fuel cut-off equipment.
2. Describe the testing and maintenance of float and electrode low water level fuel cut-offs.
3. Describe the operation of a feedwater float switch operating a valve and a float switch operating a pump.
4. Explain the purpose and function of heating boiler feedwater and condensate piping connections.

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Topic 8 Heating Boiler Operating Controls

Learning Outcome

Name and describe the various operating controls found on low-pressure boilers.

Learning Objectives

1. Describe the operation of the on-off control, the high-low fire control, the modulating control, and the high limit control found on low-pressure steam boilers and hot water heating boilers.
2. Explain the operation of the common control switches found on a low-pressure heating boiler.
3. Describe the operation of the safety switches or interlocks found on the fuel supplies of low-pressure heating boilers.
4. Explain the required testing and maintenance of heating boiler controls.

Topic 9 Boiler Combustion Controls

Learning Outcome

Explain the design and operation of various combustion controls on heating boilers.

Learning Objectives

1. List and discuss the various types of boiler flame failure detectors.
2. Describe the testing of boiler flame failure safety devices.

Topic 10 Boiler Programming Controls

Learning Outcome

Describe the basic operation of boiler programming controls.

Learning Objectives

1. Describe the operation of equipment that is used to automatically start up and shut down boilers.
2. List a typical sequence of startup and shutdown events.
3. Describe common 5th Class Power Engineer responses to a boiler programmer startup or shutdown.

Topic 11 Basic Boiler Operation

Learning Outcome

Describe the preparation, start-up and shutdown, abnormal conditions, and routine operational checks in the operation of steam and hot water boilers.

Learning Objectives

1. Explain the preparation required before starting a steam or hot water boiler.
2. Explain the startup steps once the boiler has been prepared.
3. State possible abnormal conditions during startup and the cautions required to avoid uneven expansion and thermal shock.
4. Describe the procedure required when "cutting in" an additional boiler.
5. Describe the operating conditions for hot water and steam boilers that must be checked daily, and state the required monthly checks.
6. Explain the procedure for removing a hot water boiler from service.
7. Describe the procedure for removing a steam boiler from service.
8. Explain the emergency conditions that can occur during the operation of a steam boiler. Explain the causes and prevention of furnace and pressure explosions.
9. Explain the reasons for boiler accidents, and describe the role and design of operating logs in the safe operation of a boiler.
10. Operator traits, good operating practice, curiosity, using your senses, (sense-interpret-analyze-perform = SIAP), trusting your instincts, experience and due diligence.

Topic 12 Routine Boiler Maintenance and Inspection

Learning Outcome

Describe the service and maintenance required for boilers. Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical boiler cleaning methods.

Learning Objectives

1. Describe the general servicing and routine maintenance of packaged firetube and cast-iron sectional boilers.
2. Explain the importance of layups and state the procedures to be followed for wet and dry boiler layups.
3. Describe the symptoms of a leaking firetube.
4. List the steps and precautions to be taken to prepare a boiler for inspection.
5. Describe the inspection of a boiler.
6. Describe the methods and tools used for mechanical and chemical cleaning of a boiler.
7. Discuss the standard procedure for a hydrostatic test and the reason for doing the test.

Topic 13 Combustion and Draft

Learning Outcome

Discuss the characteristics of common fuels used in heating boilers, conditions for complete and incomplete combustion, draft methods, and the application of flue gas analysis.

Learning Objectives

1. Explain natural and mechanical draft arrangements.
2. Describe draft measurement using U-tube and inclined draft gauges.
3. Describe the use, advantages, and characteristics of common boiler fuels.
4. State the requirements and reactions for complete and incomplete combustion.
5. Explain the difference between a pressure explosion and a furnace explosion.

Topic 14 Burners for Boilers

Learning Outcome

Describe the operation of the various types of gas and oil burners used on boilers.

Learning Objectives

1. Describe the operation of atmospheric and ring gas burners.
2. Describe the construction and operation of automatic valves.
3. Describe the principle of oil atomizing burners for boilers.
4. List and describe the auxiliary equipment needed for an oil combustion system.
5. Describe the overall components and operation of fuel oil systems.

Topic 15 Piping Materials and Connections

Learning Outcome

Discuss the various construction materials, size classification, and connection methods for the piping in a plant.

Learning Objectives

1. Explain the characteristics and applications of the various materials used to manufacture piping and fittings.
2. Explain pipe size, schedules, and classifications.
3. Identify screwed, flanged, and welded pipe connections.

Topic 16 Piping Expansion, Support, and Insulation

Learning Outcome

Discuss piping expansion, support, and insulation.

Learning Objectives

1. Explain pipe expansion and the principle of expansion bends and joints.
2. Explain the purpose of pipe supports and describe various pipe support designs.
3. Explain the purposes for pipe insulation and describe the use of the common insulation materials.

Topic 17 Steam Traps

Learning Outcome

Explain the purpose of steam traps and describe the installation and operating principles of the various steam traps found on piping systems.

Learning Objectives

1. Describe the designs and operating principles of mechanical traps.
2. Describe the designs and operating principles of thermostatic steam traps.
3. Describe the correct piping arrangement and procedures for a steam trap.
4. Explain the purpose and design of a strainer.
5. Explain the causes, effects, and prevention of water hammer.

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Topic 18 Introduction to Valves

Learning Outcome

Discuss the design, application, and maintenance of common types of valves used in piping systems.

Learning Objectives

1. Describe five standard valve designs: gate, globe, butterfly, ball, and plug.
2. Describe the design and operation of check and non-return valves.
3. Describe the function of a pressure-reducing valve.
4. Describe valve identification markings.
5. Describe typical valve maintenance requirements.

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Major Topic: Elements of Human Comfort in Facility Operation

Topic 1 Steam Heating Equipment

Learning Outcome

Describe the operating principles of steam heating equipment and components.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. List and describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.

Topic 2 Steam Heating Systems

Learning Outcome

Describe the operating principles and maintenance procedures of steam heating systems and the components of these systems.

Learning Objectives

1. Describe standard types of piping and equipment layout for steam heating systems.
2. Describe the general operation and maintenance of steam heating systems.
3. Apply a steam heating system troubleshooting guide.

Topic 3 Hot Water Heating Systems

Learning Outcome

Describe the various designs of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe radiant panel and snow melting hot water systems.

Topic 4 Hot Water Heating System Equipment and Operation

Learning Outcome

Describe accessories, operation and troubleshooting of a hot water heating system.

Learning Objectives

1. Describe the purpose and function of standard hot water heating system components such as diverter fittings, air vents, air separators, flow control valves, balancing valves and fittings, riser stop valves, pressure reducing valves, circulating pumps, expansion tanks, and steam to hot water converters.
2. Explain how the location of the hot water circulating pump and the expansion tank are determined.
3. Describe the cleaning, filling, starting, routine operation, and troubleshooting of hot water heating systems.
4. Apply a hot water heating system troubleshooting guide.

Topic 5 Warm Air Heating System Equipment

Learning Outcome

Describe the operating principles of warm air heating sources.

Learning Objectives

1. Compare the advantages and disadvantages of forced air and gravity warm air systems.
2. List and describe the common sources of warm air heat.
3. List and describe the operational characteristics of directly fired space heaters.

Topic 6 Warm Air Furnace Components and Maintenance

Learning Outcome

Describe the components and maintenance requirements of typical warm air heating and ventilating systems.

Learning Objectives

1. Describe the operation of furnace components.
2. Describe and discuss the relative merits of three types of air distribution and duct systems.
3. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
4. Apply a troubleshooting guide for forced warm air systems and components.

Topic 7 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems found in buildings, as well as describe the various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the types of contaminants found in air.
3. Describe the types of air cleaning devices used in buildings.

Topic 8 Electric Controls for Heating Systems

Learning Outcome

Describe and explain the function of the various components of an electric control circuit.

Learning Objectives

1. Discuss the various terms associated with electric control systems.
2. Describe the basic construction and operation of electric thermostats, humidity controllers, and pressure controllers.
3. Describe the function and operation of the controlled devices in electric control systems.
4. Explain the operating sequence of a basic electric control circuit.

Topic 9 Refrigeration Theory

Learning Outcome

Explain the theory and terms associated with refrigeration.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the practical cycle of operations in a vapor compression refrigeration system.
3. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.

Topic 10 Refrigerants

Learning Outcome

Describe the different refrigerants used and explain the various properties of these refrigerants.

Learning Objectives

1. Describe the identification and classification of refrigerants.
2. Describe the characteristics and thermodynamic properties of refrigerants.
3. Describe the physical properties of refrigerants.

Topic 11 Compression Refrigeration Systems

Learning Outcome

Describe the operating principle of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Distinguish between direct and indirect refrigeration systems.
3. Explain how compression refrigeration system temperatures and pressures are related.
4. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizer.

Topic 12 Refrigeration Compressors

Learning Outcome

Describe the operating principles and the components of refrigeration compressors and perform simple compressor calculations.

Learning Objectives

1. Describe the construction and operation of a reciprocating refrigeration compressor.
2. Describe the construction and operation of a rotary refrigeration compressor.
3. Describe the construction and operation of a centrifugal refrigeration compressor.
4. Describe the construction and operation of seals for refrigeration compressors.
5. Calculate the capacity, efficiency, and ratio of a refrigeration compressor.

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Topic 13 Heat Exchangers for Refrigeration Systems

Learning Outcome

Describe the different types of heat exchangers used in refrigeration systems.

Learning Objectives

1. Describe the designs and construction of refrigeration system evaporators.
2. Describe the designs and construction of refrigeration system condensers.
3. Discuss refrigeration condenser operation and maintenance.

Topic 14 Refrigeration Accessories

Learning Outcome

Describe the various accessories used in refrigeration systems.

Learning Objectives

1. List and describe the operation of the gauges, separators, strainers, and indicators that are used as accessories in refrigeration systems.

Topic 15 Cooling Towers

Learning Outcome

Describe the operation and maintenance of cooling towers.

Learning Objectives

1. List the factors that determine rate of cooling in a cooling tower and the basic components of a cooling tower.
2. Describe the construction and operation of a natural draft cooling tower.
3. Describe the construction and operation of a mechanical draft cooling tower.
4. Discuss cold climate operation for cooling towers.
5. Apply a cooling tower troubleshooting guide.

Topic 16 Air Conditioning Systems

Learning Outcome

Describe the operation of various air conditioning systems.

Learning Objectives

1. List the functional components and categories of air conditioning systems.
2. Describe the operation of air handling units.
3. Describe the general layout and operation of unitary air conditioning systems.
4. Describe the general layout and operation of central air conditioning systems.

Topic 17 Air Compression

Learning Outcome

Describe the operating principles of the different types of air compressors.

Learning Objectives

1. Describe the main classifications and types of air compressors.
2. Describe air compressor auxiliary equipment, including capacity control systems.
3. Discuss preventive maintenance for reciprocating air compressors.

REFERENCE CURRICULUM

For

Steam Boiler Operator (LP)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Steam Boiler Operator (LP) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Steam Boiler Operator (LP) Examination Candidates

Major Topic: Basic Physical Science, Safety, and Regulation for Facility Operations

Topic 1 Introduction to Thermodynamics

Learning Outcome

Explain the principles of thermodynamics and the modes of heat transfer.

Learning Objectives

1. Describe the three states of matter.
2. Describe the expansion of solids and liquids.
3. Explain the different temperature scales used in thermodynamics (Celsius and Fahrenheit).
4. Explain sensible and latent heat, and the thermodynamic transformation of ice to steam.
5. Describe the three modes of heat transfer.
6. Explain the energy in the expansion of water to steam.

Topic 2 Fire Safety and Site Hazards

Learning Outcome

Discuss acceptable methods of extinguishing various classifications of fire. Briefly describe site hazards awareness.

Learning Objectives

1. Explain the overall need for and the intent of fire protection standards, laws, and regulations.
2. Explain the different fire classifications and describe the extinguishing methods for each.
3. Explain the application and operation of standpipes, hoses, and sprinklers in buildings.
4. Explain the various types of fire and smoke detectors.
5. Describe the operation, placement, and maintenance of the common types of portable extinguishers.
6. Discuss the need for and use of a fire pump.
7. Briefly describe safety aspects of common site hazards.
8. Explain how to perform a pre-job hazard assessment.

Topic 3 Building Safety

Learning Outcome

Describe how the building operator can prevent accidental situations to protect the occupants of their facility.

Learning Objectives

1. Explain the personal safety responsibilities and precautions that must be applied by the building operator.
2. Describe the general safety precautions required in the maintenance and operation of buildings.
3. Identify common scenarios where the building operator can prevent accidents, and explain the importance of first aid and CPR training.

Topic 4 Confined Space Entry

Learning Outcome

Describe procedures needed to enter into, or work safely in confined spaces.

Learning Objectives

1. Define confined space, list some confined spaces, and describe the hazards of being in a confined space.
2. Refer to local jurisdictional regulations and describe procedures to be followed when performing a confined space entry, including completion of an entry checklist.

Topic 5 Introduction to Occupational Health and Safety Legislation

Learning Outcome

Discuss the provincial legislation addressing occupational health and safety.

Learning Objectives

1. Explain the general intent of occupational health and safety standards.
2. Discuss some of the responsibilities, according to the Act, of workers, employers, and others in relation to health and safety.
3. Describe the conditions that must exist before a worker can refuse to work.
4. Identify jurisdictional regulations related to health and safety.
5. List the two different types of logs kept in boiler plants and the importance of each.

Topic 6 Introduction to Heating Plant Safety

Learning Outcome

Describe general plant safety as it relates to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may exist in an energy plant, and the basic personal protective equipment that may be required.
3. Define, give examples of, and describe common workplace hazards. (Note that additional training will be required beyond this course material.)
4. Describe equipment isolation and lockout procedures.

Topic 7 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous goods and materials.

Learning Objectives

1. Discuss the WHMIS.
2. Describe the Safety Data Sheets (SDS) and Material Safety Data Sheets (MSDS) required in the WHMIS.
3. Identify the labels required in the WHMIS.
4. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
5. Discuss the safe handling of hydrocarbons.

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Topic 8 Introduction to Electricity

Learning Outcome

Discuss the design and accessories of an electrical circuit; describe the design and troubleshooting of lighting systems and electric motors.

Learning Objectives

1. Explain electricity, electric circuits, and voltage drop.
2. Calculate current and power in an electric circuit, estimate the cost of electrical power for a facility, and describe how to read a power meter.
3. Describe circuit accessories, including switches, fuses, breakers, and receptacles. Explain the danger of electric shock.
4. Explain what constitutes a good lighting system. Explain maintenance of a lighting system and troubleshooting of incandescent and fluorescent systems.
5. Describe simple electrical system problems, including short circuits, grounds, and bad connections. Describe static electricity.
6. Describe transformers and electric motors. Explain motor types, bearing care, and troubleshooting of motors.
7. Explain the CSA approval and markings for electrical appliances.

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Major Topic: Low Pressure Boiler Components and Operation

Topic 1 Watertube Boilers (Heating, Power, and Tubular)

Learning Outcome

Describe the various types of watertube boilers used in small industrial and heating systems.

Learning Objectives

1. Describe the construction of watertube and copper-tubular boilers.
2. Describe the water circulation in a longitudinal drum straight tube boiler.
3. Describe two-drum bent tube boilers, and the advantages of a bent tube boiler compared to a straight tube boiler.
4. Describe the construction of the “A” type, “D” type, and “O” type and the advantages of packaged watertube boilers.

Topic 2 Cast-Iron Sectional and Modular Boilers

Learning Outcome

Describe and explain the uses of cast-iron boilers.

Learning Objectives

1. Describe the general construction of cast-iron sectional boilers.
2. List the advantages of cast-iron sectional boilers over watertube and firetube boilers.
3. Describe the arrangement of equipment in a multiple cast-iron sectional boiler heating plant.
4. Describe the construction and operation of cast-iron modular boilers.

Topic 3 Firetube Boilers (Heating and Power)

Learning Outcome

Describe the various types of firetube boilers used in power and heating systems.

Learning Objectives

1. Explain the difference between power and heating boilers.
2. Describe the historical significance, the construction, and application of the early types of firetube boilers: the HRT, or horizontal return tubular, locomotive, and firebox boilers.
3. Describe the construction and application of wetback and dryback Scotch boilers.
4. Describe the construction and application of vertical firetube boilers and tubeless boilers used in heating plant service.
5. Describe the construction of packaged firetube boilers.

Topic 4 Electric Boilers

Learning Outcome

Describe electric boilers with regard to their use and general design.

Learning Objectives

1. Compare electric boilers to fuel-fired boilers.
2. Describe the construction and operating principle of electrode-type electric boilers.
3. Describe the construction and operating principle of immersion-type electric boilers.

Topic 5 Basic Fittings for Steam Boilers

Learning Outcome

Name, identify, and explain the operating principles and the differences, if any, between the following low and high pressure boiler fittings: pressure gauges, gauge siphons, safety valves, gauge glasses and water columns, safety shutoff valves, quick opening valves, stop valves, check valves, and vent valves.

Learning Objectives

1. Describe the construction, purpose, and operation of pressure gauges and gauge siphons (pigtails).
2. Describe the testing of pressure gauges.
3. Describe the construction, operation, installation, and testing of low-pressure (safety relief) and high-pressure (safety or pop) valves.
4. Describe the purpose, function, and testing of gauge glasses and water columns.
5. Explain how to change a gauge glass.
6. Describe the construction, operation, and purpose of the following valves: gauge glass safety shutoff valves, gauge glass quick closing valves, stop valves, check valves, blowoff (blowdown) valves, and vent valves.

Topic 6 Basic Fittings for Hot Water Boilers

Learning Outcome

Name, identify and explain the operating principles of the following hot water boiler fittings and equipment: pressure, altitude or combination gauges, thermometers, safety relief valves, temperature relief devices, stop valves or drain valves, backflow preventers, and expansion tanks.

Learning Objectives

1. Identify the required instruments, fittings, and controls on a hot water boiler system.
2. Explain how to change a gauge glass on an expansion tank.
3. Describe the construction and operation of the “auto fill valve.”
4. List the usual devices and fittings that are used in hot water heating boiler systems.

Topic 7 Low Water Fuel Cut-Offs and Feedwater Controls

Learning Outcome

Discuss the design, operation and testing of low-water fuel cutoffs and describe feedwater control methods and devices used on low-pressure boilers.

Learning Objectives

1. Describe the construction and operation of float and electrode low water level fuel cut-off equipment.
2. Describe the testing and maintenance of float and electrode low water level fuel cut-offs.
3. Describe the operation of a feedwater float switch operating a valve and a float switch operating a pump.
4. Explain the purpose and function of heating boiler feedwater and condensate piping connections.

Topic 8 Heating Boiler Operating Controls

Learning Outcome

Name and describe the various operating controls found on low-pressure boilers.

Learning Objectives

1. Describe the operation of the on-off control, the high-low fire control, the modulating control, and the high limit control found on low-pressure steam boilers and hot water heating boilers.
2. Explain the operation of the common control switches found on a low-pressure heating boiler.
3. Describe the operation of the safety switches or interlocks found on the fuel supplies of low-pressure heating boilers.
4. Explain the required testing and maintenance of heating boiler controls.

Topic 9 Boiler Combustion Controls

Learning Outcome

Explain the design and operation of various combustion controls on heating boilers.

Learning Objectives

1. List and discuss the various types of boiler flame failure detectors.
2. Describe the testing of boiler flame failure safety devices.

Topic 10 Boiler Programming Controls

Learning Outcome

Describe the basic operation of boiler programming controls.

Learning Objectives

1. Describe the operation of equipment that is used to automatically start up and shut down boilers.
2. List a typical sequence of startup and shutdown events.
3. Describe common 5th Class Power Engineer responses to a boiler programmer startup or shutdown.

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Topic 11 Basic Boiler Operation

Learning Outcome

Describe the preparation, start-up and shutdown, abnormal conditions, and routine operational checks in the operation of steam and hot water boilers.

Learning Objectives

1. Explain the preparation required before starting a steam or hot water boiler.
2. Explain the startup steps once the boiler has been prepared.
3. State possible abnormal conditions during startup and the cautions required to avoid uneven expansion and thermal shock.
4. Describe the procedure required when "cutting in" an additional boiler.
5. Describe the operating conditions for hot water and steam boilers that must be checked daily, and state the required monthly checks.
6. Explain the procedure for removing a hot water boiler from service.
7. Describe the procedure for removing a steam boiler from service.
8. Explain the emergency conditions that can occur during the operation of a steam boiler. Explain the causes and prevention of furnace and pressure explosions.
9. Explain the reasons for boiler accidents, and describe the role and design of operating logs in the safe operation of a boiler.
10. Operator traits, good operating practice, curiosity, using your senses,

(sense-interpret-analyze-perform = SIAP), trusting your instincts, experience and due diligence.

Topic 12 Routine Boiler Maintenance and Inspection

Learning Outcome

Describe the service and maintenance required for boilers. Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical boiler cleaning methods.

Learning Objectives

1. Describe the general servicing and routine maintenance of packaged firetube and cast-iron sectional boilers.
2. Explain the importance of layups and state the procedures to be followed for wet and dry boiler layups.
3. Describe the symptoms of a leaking firetube.
4. List the steps and precautions to be taken to prepare a boiler for inspection.
5. Describe the inspection of a boiler.
6. Describe the methods and tools used for mechanical and chemical cleaning of a boiler.
7. Discuss the standard procedure for a hydrostatic test and the reason for doing the test.

Topic 13 Combustion and Draft

Learning Outcome

Discuss the characteristics of common fuels used in heating boilers, conditions for complete and incomplete combustion, draft methods, and the application of flue gas analysis.

Learning Objectives

1. Explain natural and mechanical draft arrangements.
2. Describe draft measurement using U-tube and inclined draft gauges.
3. Describe the use, advantages, and characteristics of common boiler fuels.
4. State the requirements and reactions for complete and incomplete combustion.
5. Explain the difference between a pressure explosion and a furnace explosion.

Topic 14 Burners for Boilers

Learning Outcome

Describe the operation of the various types of gas and oil burners used on boilers.

Learning Objectives

1. Describe the operation of atmospheric and ring gas burners.
2. Describe the construction and operation of automatic valves.
3. Describe the principle of oil atomizing burners for boilers.
4. List and describe the auxiliary equipment needed for an oil combustion system.
5. Describe the overall components and operation of fuel oil systems.

Topic 15 Piping Materials and Connections

Learning Outcome

Discuss the various construction materials, size classification, and connection methods for the piping in a plant.

Learning Objectives

1. Explain the characteristics and applications of the various materials used to manufacture piping and fittings.
2. Explain pipe size, schedules, and classifications.
3. Identify screwed, flanged, and welded pipe connections.

Topic 16 Piping Expansion, Support, and Insulation

Learning Outcome

Discuss piping expansion, support, and insulation.

Learning Objectives

1. Explain pipe expansion and the principle of expansion bends and joints.
2. Explain the purpose of pipe supports and describe various pipe support designs.
3. Explain the purposes for pipe insulation and describe the use of the common insulation materials.

Topic 17 Steam Traps

Learning Outcome

Explain the purpose of steam traps and describe the installation and operating principles of the various steam traps found on piping systems.

Learning Objectives

1. Describe the designs and operating principles of mechanical traps.
2. Describe the designs and operating principles of thermostatic steam traps.
3. Describe the correct piping arrangement and procedures for a steam trap.
4. Explain the purpose and design of a strainer.
5. Explain the causes, effects, and prevention of water hammer.

Topic 18 Introduction to Valves

Learning Outcome

Discuss the design, application, and maintenance of common types of valves used in piping systems.

Learning Objectives

1. Describe five standard valve designs: gate, globe, butterfly, ball, and plug.
2. Describe the design and operation of check and non-return valves.
3. Describe the function of a pressure-reducing valve.
4. Describe valve identification markings.
5. Describe typical valve maintenance requirements.

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Major Topic: Elements of Human Comfort in Facility Operation

Topic 1 Steam Heating Equipment

Learning Outcome

Describe the operating principles of steam heating equipment and components.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. List and describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.

Topic 2 Steam Heating Systems

Learning Outcome

Describe the operating principles and maintenance procedures of steam heating systems and the components of these systems.

Learning Objectives

1. Describe standard types of piping and equipment layout for steam heating systems.
2. Describe the general operation and maintenance of steam heating systems.
3. Apply a steam heating system troubleshooting guide.

Topic 3 Hot Water Heating Systems

Learning Outcome

Describe the various designs of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe radiant panel and snow melting hot water systems.

Topic 4 Hot Water Heating System Equipment and Operation

Learning Outcome

Describe accessories, operation and troubleshooting of a hot water heating system.

Learning Objectives

1. Describe the purpose and function of standard hot water heating system components such as diverter fittings, air vents, air separators, flow control valves, balancing valves and fittings, riser stop valves, pressure reducing valves, circulating pumps, expansion tanks, and steam to hot water converters.
2. Explain how the location of the hot water circulating pump and the expansion tank are determined.
3. Describe the cleaning, filling, starting, routine operation, and troubleshooting of hot water heating systems.
4. Apply a hot water heating system troubleshooting guide.

Topic 5 Warm Air Heating System Equipment

Learning Outcome

Describe the operating principles of warm air heating sources.

Learning Objectives

1. Compare the advantages and disadvantages of forced air and gravity warm air systems.
2. List and describe the common sources of warm air heat.
3. List and describe the operational characteristics of directly fired space heaters.

Topic 6 Warm Air Furnace Components and Maintenance

Learning Outcome

Describe the components and maintenance requirements of typical warm air heating and ventilating systems.

Learning Objectives

1. Describe the operation of furnace components.
2. Describe and discuss the relative merits of three types of air distribution and duct systems.
3. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
4. Apply a troubleshooting guide for forced warm air systems and components.

Topic 7 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems found in buildings, as well as describe the various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the types of contaminants found in air.
3. Describe the types of air cleaning devices used in buildings.

Topic 8 Electric Controls for Heating Systems

Learning Outcome

Describe and explain the function of the various components of an electric control circuit.

Learning Objectives

1. Discuss the various terms associated with electric control systems.
2. Describe the basic construction and operation of electric thermostats, humidity controllers, and pressure controllers.
3. Describe the function and operation of the controlled devices in electric control systems.
4. Explain the operating sequence of a basic electric control circuit.

Topic 9 Refrigeration Theory

Learning Outcome

Explain the theory and terms associated with refrigeration.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the practical cycle of operations in a vapor compression refrigeration system.
3. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.

Topic 10 Air Compression

Learning Outcome

Describe the operating principles of the different types of air compressors.

Learning Objectives

1. Describe the main classifications and types of air compressors.
2. Describe air compressor auxiliary equipment, including capacity control systems.
3. Discuss preventive maintenance for reciprocating air compressors.

REFERENCE CURRICULUM

For

Steam Boiler Operator (1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Steam Boiler Operator (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Steam Boiler Operator (1st Class) Examination Candidates

Topic 1 Watertube Boiler Designs

Learning Outcome

Describe common designs, configurations and circulation patterns for modern bent-tube watertube boilers and steam generators and explain how boilers are rated.

Learning Objectives

1. Explain the difference between packaged, shop assembled, and field-erected watertube boilers. Explain how boilers are rated.
2. Explain the process of water circulation in a watertube boiler and the factors that influence circulation.
3. Identify examples of and describe the A, O, and D design configurations and explain the water and gas circulation patterns for each. Define integral furnace.
4. Define a steam-generating unit, identify oil and gas-fired units, and explain the components, heating surfaces, and flow patterns through a typical unit. State typical temperatures throughout the unit.
5. Differentiate between critical and super-critical boilers.
6. Explain the purpose and advantage of forced circulation and describe the flow through a typical controlled circulation boiler.
7. Explain the purpose and design of a once-through boiler.

Topic 2 Special Boiler Designs

Learning Outcome

Describe the designs, components, firing methods, and operating considerations for some special boilers used in industry.

Learning Objectives

1. Describe typical designs, components and operating strategies for once-through, steam flood boilers.
2. Describe typical designs, components and operating strategies for Fluidized Bed boilers.
3. Describe typical designs, components and operating strategies for Heat Recovery Steam Generators.
4. Describe typical designs, components and operating strategies for Black Liquor Recovery boilers used in pulp mills.
5. Describe typical designs, components and operating strategies for Refuse boilers used in waste disposal.
6. Describe typical designs, components and operating strategies for waste heat, biomass boilers.

Topic 3 Boiler Construction

Learning Outcome

Explain Code requirements, in general terms, and describe construction and assembly methods for the major components of a large boiler.

Learning Objectives

1. Explain top and bottom support and describe the support techniques for various components of a large boiler, including lateral supports for furnace walls. Explain allowances for expansion.
2. Explain the purpose, design, locations and installation methods for boiler casing insulation, refractory, and cladding.
3. Describe the methods used to fabricate boiler tubes.
4. Describe the preparation, fabrication, and testing of boiler drums.
5. Describe methods of attaching tubes to drums and headers, including expanding and welding, and explain where each method would be used.
6. Explain code requirements/sizes for, and describe the designs and installation of, manholes and handholes, including welded handholes. Explain procedures for removing and installing covers.
7. Describe the field assembly of a large boiler or steam generating unit.

Topic 4 Boiler Heat Transfer Components

Learning Outcome

Explain the purpose, location, design and operating conditions for the major heat transfer components of a large watertube boiler or steam generator.

Learning Objectives

1. Describe baffle designs and locations and explain their significance to boiler heat transfer.
2. Describe the designs of integral furnace sidewall and header arrangements, including tube-and-tile, tangent tube, and membrane.
3. Define primary, secondary, convection, radiation, platen, and pendant as they apply to superheaters. Describe the locations of superheaters within a steam generator and state the operating characteristics of convection and radiant superheaters.
4. Explain the purpose and design of a separately-fired superheater.
5. Explain the purpose and describe the locations of reheaters. Explain the position of and flow through the reheater in relation to the superheaters.
6. Describe designs and locations for integral and separate economizers.
7. Describe the designs, operation, and location of plate, tubular, and rotary regenerative air heaters.
8. Explain operating care and considerations that must be given to the various heat transfer sections of the boiler.
9. Explain a typical water and gas temperature profile through a large steam generating unit.

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Topic 5 High Pressure Boiler Fittings

Learning Outcome

Describe the design and operation of common external and internal fittings attached to the pressure side of a high-pressure boiler.

Learning Objectives

1. Describe the design, installation, operation, and setting of a high-pressure pressure relief valve. Explain the Code requirements for size, capacity and locations of the pressure relief valves on a boiler.
2. Describe the code requirements for boiler pressure gages, including attachment and locations.
3. Describe common designs, connections and components of high-pressure water columns and flat gage glasses, including illumination and quick shut-off devices and bulls-eye glasses. Explain testing and maintenance of a high-pressure gage glass.
4. Describe the float and probe designs for low-water fuel cutoffs and explain how these are tested.
5. Describe boiler steam outlet arrangements and fittings including gate, angle, and globe stop valves and globe, Y, angle, and spring-cushioned non-return valves.
6. Describe manual blowoff piping arrangements. Describe the design and operation of sliding disc, seatless sliding plunger, seat and disc, and combination valves. Explain manual blowoff procedures. Describe the requirements for a blowoff tank.
7. Explain the components of the steam drum internals of a watertube boiler. Describe the design and operation of various steam separation devices, including baffles, primary and secondary separators, and scrubbers.

Topic 6 Boiler Draf t and Flue Gas Equipment

Learning Outcome

Explain boiler draft systems and fans and describe the equipment used to remove ash from flue gas.

Learning Objectives

1. Define and explain the applications and designs of natural, forced, induced and balanced draft.
2. Explain how draft is measured, monitored, and controlled in a large, balanced draft boiler. Explain the position of control dampers.
3. Describe typical draft fan designs, single and double inlet arrangements, and explain methods used to control fan output.
4. Explain the start-up and running checks that must be made on draft fans.
5. Describe typical windbox and air louver arrangements and distinguish between primary and secondary air.
6. Describe the design and operation of flue gas particulate clean-up equipment, including mechanical and electrostatic precipitators and baghouse filters.
7. Describe the design and operation of ash handling systems, including hydro and air systems, bottom ash systems, and scraper conveyor systems.
8. Describe the designs and operation of SO_2 recovery systems, including lime and wet gas scrubbing.

Topic 7 Fuels, Combustion, and Flue Gas Analysis

Learning Outcome

Explain the properties and combustion of common fuels and the analysis of combustion flue gas.

Learning Objectives

1. Explain/define complete combustion, incomplete combustion, combustion products, and write balanced combustion equations.
2. Explain the purpose and benefits of excess air and calculate the theoretical and excess air required for the complete combustion of a given fuel.
3. Explain proximate analysis, ultimate analysis, and heating value of a fuel and describe the use of calorimetry to determine heating value. Explain higher and lower heating values.
4. Given the ultimate analysis of a fuel, use Dulong's Formula to calculate the heating value of the fuel.
5. Describe the properties, classifications and combustion characteristics of coal.
6. Describe the properties, classifications and combustion characteristics of fuel oil.
7. Describe the properties and combustion characteristics of natural gas.
8. Explain the use and combustion characteristics of alternatives to traditional fossil fuels, including biomass, coke and oil emulsions.
9. Explain the analysis of flue gas for the measurement of O_2, CO, and CO_2 in relation to combustion efficiency. Describe typical, automatic flue gas analyzers.
10. Explain the formation, monitoring and control of nitrogen oxides (NO_X), sulfur dioxide, and particulates.

Topic 8 Control Loops and Strategies

Learning Outcome

Explain the operation and components of pneumatic, electronic and digital control loops, and discuss control modes and strategies.

Learning Objectives

1. Describe the operation, components and terminologies for a typical control loop.
2. Describe the operation and components of a purely pneumatic control loop. Explain the function of each component.
3. Describe the operation and components of an analog/electronic control loop. Explain the function of each component.
4. Describe the operation and components of a digital control loop. Explain the function of each component.
5. Explain the purpose, operation, and give examples of on-off, proportional, proportional-plus-reset, and proportional-plus-reset-plus-derivative control. Define proportional band and gain.
6. Describe and give typical examples of feed forward, feed back, cascade, ratio, split-range, and select control.
7. Explain, with examples, the purpose and incorporation of alarms and shutdowns into a control loop/ system.
8. Explain the interactions that occur and the interfaces that exist between an operator and the various components of a control loop/system, including the components of a controller interface.

Topic 9 Instrument and Control Devices

Learning Outcome

Explain the operating principles of various instrument devices that are used to measure and control process conditions.

Learning Objectives

1. Describe the design, operation and applications for the following temperature devices: bimetallic thermometer, filled thermal element, thermocouple, RTD, thermistor, radiation and optical pyrometers
2. Describe the design, operation and applications for the following pressure devices: bourdon tubes, bellows, capsules, diaphragms, and absolute pressure gage.
3. Describe the design, operation and applications for the following flow devices: orifice plate, venturi tube, flow nozzle, square root extractor, pitot tube, elbow taps, target meter, variable area, nutating disc, rotary meter and magnetic flowmeter.
4. Describe the design, operation and applications for the following level devices: atmospheric and pressure bubblers, diaphragm box, differential pressure transmitter, capacitance probe, conductance probes, radiation and ultrasonic detectors and load cells.

Topic 10 Distributed and Logic Control

Learning Outcome

Explain the general purpose, design, components and operation of distributed and programmable logic control systems.

Learning Objectives

1. Explain distributed control and describe the layout and functioning of a typical distributed control system. Explain the function of each major component of the system.
2. Identify and explain the functions of the major components of the operator interface unit (OIU), including controller interfaces, displays, alarms and shutdown.
3. State typical applications and explain the purpose and functioning of a programmable logic controller, including the operator interfaces. Explain a ladder logic diagram.
4. State the purpose and explain the general functioning of a communication and data acquisition system (eg. SCADA) as it relates to process control.

Topic 11 Boiler Control Systems

Learning Outcome

Explain the components and operation of automatic control systems for boiler water level, combustion, steam temperature, and start-up.

Learning Objectives

1. Describe on-off and single element control of boiler feedwater.
2. Explain swell and shrinkage in a boiler. Describe the components and operation of a two-element feedwater control system, explaining the interaction of the controllers.
3. Describe the components and operation of a three-element feedwater control system.
4. Describe the components and operation of a direct combustion control system.
5. Describe the components and operation of a ‘steam flow – airflow’ combustion control system.
6. Describe the components and operation of a ‘fuel flow – airflow’ combustion control system.
7. Describe the components and operation of an ‘airflow – fuel flow’ combustion control system.
8. Describe the components and operation of a multi-element combustion control system.
9. Describe steam temperature control methods and equipment, including attemperation (desuperheating), gas recirculation, gas bypass, and tilting burners.
10. Describe the automatic, programmed start-up sequence for a gas-fired boiler.

Topic 12 Boiler Procedures

Learning Outcome

Describe common procedures in the operation and maintenance of high pressure boilers.

Learning Objectives

1. Explain the steps involved in the commissioning of a new boiler or before starting a boiler after major repairs, including:
   a) hydrostatic test
   b) external and internal inspections
   c) drying out refractory
   d) boiling out
   e) testing shutdowns and safety devices
2. Describe the wet and dry methods when laying up a boiler for an extended time, including nitrogen blanketing.
3. Describe the proper shut down and preparation of a boiler for internal inspection.
4. Describe a thorough inspection of the water and furnace sides of a boiler.
5. Describe typical equipment and procedures for cleaning the water side of a boiler:
   a) mechanically
   b) chemically
6. Explain routine tasks and visual monitoring that the operator must perform on a large operating boiler.
7. Explain the procedures and precautions that an operator must exercise to avoid furnace and pressure-side explosions.
8. Describe sootblowing systems and describe the procedures for operating sootblowers.

Topic 13 Internal Water Treatment for Boilers

Learning Outcome

Discuss internal water treatment methods and systems for the control of scale, corrosion, and carryover and explain testing and monitoring strategies.

Learning Objectives

1. Explain the causes and effects of boiler scale; explain the most common internal methods of scale control, including phosphate treatment, chelate treatment, sludge conditioning and dispersion.
2. Explain the causes and effects of boiler and condensate return line corrosion; explain treatment methods for acidic, caustic, oxygen, and carbon dioxide corrosion, including sulphite, hydrazine, and amine treatment.
3. Explain the mechanical and chemical causes, effects and types of carryover; explain methods of carryover control, including the use of antifoam and blowdown.
4. Describe the design and explain the operation of simple blowdown, heat recovery, and automatic blowdown systems.
5. Explain, in general terms, the sampling and testing strategies for boiler internal conditions; describe typical sampling and automatic monitoring equipment.
6. Describe typical chemical feed systems, including pot feeders, continuous feed with day tanks, and continuous feed with pump tanks.

Topic 14 Boiler Water Pretreatment

Learning Outcome

Explain the purpose, principles, equipment, and monitoring of boiler water pretreatment processes.

Learning Objectives

1. Describe the design and explain the terms, purpose and operation of a clarifier, using coagulation, flocculation, and subsidence.
2. Describe the design and explain the terms, purpose and operation of gravity and pressure filters.
3. Describe the design and explain the terms, purpose and operation, including chemical reactions for a cold lime softener.
4. Describe the design and explain the terms, purpose and operation of a hot lime softener.
5. Explain the principles of ion exchange softening in general, identifying the common anions and cations in untreated water.
6. Describe the design, components, and operation of a sodium zeolite softening system including chemical reactions.
7. Describe the design, components, and operation of a hydrogen zeolite softening system including chemical reactions.
8. Describe the design, components, and operation of a dealkalization system including chemical reactions.
9. Describe the design, components, and operation of a demineralizer system, including mixed bed and degasification.
10. Explain the principle and operation of a reverse osmosis system.
11. Describe the design, principle, and operation controls of a typical deaerator.

Topic 15 Welding Procedures and Inspection

Learning Outcome

Explain the processes and applications of different welding techniques and describe the testing of welds and procedures.

Learning Objectives

1. Describe the equipment, procedure and applications of shielded metal arc welding (SMAW). Explain the classification of arc welding electrodes.
2. Describe the equipment, procedure and applications of submerged arc welding (SAW).
3. Describe the equipment, procedure and applications of gas tungsten arc welding (GTAW).
4. Describe the equipment, procedure and applications of gas metal arc welding (GMAW).
5. Explain weld preparation and terminology of a butt weld; explain preheating and post-weld heat treatment.
6. Describe common defects in welds, including undercut, lack of penetration, porosity, slag inclusion, and cracking; explain how each occurs and its effect on the integrity of the weld.
7. Explain the equipment and procedures for dye penetrant, magnetic particle, radiographic, and ultrasonic inspection of a weld; explain the potential weld defects revealed by each test.
8. Explain the requirements and process for Weld Procedure and Welder Performance qualification, per the ASME Code, Section IX.

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Topic 16 Pressure Vessels

Learning Outcome

Explain pressure vessel design, stresses, and operating considerations.

Learning Objectives

1. Define “pressure vessel” and explain, in general terms, how pressure vessels are regulated in design, construction and repair (including purpose of Section VIII, ASME).
2. Explain the stamping/nameplate requirements for pressure vessels and identify terms and specifications on a typical nameplate.
3. Describe the weld locations on a typical pressure vessel and identify head designs, including ellipsoidal, torispherical, hemispherical, conical, and toriconical.
4. Describe acceptable nozzle attachment methods, including reinforcements; describe inspection openings.
5. Explain the loads that contribute to stresses in pressure vessels, including pressure, thermal, attachments, static, wind, seismic, and cyclic loads.
6. Explain the components and fittings of a typical pressure vessel.
7. Explain operating and maintenance considerations for the safe operation of pressure vessels, including the appropriate use of hydrostatic and pneumatic testing.

REFERENCE CURRICULUM

For

Steam Boiler Operator (2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

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Recommended Study Program:

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Reference Curriculum for Steam Boiler Operator (2nd Class) Examination Candidates

Major Topic: Safety

Topic 1 The Cost and Effects of Workplace Injuries

Learning Outcome

Describe the cost and effects of workplace injuries on the individual worker and the business.

Learning Objectives

1. Describe the financial cost of injuries and the impact an injury has on the injured person.
2. Discuss the social and legal implications of injuries.
3. List the steps that can be taken by management to minimize the effects of workplace injuries.

Topic 2 Personal Protective Equipment

Learning Outcome

Describe the use, selection and care of personal protective equipment.

Learning Objectives

1. Describe the basic types of personal protective equipment available.
2. Describe the various types and the training, care and maintenance of respiratory protection.

Topic 3 Isolation of Mechanical and Electrical Equipment

Learning Outcome

Describe the general procedures involved in the isolation of plant equipment.

Learning Objectives

1. Discuss the general considerations required for the mechanical and electrical isolation of equipment.
2. Describe the typical safe isolation of various pieces of plant equipment.

Topic 4 Confined Space Entry

Learning Outcome

Describe procedures needed to enter into and work safely within confined spaces.

Learning Objectives

1. Define and describe the hazards of being in a confined space.
2. Describe procedures to be used when performing a confined space entry, including completion of an entry checklist.

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Major Topic: High Pressure Boiler Design

Topic 5 Introduction to Boilers

Learning Outcome

By using common terms relating to boilers discuss the historical developments of, and the general requirements for proper boiler design.

Learning Objectives

1. Apply common terminology used in the description of boilers.
2. Describe early boiler designs and explain developments that improved boiler operation.
3. List the general requirements for proper boiler design.

Topic 6 Firetube Boilers

Learning Outcome

Discuss the design, components and characteristics of HRT, locomotive, firebox, Scotch and packaged firetube boilers.

Learning Objectives

1. Describe horizontal return tubular and locomotive type boilers.
2. Describe firebox, scotch and heating boilers.
3. Describe vertical and packaged firetube boilers.

Topic 7 Watertube Boilers

Learning Outcome

Describe various watertube boiler designs, including large generating units.

Learning Objectives

1. Describe the operating principle and design of watertube boilers.
2. Explain the design and application of packaged watertube boilers.
3. Describe the design, construction and components of large scale steam generating units.
4. Describe the design of watertube and copper-tubular heating boilers.

Topic 8 Electric Boilers

Learning Outcome

Describe electric boilers in regard to their use and general design.

Learning Objectives

1. Describe the construction and operating principle of electric boilers.

Topic 9 Basic Boiler Construction

Learning Outcome

Describe fabrication and general construction features of watertube and firetube boilers.

Learning Objectives

1. Describe the design and manufacturing of boiler shells and drums.
2. Describe the standard types of welded joints, heat treatments and welding inspection used in the construction of pressure vessels.
3. Describe the general design of riveted joints.
4. Describe the tools and standard methods used to attach boiler tubes to tubesheets, headers and drums.
5. Describe the need for, and application of, boiler stays.
6. Describe boiler access and inspection openings and drum connections.
7. Identify the different types of internal firetube furnace designs.
8. Describe boiler foundations and supports.
9. Describe the design and construction of water-cooled furnace walls in watertube boilers.

Major Topic: Draft, Combustion and High Pressure Boiler Fittings

Topic 10 Boiler Draf t Equipment

Learning Outcome

Discuss draft and describe the basic equipment used to supply combustion air to a boiler furnace.

Learning Objectives

1. Describe the forced, induced and balanced methods of mechanical draft.
2. Discuss the common methods of controlling combustion air flow.
3. Discuss the common methods of measuring furnace pressures.

Topic 11 Introduction to Boiler Combustion

Learning Outcome

Discuss the basic theory of combustion in a boiler, and the equipment used to provide proper combustion conditions.

Learning Objectives

1. Describe the principles of combustion, combustion equations and the relationships between theoretical and excess air.
2. Describe the three general classes of boiler fuels.
3. Describe the firing methods used in the combustion of various fuels, the effects of combustion on refractory and how the flow of fuel is controlled.
4. Describe flue gas analysis and its relationship to boiler efficiency.

Topic 12 Fluidized Bed Combustion

Learning Outcome

Discuss the basic theory and design of a fluidized bed steam generator and describe the special operational and control aspects of fluidized bed combustion.

Learning Objectives

1. Define and discuss the history and benefits of "fluidized bed combustion".
2. Explain the types and operation of fluidized bed combustion units.
3. Discuss the advantages and disadvantages of fluidized bed combustion.
4. Discuss two start-up strategies and explain bed expansion.

Topic 13 Safety and Relief Valves

Learning Outcome

Discuss the design and operation of safety valves for power and heating boilers.

Learning Objectives

1. Describe the ASME code requirements and the construction and operation of high pressure safety valves.
2. Describe the ASME code requirements for the construction and operation of low pressure heating boiler safety valves.
3. Describe the testing and repair of safety valves.
4. Describe the construction and operation of a temperature relief device.

Topic 14 Water Columns and Gage Glasses

Learning Outcome

Describe different types of direct and inferential level gages or indicators.

Learning Objectives

1. Describe direct type water level indicators.
2. Describe indirect type water level indicators.

Topic 15 Drum Internals

Learning Outcome

Describe typical internal components of a boiler steam drum.

Learning Objectives

1. Describe the purposes of and the general principles and equipment used to separate steam and water in a steam drum.
2. Describe steam drum internal feedwater, continuous blowdown and chemical feed pipes.

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Major Topic: Piping Topic 16

Sootblowers Learning Outcome

Discuss the design and operation of sootblowers.

Learning Objectives

1. Describe the construction and operation of retractable and stationary sootblowers.
2. Describe an arrangement for shot cleaning.

Topic 17 Continuous and Intermittent Blowdown

Learning Outcome

Describe the purposes, equipment and operation of continuous and intermittent blowdown.

Learning Objectives

1. Describe the equipment and processes involved in continuous and intermittent blowdown systems.

Topic 18 Boiler Preparation, Start-up and Shutdown

Learning Outcome

Describe the basic preparation of a boiler for start-up and shutdown procedures.

Learning Objectives

1. Describe the steps that must be taken to prepare a boiler for start-up.
2. Describe a typical boiler start-up procedure.
3. Describe the boiler and steam header warm-up procedures.
4. Describe the procedure for shutting down a boiler.

Topic 19 Routine and Emergency Boiler Operation

Learning Outcome

Discuss routine and emergency practices for operation of a packaged boiler.

Learning Objectives

1. Describe the proper routine care and operation of a boiler.
2. Describe emergency conditions in boilers and the required responses.
3. List types and causes of boiler accidents and explosions.
4. Discuss the need for boiler operating and maintenance logs and the type of information that should be recorded.

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Major Topic: Electricity Topic 20

Basic Electricity Learning Outcome

Describe the concepts of basic electricity and perform simple calculations using voltage, current, resistance and power.

Learning Objectives

1. Describe the atomic structure of matter and its relationship to electricity.
2. Describe basic electrical circuits.
3. State Ohm's Law and apply it to single resistor circuits.
4. Apply Ohm's Law to series resistance circuits.
5. Apply Ohm's Law to parallel resistance circuits.
6. List the factors affecting resistance.
7. Calculate the power developed in an electrical circuit.

Topic 21 Magnetism and Electromagnetism

Learning Outcome

Describe the basic principles of magnetism.

Learning Objectives

1. Describe magnetism and the relationship between magnetism and electricity.
2. Describe the relationship between electricity and magnetism in an electrical generator.
3. Describe the relationship between electricity and magnetism in an electric motor.

Topic 22 Electrical Metering Devices

Learning Outcome

Discuss the designs and uses of electrical metering devices.

Learning Objectives

1. Describe how voltage, current and resistance are measured in an electric circuit.
2. Describe the construction and operation of a kilowatt hour meter.

Topic 23 Motors and Generators

Learning Outcome

Describe the operating principles of the various types of AC and DC motors or generators.

Learning Objectives

1. Describe the construction and operation of DC generators and motors.
2. Describe the construction and operation of AC generators (alternators) and motors.
3. Interpret the information on a motor nameplate.
4. Discuss and perform basic calculations relating to power factor and power factor correction.

Topic 24 Transformers

Learning Outcome

Describe the operating principle of transformers.

Learning Objectives

1. Describe the principle of operation of transformers.
2. Describe the construction and operation of single phase transformers and perform basic transformer calculations.
3. Describe the construction and operation of three-phase transformers.
4. Discuss transformer maintenance and cooling.

Topic 25 Electrical Distribution Circuits

Learning Outcome

Describe an electrical distribution system.

Learning Objectives

1. List and describe the standard types of electrical voltage systems.
2. Interpret electrical circuit symbols as used in building systems.
3. Describe the major components of an electrical distribution system.
4. Describe the function and operation of alternate power supply system equipment.

Major Topic: Controls and Instrumentation Topic 26

Introduction to Instrumentation Learning Outcome

Describe the overall purpose and function of plant instrumentation systems.

Learning Objectives

1. Describe the concept and basic components of a control loop.
2. Describe the various means by which control signals are transmitted.
3. Describe the function of transducers.
4. List and describe the types of instrumentation which are not necessarily part of a control loop.

Topic 27 Introduction to Process Measurement

Learning Outcome

Describe the construction and operation of common devices used to measure pressure, level, temperature, flow, and composition.

Learning Objectives

1. Describe the standard types of pressure measuring devices.
2. Describe the standard types of level sensing and measuring devices.
3. Describe the standard types of flow sensing and measuring devices.
4. Describe the standard types of temperature sensing and measuring devices.
5. Describe the principle and basic operation of a chromatograph.

Topic 28 Basic Control Loop Components

Learning Outcome

Describe the basic types and functions of transmitters, recorders, controllers and control valves.

Learning Objectives

1. Describe the principle, construction and operation of instrumentation transmitters.
2. Describe the principle, construction and operation of instrumentation indicators and recorders.
3. Describe the principle, construction and operation of instrumentation controllers and control valves.

Topic 29 Boiler Water Level and Combustion Controls

Learning Outcome

Describe specific types of instrumentation and controls used on boilers.

Learning Objectives

1. Describe the construction and operation of boiler low water level fuel cutoff equipment.
2. List the ASME code regulations regarding low water fuel cutoffs.
3. Describe the testing and maintenance of boiler low water level fuel cutoffs.
4. Describe the components and component functions of boiler water level control systems.
5. Describe basic boiler combustion control systems.

Topic 30 Boiler Programming Controls

Learning Outcome

Describe the operation of programming controls for boilers and discuss testing and maintenance procedures for these controls.

Learning Objectives

1. Describe the operation of equipment that is used to automatically start up and shut down boilers.
2. Interpret operating sequence bar graphs and provide a typical sequence of start up and shutdown events.
3. Apply a boiler start up and shutdown programmer troubleshooting guide.

Topic 31 Introduction to Process Computer Applications

Learning Outcome

Describe the major components of process computers, their basic functions and the types of tasks performed by the computer systems.

Learning Objectives

1. Define the types of computer systems, components and peripherals used in process control.
2. Describe basic computer working principles.
3. Describe the application of computers to process control.

Major Topic: Heating Boilers

Topic 32 Cast Iron Sectional and Modular Boilers

Learning Outcome

Describe cast iron boilers and explain their uses.

Learning Objectives

1. Describe the general construction and the advantages of cast-iron sectional heating boilers over watertube and firetube boilers.
2. Describe the arrangement of equipment in a multiple, cast-iron sectional boiler heating plant.
3. Describe the construction and operation of cast-iron modular heating boilers.

Topic 33 Oil Burners for Heating Boilers

Learning Outcome

Describe the various oil burners used on heating boilers.

Learning Objectives

1. Describe air, steam and mechanical oil atomizing burners for boilers.
2. Describe the auxiliary equipment needed for an oil combustion system.
3. Describe the design and operation of fuel oil systems, including storage.

Topic 34 Gas Burners for Heating Boilers

Learning Outcome

Describe the operation of the various types of gas burners used on heating boilers.

Learning Objectives

1. Describe the operation of various types of gas burners.
2. Describe the construction and operation of automatic gas valves.

Topic 35 Basic Fittings for Low Pressure Steam Boilers

Learning Outcome

Describe, and explain the operating principles of pressure gages and safety valves found on low-pressure steam boilers.

Learning Objectives

1. Describe the code requirements for pressure gages on low-pressure steam boilers.
2. Describe the code requirements for the boiler connections and valves on low-pressure steam boilers.

Topic 36 Basic Fittings for Hot Water Boilers

Learning Outcome

Describe the purpose and operating principles of basic boiler fittings on hot water boilers.

Learning Objectives

1. Describe the code requirements for the required fittings on hot water heating boilers.
2. Discuss the types of non-required fittings that are used on hot water heating boilers.

Topic 37 Hot Water and Steam Heating Boiler Operation

Learning Outcome

Describe the specific safe and efficient operational procedures that relate to automatically-fired, low-pressure hot water and steam heating boilers.

Learning Objectives

1. Describe the general preparation and start-up of a hot water heating boiler.
2. Describe the operation of a hot water heating boiler under routine conditions, including removal from service.
3. Describe the preparation, start-up, routine operation and removal from service of a steam heating boiler.

Major Topic: Heating Boiler and Heating System Controls

Topic 38 Heating Boiler Feedwater Controls

Learning Outcome

Describe the various feedwater control methods and devices used on low-pressure steam boilers.

Learning Objectives

1. Describe the operation of a feedwater float switch operating a valve and a pump.
2. Describe how condensate is collected and returned to the boiler.
3. Explain the purpose and function of heating boiler feedwater and condensate piping connections.

Topic 39 Heating Boiler Operating Controls

Learning Outcome

Name and describe the various operating controls found on low-pressure heating boilers.

Learning Objectives

1. Discuss the various operating controls for low-pressure steam and hot water heating boilers.
2. Describe the operation of the control and safety switches found on the fuel supplies of low-pressure heating boilers.
3. Explain the required testing and maintenance of boiler controls.

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Topic 40 Heating Boiler Combustion Controls

Learning Outcome

Explain the design and operation of various combustion controls on heating boilers.

Learning Objectives

1. Describe the construction and operation of heating boiler flame failure detectors.
2. Describe the testing of hot water heating boiler flame failure safety devices.

Major Topic: Boiler Maintenance Topic 41

Powerhouse Maintenance I Learning Outcome

Describe the safe use of common hand tools in the powerhouse.

Learning Objectives

1. List the general safe working practices identified by the Workers' Compensation Board.
2. Describe the types and proper use of hacksaws, files, chisels, hammers, screwdrivers and wrenches.
3. Describe the types and proper use of hand threading tools.
4. Describe the types and proper use of measuring tools.
5. Describe the proper layout of work and the use of layout tools.
6. Describe the types and proper use of portable and fixed grinders, hand drills, drill presses and the care of drill bits.

Topic 42 Powerhouse Maintenance II

Learning Outcome

Discuss and describe the safe and proper setup of equipment for hoisting and working above ground.

Learning Objectives

1. Describe the requirements for setting up work platforms in general and ladders and scaffolding in particular.
2. Describe the general safety precautions and calculations used when rigging equipment.
3. Describe the general safety precautions used when hoisting equipment.

Topic 43 Powerhouse Maintenance III

Learning Outcome

Discuss the designs and safe applications and attachment of lifting cables and ropes, and the designs and uses of metal fasteners.

Learning Objectives

1. Discuss the correct use and limitations of wire cable and rope, including cable attachments and rope knots.
2. List and describe common types of metal fasteners, such as screws, bolts, studs, nuts and washers.

Topic 44 Boiler Maintenance

Learning Outcome

Describe the service and maintenance required for boilers.

Learning Objectives

1. Describe the general maintenance and servicing of packaged firetube and cast-iron sectional boilers.
2. State the procedures to be followed for wet and dry boiler lay-ups.
3. Describe the causes and symptoms of a leaking firetube and the procedure for removing a firetube from service.
4. Describe two methods of detecting cracks in firetube ends and tube sheets.
5. Describe the general procedure for the removal and replacement of a defective firetube.

Topic 45 Boiler Cleaning

Learning Outcome

Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical and chemical boiler cleaning methods.

Learning Objectives

1. List the steps and precautions to be taken to prepare a boiler for inspection.
2. Describe the internal inspection of a boiler.
3. Describe the methods and tools used for mechanical cleaning of a boiler.
4. Describe two methods used for the chemical cleaning of a boiler.

REFERENCE CURRICULUM

For

Water Treatment Plant Manager

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Water Treatment Plant Manager Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Water Treatment Plant Manager Examination Candidates

Topic 1 Metallurgy

Learning Outcome

Discuss the selection, properties, and stress effects of steel.

Learning Objectives

1. Describe the structure of metals.
2. Explain the nature and significance of phase changes in iron and steel due to temperature change.
3. Explain how alloying elements affect phase changes in steel and state the major alloying elements used in steel.
4. Explain the effect of temperature on the tensile strength of steel.
5. Explain the criteria for the assessment of materials.
6. Explain what creep is, and why it is important to monitor its effects on equipment.
7. Explain the methods of stress analysis.
8. Explain failure analysis.

Topic 2 Corrosion Chemistry and Processes

Learning Outcome

Explain the chemistry and processes of corrosion mechanisms.

Learning Objectives

1. Explain how atomic and molecular structures affect corrosion.
2. Explain the anodic and cathodic processes of corrosion.
3. Explain the electromotive force series and galvanic series.
4. Explain the effect of polarization.
5. Explain corrosion of single metals.
6. Explain the processes of crevice corrosion and pitting corrosion.
7. Explain the process of microbiologically influenced corrosion.
8. Explain the process of stress induced corrosion.
9. Explain the processes of erosion-corrosion.

Topic 3 Boiler Corrosion

Learning Outcome

Discuss the mechanisms of corrosion in boilers.

Learning Objectives

1. Explain the impact of corrosion.
2. Explain the agents of corrosion found in water.
3. Explain the mechanisms and significance of magnetite formation and magnetite depletion on boiler tube surfaces.
4. Explain the mechanisms and significance of economizer and superheater corrosion.
5. Explain the mechanism, identification and significance of flue gas side corrosion of boiler components.
6. Explain the mechanism, identification and significance of low temperature corrosion of boiler components.
7. Explain the relationship between boiler water chemistry and corrosion of copper alloys in feedwater systems.
8. Explain the mechanisms and significance of deaerator cracking and corrosion.

Topic 4 Corrosion Monitoring and Prevention Techniques

Learning Outcome

Explain techniques used to monitor and prevent corrosion.

Learning Objectives

1. Describe the methods of monitoring and analyzing corrosion.
2. Explain the design, applications, and operation of cathodic protection systems.
3. Explain the use of protective coatings for corrosion control.
4. Describe the regulatory and safety requirements relating to corrosion monitoring.
5. Describe chemical control of corrosion.

Topic 5 Corrosion Prevention Programs

Learning Outcome

Explain corrosion prevention programs.

Learning Objectives

1. Explain the corrosion characteristics and susceptibility of engineering materials and their selection for various purposes.
2. Describe the chemical, mechanical, and operational factors that are considered in controlling corrosion in steels.
3. Describe the chemical, mechanical and operational factors that are considered in controlling corrosion in copper alloys.
4. Explain the risks and required precautions involved with chemical cleaning of boiler surfaces.
5. Explain the steps taken to reduce waterside and fireside corrosion during dry and wet storage of a boiler.
6. Explain the development, components and management of a corrosion prevention program for cooling water systems, including the selection, application and characteristics of biocides.
7. Explain the development, components and management of a corrosion prevention program for piping and pressure vessels.
8. Explain the development, components and management of a corrosion prevention program for rotating equipment.

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Topic 6 Water Pre-Treatment

Learning Outcome

Describe the process used to treat raw water for power plants, including detailed chemistry where applicable.

Learning Objectives

1. Describe the mechanisms of coagulation and flocculation.
2. Describe the chemical processes and reactions of oxidation of organic contaminants.
3. Describe the chemical processes and reactions of iron and manganese removal from raw water.
4. Describe the chemical processes and reactions in a lime/soda softener.
5. Describe the chemical processes and reactions in a sodium zeolite softener.
6. Describe the chemical processes and reactions in a hydrogen zeolite softener.
7. Describe the chemical processes and reactions in a demineralizer.
8. Describe the chemical processes and reactions in a dealkalizer.
9. Describe the mechanisms of membrane technology, including chemical and mechanical cleaning methods and clean-in-place design.
10. Describe the chemical processes and mechanisms of electrodialysis (ED) and electrodeionization (EDI).
11. Describe the chemical processes and reactions of oxygen scavenging and metal passivation.
12. Describe the methods by which silica is removed from feedwater and condensate.

Topic 7 Internal Water Treatment

Learning Outcome

Describe the processes used to treat boiler water and condensate, including detailed chemistry where applicable.

Learning Objectives

1. Explain the principles, reactions and control of chelation.
2. Explain the principles, reactions and control of a coordinated phosphate program.
3. Explain the phenomenon of phosphate hideout.
4. Explain the principles, reactions and control of a congruent phosphate program.
5. Explain the principles, reactions and control of an equilibrium phosphate program.
6. Explain the principles, reactions and control of an all-volatile treatment program.
7. Explain the principles, reactions and control of a polymer treatment program.
8. Explain the principles, reactions and control of an oxygenated water treatment program.
9. Describe the mechanism of sludge conditioning.
10. Describe the mechanism of antifoam conditioning.
11. Describe the chemical processes and reactions of condensate treatment, including corrosion prevention, deaeration and polishing.

Topic 8 Non-Boiler Water Treatment

Learning Outcome

Explain the monitoring and management of potable water and cooling water treatment systems.

Learning Objectives

1. Describe the regulatory requirements for potable water quality and monitoring.
2. Describe the parameters and interpretation of potable water analyses.
3. Describe the selection and mechanism of oxidation agents.
4. Describe the mechanism of ultra-violet sterilization.
5. Explain the components and management of a cooling water treatment program.
6. Describe the use and chemistry of biocides in cooling water.
7. Describe the use and chemistry of corrosion inhibitors in cooling water.
8. Explain the use of chelants in cooling water.
9. Explain the use of threshold scale inhibitors in cooling water.
10. Explain the use of surfactants, dispersants and biodispersants in cooling water.

Topic 9 Water Treatment Management

Learning Outcome

Explain the monitoring, management, and maintenance of water treatment systems.

Learning Objectives

1. Explain the financial management of the costs and benefits of water treatment.
2. Apply raw water analysis to the selection of a water treatment system.
3. Explain monitoring and control of cycle chemistry.
4. Describe the troubleshooting process when a cycle chemistry parameter deviates from the acceptable range.
5. Describe the selection and maintenance of resins for zeolite, demineralizer, dealkalizer, and condensate polisher service.
6. Describe the procedures and interpretation for tube deposit analyses.
7. Explain the inspection procedure for internal boiler components in relation to water treatment.
8. Describe a typical maintenance program for the components of water treatment systems, including: water filters, clarifiers and lime-soda softeners, sodium zeolite softeners, demineralizers, mixed bed and condensate polishers, reverse osmosis units, microfiltration, electrodialysis and electrodeionization units and deaerators.
9. Describe the selection, responsibilities and management of water treatment consultants.

REFERENCE CURRICULUM

For

Water Treatment Operator (1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Water Treatment Operator (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Pittsburgh, PA 15242-0369

Reference Curriculum for Water Treatment Operator (1st Class) Examination Candidates

Topic 1 Water Chemistry and Analysis

Learning Outcome

Discuss the significance of common water impurities, and the application of water analyses.

Learning Objectives

1. Describe the sources of the impurities found in raw water.
2. Describe the effect of the listed water impurities on power plant equipment and processes.
3. Explain the significance and importance of standard methods of water analysis.
4. Describe which analyses are appropriate at given sampling points including the significance of the sampling point locations.
5. Interpret the results of a comprehensive standardized water analysis including the relationship of the various parameters.
6. Explain the purposes and principles of testing instruments, including embrittlement detector, total solids meter, and pH meter.
7. Explain the purpose of steam purity measurement and process of steam sampling.

Topic 2 Water Pre-Treatment I

Learning Outcome

Describe water pre-treatment processes for removal of suspended solids, oil, and gases.

Learning Objectives

1. Explain the purpose, equipment, operation, and limitations of sedimentation.
2. Explain the purpose, equipment, operation, and limitations of coagulation and flocculation.
3. Explain the purpose, equipment, operation, and limitations of filtration.
4. Explain the purpose, principles, equipment, operation, and limitations of microfiltration.
5. Describe how oil is removed from water.
6. Explain the purpose, equipment, operation, and limitations of mechanical deaeration.
7. Explain the purpose, equipment, operation, and limitations of evaporation.

Topic 3 Water Pre-Treatment II

Learning Outcome

Describe water pre-treatment processes for ion removal.

Learning Objectives

1. Explain the purpose, equipment, and operation of lime-soda softening.
2. Explain the purpose, equipment, operation, and limitations of hot process phosphate softening.
3. Explain the purpose, equipment, operation, and limitations of sodium zeolite softening.
4. Explain the purpose, equipment, and operation of hydrogen zeolite softening.
5. Describe how silica is removed from water.
6. Explain the purpose, equipment, and operation, of demineralization, including condensate polishing.
7. Explain the purpose, equipment, and operation of electrodialysis (ED) and electrodeionization (EDI).
8. Explain the purpose, equipment and operation of reverse osmosis (RO).

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Topic 4 Internal Water Treatment

Learning Outcome

Describe water pre-treatment processes for ion removal.

Learning Objectives

1. Explain the causes, effects, and control of scale.
2. Explain the causes, effects, and control of foam in boiler water.
3. Explain the causes, effects, and control of caustic embrittlement.
4. Explain the causes, effects, and control of return line corrosion.
5. Explain the use of chelating agents in boiler water.
6. Explain the use of sludge conditioning in boiler water.
7. Explain the use of pH control in boiler water.
8. Explain the use of chemical deaeration in boiler water.
9. Explain the causes, effects, and control of carryover of boiler water.
10. Explain the use of blowdown from boiler water.
11. Explain the use and control of chemical feed systems for boiler water.
12. Explain the control of silica to avoid turbine blade deposits.

Topic 5 Non-Boiler Water Treatment

Learning Outcome

Describe water pre-treatment processes for ion removal.

Learning Objectives

1. List the water impurities of concern in a cooling water system and the effects caused by each one.
2. Describe control methods for a cooling water system for control of corrosion, fouling, and microbiological attack including chloride corrosion, and delignification.
3. Describe the potential effects of wastewater discharge.
4. Compare and contrast mechanical, chemical, and biological methods of wastewater treatment including the advantages and disadvantages of each.
5. Specify an appropriate method of wastewater treatment for a particular case study.
6. Describe the methods used for potable water treatment and analysis.

Topic 6 Water Treatment Management

Learning Outcome

Explain the monitoring, management, and maintenance of water treatment systems.

Learning Objectives

1. Explain the financial management of the costs and benefits of water treatment.
2. Apply raw water analysis to the selection of a water treatment system.
3. Explain monitoring and control of cycle chemistry.
4. Describe the troubleshooting process when a cycle chemistry parameter deviates from the acceptable range
5. Describe the selection and maintenance of resins for zeolite, demineralizer, dealkalizer, and condensate polisher service.
6. Describe the procedures and interpretation for tube deposit analyses.
7. Explain the inspection procedure for internal boiler components in relation to water treatment.
8. Describe a typical maintenance program for the components of water treatment systems, including: water filters, clarifiers and lime-soda softeners, sodium zeolite softeners, demineralizers, mixed bed and condensate polishers, reverse osmosis units, microfiltration, electrodialysis and electrodeionization units and deaerators.
9. Describe the selection, responsibilities and management of water treatment consultants.

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REFERENCE CURRICULUM

For

Water Treatment Operator (2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Water Treatment Operator (2nd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

National Institute for the Uniform Licensing of Power Engineers, Inc.
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Reference Curriculum for Water Treatment Operator (2nd Class) Examination Candidates

Major Topic: Water Treatment

Topic 1 External Boiler Water Treatment

Learning Outcome

Describe the general principle, methods, and equipment used in preparing raw feedwater for steam production.

Learning Objectives

1. Describe typical impurities and their effects on plant and boiler water pre-treatment systems, and their treatment process.
2. Describe the equipment requirements for pre-treatment of plant water systems.
3. Describe water filtration and the removal of suspended solids.
4. Describe the purpose, processes, and equipment used in water softening.
5. Describe the theory, process, and equipment used in deaeration.

Topic 2 Internal Boiler Water Treatment

Learning Outcome

Describe the general principles, methods, and equipment used for internal boiler water treatment.

Learning Objectives

1. Describe the types of problems, and associated treatments, related to internal boiler water contamination.
2. Describe internal boiler feedwater chemical feed systems.
3. Describe standard boiler water testing.

Topic 3 Condensate Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condensate.

Learning Objectives

1. Describe condensate treatment and the effects of non-treatment.
2. Describe the tests conducted on condensate.

Topic 4 Cooling Tower and Condenser Water Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condenser water, and their effects on the cooling tower.

Learning Objectives

1. Describe the effects of water on condensers and cooling tower materials.
2. Describe condenser and cooling tower water treatment.
3. Describe cooling tower and condenser water tests for common treatment methods.

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Topic 5 Recirculating System Water Treatment

Learning Outcome

Describe recirculating water systems, their effects, treatment, and tests.

Learning Objectives

1. Describe recirculating water system corrosion and deposition.
2. Describe the use of sacrificial anodes, and measurement techniques to determine corrosion.
3. Describe glycol system testing requirements.
4. Discuss the monitoring tools, procedures, and tests used in recirculating water systems.

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REFERENCE CURRICULUM

For

Combined Cycle Plant Operator (1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Combined Cycle Plant Operator (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Combined Cycle Plant Operator (1st Class) Examination Candidates

Topic 1 Gas Turbine Design and Auxiliaries

Learning Outcome

Explain the design and components of a large gas turbine and related auxiliaries.

Learning Objectives

1. Explain applications and selection criteria for the different types of gas turbine engines.
2. Describe the principles and design of open and closed cycle gas turbine systems.
3. Describe the principles and design of combined cycle and cogeneration systems using gas turbines.
4. Describe the principles and design of gas turbine regeneration, intercooling, and reheating.
5. Describe the principles and design of gas turbine shaft arrangements.
6. Describe the design and components of gas turbine compressors, combustors (combustion chambers) and turbines.
7. Describe the design and operation of gas turbine air intake and exhaust systems.
8. Describe the design and operation of a gas turbine lubricating oil system.
9. Describe the design and operation of a gas turbine fuel system.
10. Describe the design and operation of a gas turbine steam or water.

Topic 2 Gas Turbine Operation and Control

Learning Outcome

Discuss operating procedures, and control and monitoring components of a large gas turbine.

Learning Objectives

1. Describe the components and operation of gas turbine supervisory and control systems.
2. Describe the principles and design of gas turbine protection devices.
3. Describe the detailed hot and cold startup procedures for a gas turbine, including safety precautions.
4. Describe the detailed shutdown procedure for a gas turbine, including safety precautions.
5. Explain the routine maintenance and monitoring requirements for a gas turbine.
6. Describe the major maintenance and overhaul requirements for a gas turbine.
7. Explain the troubleshooting of gas turbine problems.

Topic 3 Introduction to Cogeneration

Learning Outcome

Explain cogeneration and describe common configurations, components and applications.

Learning Objectives

1. Define cogeneration.
2. Describe two ways in which cogeneration can be achieved.
3. Explain the flows through a typical cogeneration system.
4. Explain the advantages of cogeneration.
5. State some common users of cogeneration.
6. Describe typical cogeneration installations using internal combustion engines and gas turbines.
7. Describe control of a cogeneration system.

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Topic 4 Cogeneration Systems and Operation

Learning Outcome

Explain cogeneration and describe common configurations, components and applications.

Learning Objectives

1. Define cogeneration and explain its purpose, advantages, and applications.
2. Explain the components and operation of simple-cycle cogeneration systems.
3. Explain the components and operation of combined-cycle, gas/steam turbine cogeneration systems.
4. Explain the components and operation of a fully fired, combined-cycle cogeneration system.
5. Explain single-shaft and dual-shaft combined-cycle power plants.
6. Explain the general control strategies and components, for both power and steam production, including diverter and duct burner operation.
7. Describe the various designs of heat recovery steam generators (HRSGs) and explain their industrial applications.
8. Explain the environmental considerations and techniques in the operation of a cogeneration system.
9. Describe typical cogeneration systems that use internal combustion engines (gas or diesel) and heat recovery water heaters (HRWHs).
10. Explain a typical start-up procedure for a combined cycle cogeneration system.

Topic 5 Lubrication

Learning Outcome

Explain cogeneration and describe common configurations, components and applications.

Learning Objectives

1. Describe the methods of manufacture and the different classifications of lubricants.
2. Describe the significance and measurement of lubricating oil characteristics, including viscosity, relative density, API (American Petroleum Institute) gravity, pour point, and dielectric strength.
3. Explain the typical causes of lubricating oil deterioration.
4. Describe the types of lubrication additives.
5. Describe a typical power plant lubrication program, including a lubrication survey.
6. Explain the different types of lubricating/governing/seal oil systems.
7. Describe the components and operation of a typical lubricating oil purification system.
8. Describe the various applications of ball-and-roller bearings and their lubrication, including bearing seals.

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Topic 6 Rotating Equipment Maintenance

Learning Outcome

Explain specific maintenance procedures for, and typical maintenance problems of, rotating equipment.

Learning Objectives

1. Explain the typical maintenance problems of a large steam turbine.
2. Explain the procedures for inspection and overhaul of a large steam turbine.
3. Explain the typical maintenance problems of a gas turbine.
4. Explain the procedures for inspection and overhaul of a gas turbine.
5. Explain the typical maintenance problems of a large multi-stage pump.
6. Explain the procedures for inspection and overhaul of a large multi-stage pump.
7. Explain the typical maintenance problems of a large generator.
8. Explain the procedures for inspection and overhaul of a large generator.

Topic 7 Rotating Equipment Monitoring

Learning Outcome

Describe the parameters and methods of turbine monitoring and oil analysis.

Learning Objectives

1. Describe the purpose, importance and types of rotating equipment monitoring.
2. Explain the concept and significance of turbine thermal expansion, the general principles and placement of measuring devices and the procedures to control.
3. Explain the concept and significance of turbine differential expansion, the general principle and placement of measuring devices and the procedures to control.
4. Explain the concept and significance of turbine eccentricity, the general principle and placement of measuring devices and the procedures to control.
5. Explain the concept of vibration, including typical causes, effects, and locations of vibration in rotating equipment and how it is measured.
6. Explain the concept and significance of turbine critical speed.
7. Explain the concept and significance of oil whirl, oil whip, and steam whirl and the design and operational considerations to counter oil whirl.
8. Describe common oil problems and their effects on rotating equipment and a typical oil sampling and testing program.

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REFERENCE CURRICULUM

For

Combined Cycle Plant Operator (2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Combined Cycle Plant Operator (2nd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

Reference Curriculum for Combined Cycle Plant Operator (2nd Class) Examination Candidates

Topic 1 Gas Turbines

Learning Outcome

Describe the construction and operation of a simple gas turbine.

Learning Objectives

1. Describe the principle of operation, construction and industrial application of gas turbines.
2. List the operational characteristics of gas turbines.
3. Describe regeneration and combined steam-gas turbine operating cycles.
4. Describe the key elements of gas turbine start-up operation and auxiliaries.

Topic 2 Gas Turbine Principles and Designs

Learning Outcome

Explain common designs, major components, operating principles, and arrangements for industrial gas turbines.

Learning Objectives

1. Explain gas turbine advantages and disadvantages, background and industrial applications. Identify the types of gas turbines, their major components and describe the operating principles of a simple gas turbine.
2. Explain single and dual shaft arrangements for gas turbines. Describe open cycle and closed cycle operation.
3. Describe a typical open cycle gas turbine installation, including buildings or enclosures, intake and exhaust systems, auxiliary systems, and reducing gear.
4. Explain the efficiency and rating of gas turbines and describe the purpose and applications of gas turbine cycle improvements, including intercooling, regenerating, reheating and combined cycle.
5. Describe various aspects of compressor design and centrifugal and axial types of compressors.
6. Describe the types, operation, components and arrangements of combustors.
7. Describe turbine section design and operation especially with respect to blading and materials.
8. Explain the types and functions of the control systems and instrumentation needed for gas turbine operation.
9. Explain the typical operating parameters of a gas turbine; describe the effects of compressor inlet temperature, compressor discharge pressure, and turbine inlet temperature on gas turbine performance.

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Topic 3 Gas Turbine Auxiliaries and Operation

Learning Outcome

Describe the support auxiliaries for a gas turbine and explain common operational, control and maintenance procedures.

Learning Objectives

1. Describe the types of bearings used in a gas turbine and explain the components, operation, protective devices and routine maintenance of a typical lube oil system.
2. Describe and explain the operation and routine maintenance of a typical fuel gas supply system for a gas turbine.
3. Describe and explain the operation and routine maintenance of a typical fuel oil supply system for a gas turbine.
4. Explain the control of NO_X from a gas turbine and describe the purpose and operation of water/steam injection and dry low NO_X systems.
5. Explain the purpose, location and operation of the gas turbine starting motor and turning gear.
6. Describe the compressor intake and the turbine exhaust components.
7. Describe the preparation and complete start-up sequence for a gas turbine.
8. Describe the shutdown sequence and procedure for a gas turbine.
9. Explain the purpose and describe typical on-line and off-line waterwash procedures for gas turbine blades.

Topic 4 Lubrication Principles

Learning Outcome

Describe the importance of lubrication and the principles concerned with lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and application.
3. List the properties of lubricating oils, the additives used, and their selection criteria.

Topic 5 Types of Bearings and Lubrication

Learning Outcome

Describe bearing types, methods for care and maintenance of bearings, and bearing lubrication systems.

Learning Objectives

1. Define boundary and full fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of antifriction and thrust bearings.
4. Describe how to clean and replace roller and ball type bearings.
5. Explain the causes of bearing failure.

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REFERENCE CURRICULUM

For

Combined Cycle Plant Operator (3rd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Combined Cycle Plant Operator (3rd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Combined Cycle Plant Operator (3rd Class) Examination Candidates

Major Topic: Cogeneration for Non-Technical Plant Personnel

Topic 1 Introduction to Cogeneration

Learning Objectives

1. Define Cogeneration.
2. Describe two ways in which cogeneration can be achieved.
3. Explain the flows through a typical cogeneration system.
4. Explain the advantages of cogeneration.
5. State some common users of cogeneration.
6. Describe typical cogeneration installations using internal combustion engines and gas turbines.
7. Describe control of a cogeneration system.

Topic 2 Cogeneration Systems and Operation

Learning Objectives

1. Define cogeneration and explain its purpose, advantages, and applications.
2. Explain the components and operation of simple-cycle cogeneration systems.
3. Explain the components and operation of combined-cycle, gas/steam turbine cogeneration systems.
4. Explain the components and operation of a fully fired, combined-cycle cogeneration system.
5. Explain single-shaft and dual-shaft combined-cycle power plants.
6. Explain the control strategies and components, for both power and steam production, including diverter and duct burner operation.
7. Describe the various designs of heat recovery steam generators (HRSGs) and explain their industrial applications.
8. Explain the environmental considerations and techniques in the operation of a cogeneration system.
9. Describe typical cogeneration systems that use internal combustion engines (gas or diesel) and heat recovery water heaters (HRWHs).
10. Explain a typical start-up procedure for a combined cycle cogeneration system.

Topic 3 Heat Engines, Prime Movers, and the Simple Steam Engine

Learning Objectives

1. Define and distinguish between the terms “heat engine” and “prime mover”.
2. Describe the construction and operation of a simple steam engine.

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Topic 4 Steam Turbines

Learning Objectives

1. Describe the principle of operation and major components of a steam turbine.
2. Describe the lubrication and sealing of steam turbine shafts.
3. Describe the construction and operation of an overspeed trip.
4. Describe the general construction of a simple type of multistage steam turbine and an overall boiler-turbine cycle.
5. Describe how the rotational speed of a steam turbine is governed.
6. List the steps that are followed in a typical steam turbine start-up and shut-down.

Topic 5 Gas Turbines

Learning Objectives

1. Describe the principle of operation, construction and industrial application of gas turbines.
2. List the operational characteristics of gas turbines.
3. Describe regeneration and combined steam-gas turbine operating cycles.
4. Describe the key elements of gas turbine, start-up operation and auxiliaries.

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REFERENCE CURRICULUM

For Refrigeration Plant Operator

(1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Refrigeration Plant Operator (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Refrigeration Plant Operator (1st Class) Examination Candidates

Topic 1 Refrigeration Cycle Controls

Learning Outcome

Describe the purposes and operating principles of the operational and safety controls on a refrigeration system.

Learning Objectives

1. Describe the operation of temperature, pressure and humidity controls for refrigeration systems.
2. Describe the actuators used in refrigeration control systems.
3. List and describe the typical refrigeration system safety shutdown devices.

Topic 2 Refrigerants

Learning Outcome

Describe the different refrigerants and explain the classification and various properties of each refrigerant.

Learning Objectives

1. Describe how refrigerants are classified.
2. Describe the thermodynamic properties of refrigerants.
3. Describe the properties of refrigerants relating to miscibility, leakage tendency, odor, moisture reaction, toxicity and flammability.

Topic 3 Compression Refrigeration Systems

Learning Outcome

Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Distinguish between direct and indirect refrigeration systems.
3. Explain how compression refrigeration system temperatures and pressures are related.
4. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizers.

Topic 4 Heat Exchangers for Refrigeration Systems

Learning Outcome

Describe the different types of heat exchangers used in refrigeration systems.

Learning Objectives

1. Describe the designs and construction of refrigeration system evaporators.
2. Describe the designs and construction of refrigeration system condensers.
3. Discuss refrigeration condenser operation and maintenance.

Topic 5 Refrigeration Accessories

Learning Outcome

Describe the various accessories used in refrigeration systems.

Learning Objectives

1. List and describe the operation of the gauges, separators, strainers and indicators used as accessories in refrigeration systems.

Topic 6 Refrigeration Cycle Controls

Learning Outcome

Describe the purposes and operating principles of the operational and safety controls on a refrigeration system.

Learning Objectives

1. Describe the operation of temperature, pressure and humidity controls for refrigeration systems.
2. Describe the actuators used in refrigeration control systems.
3. List and describe the typical refrigeration system safety shutdown devices.

Topic 7 Thermodynamics of Refrigeration

Learning Outcome

Explain the terms and principles associated with the thermodynamics of refrigeration.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the cycle of operations in a vapor compression refrigeration system.
3. Explain how operating temperatures and pressures are selected and related for a vapor compression refrigeration system.
4. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.

Topic 8 Refrigeration Calculations

Learning Outcome

Perform refrigeration system calculations.

Learning Objectives

1. Describe the general refrigeration cycle and the application of the Carnot cycle.
2. Describe the relationship between enthalpy and pressure for a refrigeration cycle.
3. Define and calculate the refrigerating effect and the mass of refrigerant circulated.
4. Calculate the coefficient of performance for a refrigeration system.
5. Calculate the capacity of a refrigeration machine.
6. Calculate the theoretical power of a refrigeration compressor.
7. Calculate the theoretical bore and stroke of a refrigeration compressor.

Topic 9 Introduction to Plant Safety

Learning Outcome

Describe general plant safety as it relates to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may be in an energy plant, and the basic Personal Protective Equipment that may be required.
3. Define, give examples of, and describe common power house hazards.
4. Describe Industrial health and safety management system.
5. Describe Hazard Assessment and Control programs.

Topic 10 Plant Safety Programs

Learning Outcome

Describe common safety programs generally applied in plants.

Learning Objectives

1. Describe common occupational health and safety (OH&S) programs found in most plants.
2. Describe industrial safety programs in which Power Engineers may require additional training.
3. Discuss safe work permits.
4. Describe methods of equipment isolation and lock out.

Topic 11 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous materials.

Learning Objectives

1. Discuss the WHMIS system.
2. Discuss the essential components required in the WHMIS systems.
3. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
4. Discuss the safe handling of Hydrocarbons.

Topic 12 Plant Fire Safety

Learning Outcome

Explain fire safety in an industrial plant.

Learning Objectives

1. Discuss the theory, terminology, and the life safety issues associated with fires.
2. Explain the five classes of fires, and describe the types of fire extinguishing media and how they act on these fires.
3. Explain fire prevention.
4. Discuss fire prevention methods for the five types of fires.

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Topic 13 Fire Extinguishing Methods and Equipment

Learning Outcome

Describe typical fire extinguishing equipment and its operation in plant environments.

Learning Objectives

1. Describe the construction and operation of various types of portable fire extinguishers.
2. Discuss the inspection and maintenance requirements of portable fire extinguishers.
3. Describe the types, layout, and operation of standpipe and sprinkler systems.
4. Discuss the maintenance requirements of standpipe and sprinkler system components.
5. Describe the purpose, operation, and maintenance of fire pumps.

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REFERENCE CURRICULUM

For Refrigeration Plant Operator (2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Refrigeration Plant Operator (2nd Class) Examination.

Recommended Study Program:

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Reference Curriculum for Refrigeration Plant Operator (2nd Class) Examination Candidates

Topic 1 Legislation and Codes

Learning Outcome

Demonstrate a working knowledge of the NBBI and the ASME codes of concern to the Refrigeration Plant Operator.

Learning Objectives

1. Explain Codes and Standards.
2. Explain the purpose and scope of the National Board of Boiler Inspectors (NBBI).
3. Explain the scope of the ASME and state the purpose and general content of the following sections of the ASME Codes: Section I, II, IV, V, VI, VII, VIII, IX, B31.1, B31.3 & B31.5.

Topic 2 Introduction to Thermodynamics

Learning Outcome

Explain the principles of thermodynamics, including the laws of thermodynamics and the modes of heat transfer.

Learning Objectives

1. Define various terms associated with the study of thermodynamics.
2. Describe the laws and the different temperature scales used in thermodynamics.
3. Define heat and specific heat and perform sensible heat calculations.
4. Describe the expansion of solids and liquids.
5. Describe the three modes of heat transfer.

Topic 3 Thermodynamics of Refrigeration

Learning Outcome

Explain the terms and principles associated with the thermodynamics of refrigeration.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the cycle of operations in a vapor compression refrigeration system.
3. Explain how operating temperatures and pressures are selected and related for a vapor compression refrigeration system.
4. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.

Topic 4 Introduction to Basic Mechanics

Learning Outcome

Define basic terms used in the study of mechanics.

Learning Objectives

1. Define and perform simple calculations involving mass, force, acceleration, velocity and weight.
2. Define force, pressure, work, power and energy.

Topic 5 Welding Methods and Inspection

Learning Outcome

Describe oxyacetylene welding and electric arc welding and the applications of each.

Learning Objectives

1. Describe metal arc and brazing welding processes.
2. Discuss commonly used methods of weld inspection and testing.

Topic 6 Welding Terms, Forge and Fusion Welding Processes

Learning Outcome

Describe welding terms and methods of weld inspection.

Learning Objectives

1. Describe the common terms used in welding.
2. Describe forge and oxyacetylene fusion welding processes.

Topic 7 Types of Pumps

Learning Outcome

Describe the design and operating principles of various types of pumps used in buildings and industrial plants.

Learning Objectives

1. List the common applications of pumps in the power industry.
2. Define the terms associated with pump performance.
3. Describe the common types of pumps used in industry.

Topic 8 Pump Operation and Maintenance

Learning Outcome

Describe the major considerations and procedures for pump operation and maintenance.

Learning Objectives

1. Describe the construction and function of pump wearing rings.
2. Discuss pump shaft sealing and describe the process that is followed when replacing compression type packing.
3. Describe the standard types of mechanical seals.
4. Describe pump bearing and shaft alignment equipment and procedures.
5. Describe pump start-up and priming procedures.
6. Apply pump troubleshooting steps.

Topic 9 Introduction to Piping and Pipe Fittings

Learning Outcome

Discuss the basic types of piping, piping connections, supports and drainage devices used in industry.

Learning Objectives

1. State the applications for the most common materials and identify the sizes of commercial pipe.
2. Describe methods of connection for screwed, flanged and welded pipe and identify fittings and their markings.
3. Describe methods and devices used to allow for pipe expansion and support.
4. Explain the methods used to promote good drainage of steam piping, including the installation and maintenance of steam traps. Explain water hammer.
5. Explain the need for piping insulation and describe materials and methods of insulation.

Topic 10 Introduction to Valves

Learning Outcome

Discuss the design and uses of the valve designs most commonly used in industry and on boilers.

Learning Objectives

1. Describe standard valve designs.
2. Describe piping arrangements and the design and operation of steam system pressure-reducing valves.
3. Discuss valve details, including materials of construction and identification markings.
4. Describe typical valve maintenance requirements.

Topic 11 Lubrication Principles

Learning Outcome

Describe the importance of lubrication and the principles concerned with lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and application.
3. List the properties of lubricating oils, the additives used and their selection criteria.

Topic 12 Air Compression

Learning Outcome

Describe the operating principles of the different types of air compressors.

Learning Objectives

1. Describe the main classifications and types of air compressors.
2. Describe air compressor auxiliary equipment, including capacity control systems.
3. Discuss preventative maintenance for reciprocating air compressors.

Topic 13 Fires and Extinguishing Media

Learning Outcome

Describe the fire classifications and the types of extinguishing media suitable for each classification.

Learning Objectives

1. Discuss the theory, terminology and the life safety issues associated with fires.
2. Explain the four classes of fires and describe the types of fire extinguishing media and how they act on these fires.
3. Describe the design and operation of standpipe and sprinkler systems.

Topic 14 Portable Fire Extinguishers

Learning Outcome

Describe the types of portable fire extinguishers, and their application for each fire classification.

Learning Objectives

1. Describe the applicability, types, construction and operation of various types of portable fire extinguishers.
2. Discuss the inspection and maintenance of portable fire extinguishers.

Topic 15 Building Safety

Learning Outcome

Describe how the Power Engineer can prevent accidental situations to protect the occupants of their facility.

Learning Objectives

1. Explain the personal safety responsibilities and precautions that must be applied by the Power Engineer.
2. Describe the general safety precautions required in the maintenance and operation of buildings.
3. Identify common scenarios where the Power Engineer can prevent accidents and explain the importance of first aid and CPR training.

Topic 16 First Aid and CPR for Adult Casualties

Learning Outcome

Identify possible or potential medical difficulties in a person, and provide assistance until professional medical aid can be obtained.

Learning Objectives

1. Identify and discuss the steps in the assessment process.
2. Describe the ABC's of first aid.
3. Describe the first aid procedures associated with heart attack and stroke.
4. Describe standard emergency assistance procedures.

Note: This chapter is not intended to replace training in first aid or CPR provided by organizations such as the American Red Cross. It is strongly recommended that people take proper practical training in first aid or CPR given by those organizations.

Topic 17 Introduction to Electricity

Learning Outcome

Discuss the design and accessories of an electrical circuit; describe the design and troubleshooting of lighting systems and electric motors.

Learning Objectives

1. Explain electricity, electric circuits, and voltage drop.
2. Calculate current and power in an electric circuit, estimate the cost of electrical power for a facility, and describe how to read a power meter.
3. Describe circuit accessories, including switches, fuses, breakers, and receptacles. Explain the danger of electric shock.
4. Explain what constitutes a good lighting system. Explain maintenance of a lighting system and troubleshooting of incandescent and fluorescent systems
5. Describe simple electrical system problems, including short circuits, grounds, and bad connections. Describe static electricity.
6. Describe transformers and electric motors. Explain motor types, bearing care, and troubleshooting of motors.

Topic 18 Refrigerants

Learning Outcome

Describe the different refrigerants and explain the classification and various properties of each refrigerant.

Learning Objectives

1. Describe how refrigerants are classified.
2. Describe the thermodynamic properties of refrigerants.
3. Describe the properties of refrigerants relating to miscibility, leakage tendency, odor, moisture reaction, toxicity and flammability.

Topic 19 Environmental Impact of Chlorinated Hydrocarbons

Learning Outcome

Describe the nature and impact of chlorinated hydrocarbons on the environment.

Learning Objectives

1. Explain the importance of organic materials to our livelihood.
2. Describe the benefit and harm of pesticides and herbicides to our environment.
3. Describe the hazards of PCBs (polychlorinated biphenyls) and what actions have been taken to reduce them.
4. Describe dioxins, furans, and phenols, their sources, and their impact on the environment.
5. Explain the impact of CFCs (chlorofluorocarbons) on the ozone shield and describe actions undertaken to reduce damage.

Topic 20 Compression Refrigeration Systems

Learning Outcome

Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Distinguish between direct and indirect refrigeration systems.
3. Explain how compression refrigeration system temperatures and pressures are related.
4. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizer.

Topic 21 Absorption Refrigeration Systems

Learning Outcome

Describe the operating principle of the absorption refrigeration systems.

Learning Objectives

1. Describe the theory and operation of an ammonia absorption refrigeration system.
2. Describe the theory and operation of a lithium bromide absorption refrigeration system.
3. Compare the advantages and disadvantages of absorption and compression refrigeration systems.

Topic 22 Refrigeration Compressors

Learning Outcome

Describe the operating principles and the components of refrigeration compressors.

Learning Objectives

1. Describe the construction and operation of a reciprocating refrigeration compressor.
2. Describe the construction and operation of a rotary refrigeration compressor.
3. Describe the construction and operation of a centrifugal refrigeration compressor.
4. Describe the construction and operation of seals for refrigeration compressors.
5. Calculate the capacity, volumetric efficiency and compression ratio of a refrigeration compressor.

Topic 23 Heat Exchangers for Refrigeration Systems

Learning Outcome

Describe the different types of heat exchangers used in refrigeration systems.

Learning Objectives

1. Describe the designs and construction of refrigeration system evaporators.
2. Describe the designs and construction of refrigeration system condensers.
3. Discuss refrigeration condenser operation and maintenance.

Topic 24 Cooling Towers

Learning Outcome

Describe the operation and maintenance of cooling towers.

Learning Objectives

1. List the factors that determine rate of cooling in a cooling tower and the basic components of a cooling tower.
2. Describe the construction and operation of a natural draft cooling tower.
3. Describe the construction and operation of a mechanical draft cooling tower.
4. Discuss cold climate operation for cooling towers.
5. Describe the water treatment necessary for cooling water.
6. Apply a cooling tower troubleshooting guide.

Topic 25 Refrigeration Metering Devices

Learning Outcome

Describe the operating principles of refrigeration metering devices and capacity controls.

Learning Objectives

1. Describe the construction and operation of compression refrigeration cycle expansion valves.
2. Describe the different methods used to control the capacity of evaporators.
3. Describe the different methods used to control the capacity of refrigeration compressors.

Topic 26 Refrigeration Accessories

Learning Outcome

Describe the various accessories used in refrigeration systems.

Learning Objectives

1. List and describe the operation of the gages, separators, strainers and indicators used as accessories in refrigeration systems.

Topic 27 Refrigeration Cycle Controls

Learning Outcome

Describe the purposes and operating principles of the operational and safety controls on a refrigeration system.

Learning Objectives

1. Describe the operation of temperature, pressure and humidity controls for refrigeration systems.
2. Describe the actuators used in refrigeration control systems.
3. List and describe the typical refrigeration system safety shutdown devices.

Topic 28 Compression Refrigeration System Pre-Startup Procedures

Learning Outcome

Describe the various pre-startup procedures used on compression refrigeration systems.

Learning Objectives

1. Describe how to perform refrigeration system leak tests.
2. Describe how a refrigeration system is dried and charged prior to start-up.
3. Describe how a refrigeration system is purged of noncondensable gases prior to start-up.
4. List the steps for adding oil to a refrigeration compressor when it is in service.

Topic 29 Compression Refrigeration System Operations

Learning Outcome

Describe the various operation and maintenance procedures used on compression refrigeration systems.

Learning Objectives

1. Describe the steps in the start-up and shutdown of a compression refrigeration system.
2. List the safety shutdown devices specific to centrifugal compressor water chillers.
3. Describe the routine operation and associated log sheets for compression refrigeration systems.
4. List and describe the standard preventive maintenance procedures for compression refrigeration systems.
5. Apply a compression refrigeration system troubleshooting guide.

Topic 30 Absorption Refrigeration System Operation and Maintenance

Learning Outcome

Describe the various operation and maintenance procedures used on absorption refrigeration systems.

Learning Objectives

1. Explain crystallization, equilibrium concentration and dilution.
2. Describe how to purge the system.
3. Explain the operation and purpose of the controls found on the system.
4. Describe how to start and stop the system.

Topic 31 Psychrometric Properties of Air

Learning Outcome

Describe the psychrometric properties of air.

Learning Objectives

1. Explain the composition of air and define the terms humidity, relative humidity and dewpoint.
2. Define the terms: dry bulb temperature, wet bulb temperature, wet bulb depression and psychrometer, and state the relationship between these terms and relative humidity.
3. Define the specific volume and enthalpy of air.
4. Identify and interpret the psychrometric properties of air on a psychrometric chart.

Topic 32 Application of the Psychrometric Chart

Learning Outcome

Solve problems using a psychrometric chart.

Learning Objectives

1. Interpret the psychrometric chart to find values of specific properties.
2. Apply the psychrometric chart to the heating and cooling of air, and calculate heat added or removed.
3. Apply the psychrometric chart to the humidification and dehumidification of air and calculate moisture added or removed.
4. Apply the psychrometric chart to combined heating/cooling and humidification problems.
5. Discuss what is meant by "comfort conditions" with respect to the psychrometric chart.

Topic 33 Fans for Air Distribution Systems

Learning Outcome

Describe the air flow behavior and movement of air through distribution systems.

Learning Objectives

1. Discuss the theory of air flow and pressure conversions.
2. Describe the major types of air handling fans, their construction and operation.
3. Interpret fan performance curves.
4. Describe fan motors, drives and belt guards.
5. Describe fan volume controls.

Topic 34 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems found in buildings, as well as describe the various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the various contaminants found in air.
3. Describe the types of air cleaning devices used in industrial/commercial buildings.

Topic 35 Air Conditioning Duct Systems

Learning Outcome

Describe the designs and components of duct systems used in air conditioning.

Learning Objectives

1. Explain how air duct systems are classified.
2. Describe air duct materials, system layout, fabrication and installation.
3. Describe air duct leakage.
4. List and describe the types of liners, dampers, and louvers used in air duct systems.
5. Discuss terminal air distribution devices and the principles of diffusion, induction, entrainment and aspiration.

Topic 36 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and warm air types of humidifiers.
3. Describe industrial and commercial types of humidifiers.

Topic 37 Coil Types

Learning Outcome

Describe the various types of coils used in air conditioning systems.

Learning Objectives

1. Describe the general construction of finned type heat exchanger coils.
2. Describe the detailed construction and operational principles of water coils.
3. Describe the detailed construction and operational principles of steam coils.

Topic 38 Coil Operation

Learning Outcome

Describe the operation of the various types of coils used in air conditioning systems.

Learning Objectives

1. Explain the operational and equipment sizing issues and freezing problems associated with steam coils.
2. Explain the operational and equipment sizing issues and freezing problems associated with water coils.
3. Explain the operational and equipment sizing issues associated with glycol coils.
4. Describe the installation recommendations for coils, piping, steam traps, control valves, air vents and vacuum relief devices.

Topic 39 Air Conditioning Systems I

Learning Outcome

Describe the operation of various air conditioning systems.

Learning Objectives

1. List the functions and categories of air conditioning systems.
2. Describe the operation of air handling units.
3. Describe the general layout and operation of unitary air conditioning systems.
4. Describe the general layout and operation of central air conditioning systems.

Topic 40 Air Conditioning Systems II

Learning Outcome

Describe the design and operation of combined air conditioning systems and explain the factors to consider when selecting an air conditioning system.

Learning Objectives

1. Describe the general layout and operation of combined air conditioning systems.
2. Discuss the alternative arrangements of equipment for air conditioning systems.
3. Discuss the selection criteria for air conditioning systems.

Topic 41 Air Conditioning Heat Recovery Systems

Learning Outcome

Explain the purpose, design and operation of heat recovery in air conditioning systems.

Learning Objectives

1. Describe the general principles of air conditioning heat recovery and the operation of “run-around” systems.
2. Describe the thermal wheel air conditioning heat recovery system.
3. Describe the heat pipe air conditioning heat recovery system.
4. Describe the heat pump system.

Topic 42 Air Conditioning System Controls

Learning Outcome

Describe the control systems used in air conditioning.

Learning Objectives

1. Describe various ventilation control strategies for air conditioning systems.
2. Describe preheat coil control strategies for air conditioning systems.
3. Describe heating coil control strategies for air conditioning systems.
4. Describe humidification control strategies for air conditioning systems.
5. Describe dehumidification and cooling control strategies for air conditioning systems.
6. Describe volume control with static pressure regulation for air conditioning systems.
7. Describe complete air conditioning control systems.

REFERENCE CURRICULUM

For Refrigeration Plant Operator (3rd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Refrigeration Plant Operator (3rd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Refrigeration Plant Operator (3rd Class) Examination Candidates

Major Topic: Heating Systems and Human Comfort

Topic 1 Heat Gains and Losses

Learning Outcome

Describe the various ways a building gains and loses heat.

Learning Objectives

1. Define heat transmission terminology and identify conversions or related units.
2. Describe the heat gains that occur in a building due to conduction, infiltration, ventilation, and radiation.
3. Describe the heat gains that occur in a building due to people, lighting, electric motors, appliances, and cooking.
4. Describe the heat losses that occur in a building due to conduction, convection, radiation, infiltration, and ventilation.

Topic 2 Steam Heating Equipment

Learning Outcome

Describe the operating principles of steam heating equipment and components.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. List and describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.

Topic 3 Steam Heating Systems

Learning Outcome

Describe the operating principles and maintenance procedures of steam heating systems and the components of these systems.

Learning Objectives

1. Describe standard types of piping and equipment layout for steam heating systems.
2. Describe the general operation and maintenance of steam heating systems.
3. Apply a steam heating system troubleshooting guide.

Topic 4 Hot Water Heating Systems

Learning Outcome

Describe the various designs of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe radiant panel and snow melting hot water systems.

Topic 5 Hot Water Heating System Equipment and Operation

Learning Outcome

Describe accessories, operation and troubleshooting of a hot water heating system.

Learning Objectives

1. Describe the purpose and function of standard hot water heating system components such as diverter fittings, air vents, air separators, flow control valves, balancing valves and fittings, riser stop valves, pressure reducing valves, circulating pumps, expansion tanks, and steam to hot water converters.
2. Explain how the location of the hot water circulating pump and the expansion tank are determined.
3. Describe the cleaning, filling, starting, routine operation, and troubleshooting of hot water heating systems.
4. Apply a hot water heating system troubleshooting guide.

Topic 6 Warm Air Heating System Equipment

Learning Outcome

Describe the operating principles of warm air heating sources.

Learning Objectives

1. Compare the advantages and disadvantages of forced air and gravity warm air systems.
2. List and describe the common sources of warm air heat.
3. List and describe the operational characteristics of directly fired space heaters.

Topic 7 Warm Air Furnace Components and Maintenance

Learning Outcome

Describe the components and maintenance requirements of typical warm air heating and ventilating systems.

Learning Objectives

1. Describe the operation of furnace components.
2. Describe and discuss the relative merits of three types of air distribution and duct systems.
3. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
4. Apply a troubleshooting guide for forced warm air systems and components.

Topic 8 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems found in buildings, as well as describe the various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the types of contaminants found in air.
3. Describe the types of air cleaning devices used in buildings.

Topic 9 Infrared and Electric Heating

Learning Outcome

Describe infrared and electric heating systems.

Learning Objectives

1. Discuss the concept and application of infrared heating.
2. Describe the construction and operation of gas-fired and electric infrared heaters.
3. List the advantages of electric heating systems compared to other types of heating systems.
4. Describe the different methods of electric heating.

Topic 10 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and commercial types of humidifiers.
3. Describe industrial types of humidifiers.

Topic 11 Electric Controls for Heating Systems

Learning Outcome

Describe and explain the function of the various components of an electric control circuit.

Learning Objectives

1. Discuss the various terms associated with electric control systems.
2. Describe the basic construction and operation of electric thermostats, humidity controllers, and pressure controllers.
3. Describe the function and operation of the controlled devices in electric control systems.
4. Explain the operating sequence of a basic electric control circuit.

Major Topic: Refrigeration Topic 12

Refrigeration Theory Learning Outcome

Explain the theory and terms associated with refrigeration.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the practical cycle of operations in a vapor compression refrigeration system.
3. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.

Topic 13 Refrigerants

Learning Outcome

Describe the different refrigerants used and explain the various properties of these refrigerants.

Learning Objectives

1. Describe the identification and classification of refrigerants.
2. Describe the characteristics and thermodynamic properties of refrigerants.
3. Describe the physical properties of refrigerants.

Topic 14 Compression Refrigeration Systems

Learning Outcome

Describe the operating principle of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Distinguish between direct and indirect refrigeration systems.
3. Explain how compression refrigeration system temperatures and pressures are related.
4. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizer.

Topic 15 Refrigeration Compressors

Learning Outcome

Describe the operating principles and the components of refrigeration compressors and perform simple compressor calculations.

Learning Objectives

1. Describe the construction and operation of a reciprocating refrigeration compressor.
2. Describe the construction and operation of a rotary refrigeration compressor.
3. Describe the construction and operation of a centrifugal refrigeration compressor.
4. Describe the construction and operation of seals for refrigeration compressors.
5. Calculate the capacity, efficiency, and ratio of a refrigeration compressor.

Topic 16 Heat Exchangers for Refrigeration Systems

Learning Outcome

Describe the different types of heat exchangers used in refrigeration systems.

Learning Objectives

1. Describe the designs and construction of refrigeration system evaporators.
2. Describe the designs and construction of refrigeration system condensers.
3. Discuss refrigeration condenser operation and maintenance.

Topic 17 Refrigeration Accessories

Learning Outcome

Describe the various accessories used in refrigeration systems.

Learning Objectives

1. List and describe the operation of the gauges, separators, strainers, and indicators that are used as accessories in refrigeration systems.

Topic 18 Cooling Towers

Learning Outcome

Describe the operation and maintenance of cooling towers.

Learning Objectives

1. List the factors that determine rate of cooling in a cooling tower and the basic components of a cooling tower.
2. Describe the construction and operation of a natural draft cooling tower.
3. Describe the construction and operation of a mechanical draft cooling tower.
4. Discuss cold climate operation for cooling towers.
5. Apply a cooling tower troubleshooting guide.

Topic 19 Air Conditioning Systems

Learning Outcome

Describe the operation of various air conditioning systems.

Learning Objectives

1. List the functional components and categories of air conditioning systems.
2. Describe the operation of air handling units.
3. Describe the general layout and operation of unitary air conditioning systems.
4. Describe the general layout and operation of central air conditioning systems.

Major Topic: Refrigeration and AC System Controls

Topic 20 Refrigeration Metering Devices and Capacity Controls

Learning Outcome

Describe the operating principles of refrigeration metering devices and capacity controls.

Learning Objectives

1. Describe the construction and operation of compression refrigeration cycle expansion valves.
2. Describe the types of evaporator and compressor capacity controls.

Topic 21 Refrigeration Cycle Controls

Learning Outcome

Describe the purposes and operating principles of the operational and safety controls on a refrigeration system.

Learning Objectives

1. Describe the operation of the various operating controls for refrigeration systems.
2. Describe the actuators used in refrigeration control systems.
3. Describe the typical refrigeration system safety shutdown devices.

Topic 22 Compression Refrigeration System Pre-Startup Procedures

Learning Outcome

Describe the various pre-startup procedures used on compression refrigeration systems.

Learning Objectives

1. Describe how to perform refrigeration system leak tests.
2. Describe how a refrigeration system is dried and charged prior to startup.
3. Describe how a refrigeration system is purged of noncondensable gases prior to startup.
4. List the steps for adding oil to a refrigeration compressor when it is in service.

Topic 23 Compression Refrigeration System Operations

Learning Outcome

Describe the various operation and maintenance procedures used on compression refrigeration systems.

Learning Objectives

1. Describe the steps in the startup and shutdown of a compression refrigeration system.
2. List the safety shutdown devices that are specific to centrifugal compressors.
3. Describe the routine operation and associated log sheets for compression refrigeration systems.
4. List and describe the standard preventive maintenance procedures for compression refrigeration systems.
5. Apply a compression refrigeration system troubleshooting guide.

Topic 24 Air Compression

Learning Outcome

Describe the operating principles of the different types of air compressors.

Learning Objectives

1. Describe the main classifications and types of air compressors.
2. Describe air compressor auxiliary equipment, including capacity control systems.
3. Discuss preventive maintenance for reciprocating air compressors.

Topic 25 Introduction to Electricity

Learning Outcome

Discuss the design and accessories of an electrical circuit; describe the design and troubleshooting of lighting systems and electric motors.

Learning Objectives

1. Explain electricity, electric circuits, and voltage drop.
2. Calculate current and power in an electric circuit, estimate the cost of electrical power for a facility, and describe how to read a power meter.
3. Describe circuit accessories, including switches, fuses, breakers, and receptacles. Explain the danger of electric shock.
4. Explain what constitutes a good lighting system. Explain maintenance of a lighting system and troubleshooting of incandescent and fluorescent systems.
5. Describe simple electrical system problems, including short circuits, grounds, and bad connections. Describe static electricity.
6. Describe transformers and electric motors. Explain motor types, bearing care, and troubleshooting of motors.
7. Explain the CSA approval and markings for electrical appliances.

Major Topic: Introduction to Plant and Fire Safety

Topic 26 Introduction to Plant Safety

Learning Outcome

Describe general plant safety as it relates to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may be in an energy plant, and the basic Personal Protective Equipment that may be required.
3. Define, give examples of, and describe common power house hazards.
4. Describe Industrial health and safety management system.
5. Describe Hazard Assessment and Control programs.

Topic 27 Plant Safety Programs

Learning Outcome

Describe common safety programs generally applied in plants.

Learning Objectives

1. Describe common occupational health and safety (OH&S) programs found in most plants.
2. Describe industrial safety programs in which Power Engineers may require additional training.
3. Discuss safe work permits.
4. Describe methods of equipment isolation and lock out.

Topic 28 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous materials.

Learning Objectives

1. Discuss the WHMIS system.
2. Discuss the essential components required in the WHMIS systems.
3. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
4. Discuss the safe handling of Hydrocarbons.

Topic 29 Plant Fire Safety

Learning Outcome

Explain fire safety in an industrial plant.

Learning Objectives

1. Discuss the theory, terminology, and the life safety issues associated with fires.
2. Explain the five classes of fires, and describe the types of fire extinguishing media and how they act on these fires.
3. Explain fire prevention.
4. Discuss fire prevention methods for the five types of fires.

Topic 30 Fire Extinguishing Methods and Equipment

Learning Outcome

Describe typical fire extinguishing equipment and its operation in plant environments.

Learning Objectives

1. Describe the construction and operation of various types of portable fire extinguishers.
2. Discuss the inspection and maintenance requirements of portable fire extinguishers.
3. Describe the types, layout, and operation of standpipe and sprinkler systems.
4. Discuss the maintenance requirements of standpipe and sprinkler system components.
5. Describe the purpose, operation, and maintenance of fire pumps.

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REFERENCE CURRICULUM

For

Refrigeration Plant Operator Recreation/Ammonia

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Refrigeration Plant Operator Recreation Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Refrigeration Plant Operator Recreation Examination Candidates

Major Topic: Acts, Regulations, and Codes Topic 1

Boiler and Pressure Vessels Act Learning Outcome

Discuss the purpose of the jurisdictional acts/regulations pertaining to the operation of boilers and pressure equipment.

Learning Objectives

1. Explain the purpose and scope of your jurisdictional act and regulations.
2. Explain the purpose and intent of the regulations governing the operation of boilers and pressure equipment.
3. Discuss the regulations relating to Power Engineering qualifications.

Topic 2 Introduction to CSA and ASME Codes for Boilers

Learning Outcome

Demonstrate a working knowledge of the CSA codes, and the ASME codes of concern to the 5th Class Power Engineer.

Learning Objectives

1. Explain the content and use of the CSA-B52: Mechanical Refrigeration Code.

Topic 3 Introduction to Plant Safety

Learning Outcome

Describe general plant safety as it relates to Power Engineers.

Learning Objectives

1. Describe the basic hazards that may be in an energy plant, and the basic Personal Protective Equipment that may be required.

Topic 4 Refrigeration Plant Safety

Learning Outcome

Outline the potential hazards inherent to refrigeration plants, the CSA requirements intended to mitigate hazards, and typical responses taken in the case of a significant leak.

Learning Objectives

1. Describe the Canadian Environmental Emergency Regulations and how they relate to refrigeration plants.

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Major Topic: Basic Communication Topic 1

Technical Communications Learning Outcome

Utilize some of the best practices on various types of communication techniques. Identify the key elements of an SOP with document control and update methods. Identify the key components of a Maintenance Management System.

Learning Objectives

1. Discuss effective communication in written, verbal, and radio techniques.
2. Discuss the importance of standard operating procedures (SOPs), how they are written, and how to have them updated.
3. Explain a maintenance management system and the essential information and requirements in this system.

Topic 2 Plant Communications

Learning Outcome

Describe the types and proper usage of plant communication systems.

Learning Objectives

1. Describe the legal documentation requirements for Power Engineers, including log books and log sheets.
2. Discuss the purpose, revision, and control of Standard Operating Procedures.

Major Topic: Elementary Science

Topic 1 SI Units

Learning Outcome

Perform simple calculations involving SI units.

Learning Objectives

1. List SI units for length, mass, temperature, speed, and their symbols.
2. Identify and list symbols for unit prefixes.
3. Perform conversions between basic SI, imperial, and U.S. customary system (USCS) units.

Topic 2 Basic Arithmetic Operations

Learning Outcome

Perform basic arithmetic operations.

Learning Objectives

1. Perform basic arithmetic operations (addition, subtraction, multiplication, and division) on whole numbers without the use of a calculator.
2. Perform basic arithmetic operations on decimal numbers.
3. Perform basic arithmetic operations on fractions.
4. Reduce fractions to lowest terms.
5. Convert fractions to decimals and decimals to fractions.
6. Solve percentage problems.
7. Given a ratio, determine the correct quantity of a substance.

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Topic 3 Transposition

Learning Outcome

Transpose equations in order to find values for different variables in a formula.

Learning Objectives

1. Transpose commonly used equations involving up to two variables and all basic mathematical operations.
2. Insert values into common equations and solve them.

Topic 4 Areas and Volumes of Solids

Learning Outcome

Calculate the volumes of rectangular objects, cylinders, and spheres and the surface areas of cylinders and spheres.

Learning Objectives

1. State the SI units for area and volume.
2. Calculate the surface area and volume of a rectangular tank.
3. Calculate the surface area and volume of a cylinder.

Topic 5 Application of Basic Mechanics

Learning Outcome

Define basic terms used in the study of mechanics.

Learning Objectives

1. Define the terms force, velocity, mass, pressure, energy, work and power.
2. Explain the application of levers, pulleys, and inclined planes.
3. Identify where simple machines are used in the plant.
4. Define mechanical advantage.

Topic 6 Introduction to Thermodynamics

Learning Outcome

Explain the principles of thermodynamics and the modes of heat transfer.

Learning Objectives

1. Describe the three states of matter.
2. Describe the expansion of solids and liquids.
3. Explain the different temperature scales used in thermodynamics (Celsius and Fahrenheit).
4. Explain sensible and latent heat, and the thermodynamic transformation of ice to steam.
5. Describe the three modes of heat transfer.
6. Explain the energy in the expansion of water to steam

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Topic 7 Introduction to Matter and Chemistry

Learning Outcome

Identify basic types of matter, their properties, and the associated chemical principles.

Learning Objectives

1. Differentiate among the physical states of matter.
2. Differentiate between chemical and physical changes in matter.
3. Classify matter as either a type of mixture or a pure substance.
4. Describe the purpose and uses of the periodic table using the parts of an atom.
5. Describe the three main ways atoms bond together: covalent, ionic, and metallic bonding.
6. Discuss chemical equations and their purpose.
7. Perform simple stoichiometric calculations.
8. Demonstrate how unstable compounds are combined to make stable compounds.

Topic 8 Introduction to Electricity

Learning Outcome

Discuss the design and accessories of an electrical circuit; describe the design and troubleshooting of lighting systems and electric motors.

Learning Objectives

1. Explain electricity, electric circuits, and voltage drop.
2. Calculate current and power in an electric circuit, estimate the cost of electrical power for a facility, and describe how to read a power meter.
3. Describe circuit accessories, including switches, fuses, breakers, and receptacles. Explain the danger of electric shock.
4. Explain what constitutes a good lighting system. Explain maintenance of a lighting system and troubleshooting of incandescent and fluorescent systems.
5. Describe simple electrical system problems, including short circuits, grounds, and bad connections. Describe static electricity.
6. Describe transformers and electric motors. Explain motor types, bearing care, and troubleshooting of motors.
7. Explain the CSA approval and markings for electrical appliances.

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Major Topic: Safety

Topic 1 Fire Safety and Site Hazards

Learning Outcome

Discuss acceptable methods of extinguishing various classifications of fire. Briefly describe site hazards awareness.

Learning Objectives

1. Explain the overall need for and the intent of fi re protection standards, laws, and regulations.
2. Explain the different fire classifications and describe the extinguishing methods for each.
3. Explain the application and operation of standpipes, hoses, and sprinklers in buildings.
4. Explain the various types of fire and smoke detectors.
5. Describe the operation, placement, and maintenance of the common types of portable extinguishers.
6. Discuss the need for and use of a fire pump.
7. Briefly describe safety aspects of common site hazards.
8. Explain how to perform a pre-job hazard assessment.

Topic 2 Building Safety

Learning Outcome

Describe how the building operator can prevent accidental situations to protect the occupants of their facility.

Learning Objectives

1. Explain the personal safety responsibilities and precautions that must be applied by the building operator.
2. Describe the general safety precautions required in the maintenance and operation of buildings.
3. Identify common scenarios where the building operator can prevent accidents, and explain the importance of first aid and CPR training.

Major Topic: Environmental

Topic 1 Gas Detection and Monitoring

Learning Outcome

Describe the operating principles and maintenance of refrigeration systems.

Learning Objectives

1. Describe refrigeration system leak test procedures.

Topic 2 Environmental Impact of Refrigerants

Learning Outcome

Explain the basic concept of refrigeration and refrigerants.

Learning Objectives

1. Describe how refrigerants are classified.

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Major Topic: Principles of Refrigeration

Topic 1 Applied Thermodynamics

Learning Outcome

Explain the basic concept of refrigeration and refrigerants.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the cycle of operations in a vapor compression refrigeration system.
3. Explain how compression refrigeration system temperatures and pressures are related.

Topic 2 Refrigerants

Learning Outcome

Describe the different refrigerants used and explain the various properties of these refrigerants.

Learning Objectives

1. Describe the identification and classification of refrigerants.
2. Describe the characteristics and thermodynamic properties of refrigerants.
3. Describe the physical properties of refrigerants.

Topic 3 Basic Refrigeration Cycles

Learning Outcome

Describe the practical cycle of operations in a vapor compression refrigeration system.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizer.
3. Distinguish between direct and indirect refrigeration systems.

Major Topic: Refrigeration Equipment and Components

Topic 1 Refrigeration Compressors

Learning Outcome

Describe the operating principles and the components of refrigeration compressors and perform simple compressor calculations.

Learning Objectives

1. Describe the construction and operation of a reciprocating refrigeration compressor.
2. Describe the construction and operation of a rotary refrigeration compressor.
3. Describe the construction and operation of a centrifugal refrigeration compressor.
4. Describe the construction and operation of seals for refrigeration compressors.
5. Calculate the capacity, efficiency, and ratio of a refrigeration compressor.

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Topic 2 Oil Separators

Learning Outcome

Describe the operating principles and maintenance of refrigeration systems.

Learning Objectives

1. List and describe the operation of the gauges, separators, strainers, and indicators that are used as accessories in refrigeration systems.
2. Discuss refrigeration auxiliaries.

Topic 3 Compressor Lubrication

Learning Outcome

Describe the operating principles and maintenance of refrigeration systems.

Learning Objectives

1. List the steps for adding oil to an in-service refrigeration compressor.

Topic 4 Condensers

Learning Outcome

Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the designs and construction of refrigeration system condensers.
2: Describe the special designs of refrigeration system evaporators and condensers.

Topic 5 Cooling Towers

Learning Outcome

Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the special designs of refrigeration system evaporators and condensers.

Topic 6 Evaporators

Learning Outcome

Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the designs and construction of refrigeration system evaporators.

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Topic 7 Metering Devices

Learning Outcome

Describe the purposes and operating principles of refrigeration system operational and safety controls.

Learning Objectives

1. Describe the construction and operation of compression refrigeration cycle expansion valves.
2. Describe the construction and operation of refrigerant metering devices.

Topic 8 Cooling Coils

Learning Outcome

Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.

Major Topic: Refrigeration Controls and Instrumentation

Topic 1 Fundamentals Measuring Devices

Learning Outcome

Describe the purposes and operating principles of refrigeration system operational and safety controls.

Learning Objectives

1. Describe the operation of the various operating controls for refrigeration systems.
2. Describe the actuators used in refrigeration control systems.
3. Describe refrigeration system controls.

Topic 2 Basic Operational Controls

Learning Outcome

Describe the purposes and operating principles of refrigeration system operational and safety controls.

Learning Objectives

1. Describe the actuators used in refrigeration control systems.
2. Describe refrigeration system controls.
3. Describe the different methods used to control evaporator capacity.
4. Describe the different methods used to control the capacity of refrigeration compressors.

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Topic 3 Basic Safety Controls

Learning Outcome

Describe the purposes and operating principles of refrigeration system operational and safety controls.

Learning Objectives

1. Describe the typical refrigeration system safety shutdown devices.
2. List the safety shutdown devices specific to centrifugal compressor water chillers.
3. Describe typical refrigeration system safety shutdown devices.

Major Topic: Refrigeration System Operation and Maintenance

Topic 1 Checks

Learning Outcome

Describe the various operation and maintenance procedures used on compression refrigeration systems.

Learning Objectives

1. Describe the routine operation and associated log sheets for compression refrigeration systems.
2. List and describe the standard preventive maintenance procedures for compression refrigeration systems.

Topic 2 Safety Devices and Functions

Learning Outcome

Describe the various operation and maintenance procedures used on compression refrigeration systems.

Learning Objectives

1. List the safety shutdown devices that are specific to centrifugal compressors.

Topic 3 Troubleshooting

Learning Outcome

Describe the various operation and maintenance procedures used on compression refrigeration systems.

Learning Objectives

1. Apply a compression refrigeration system troubleshooting guide.

Topic 4 Procedures

Learning Outcome

Describe the various operation and maintenance procedures used on compression refrigeration systems.

Learning Objectives

1. Describe the steps in the startup and shutdown of a compression refrigeration system.

REFERENCE CURRICULUM

For

Facility Operator Certification Series

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Introduction

This Curriculum is intended to assist candidates studying for the NIULPE Facility Operator Certification Series Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Facility Operator Certification Series Examination Candidates

Major Topic: Preparatory Math Topics for Power Engineering

Topic 1 Numerical Unit Systems

Learning Outcome

Perform simple calculations involving SI units.

Learning Objectives

1. Describe basic SI and USCS units, matching associated symbols for unit prefixes.
2. Perform conversions both within and between SI and USCS units.

Topic 2 Basic Arithmetic Operations

Learning Outcome

Perform basic arithmetic operations without the use of a calculator.

Learning Objectives

1. Add and subtract integers.
2. Multiply and divide whole and decimal numbers.
3. Perform arithmetic operations involving combinations of addition, subtraction, multiplication, division, and powers in the proper order of operation.

Topic 3 Fractions, Decimals, and Percentages

Learning Outcome

Perform basic arithmetic operations involving fractions, decimals, and percentages.

Learning Objectives

1. Identify proper and improper fractions and mixed numbers.
2. Add, subtract, and multiply fractions, and reduce them to lowest terms.
3. Convert fractions to decimal numbers and decimal numbers to fractions.
4. Analyze percentage problems.

Topic 4 Ratio and Proportion

Learning Outcome

Describe the concepts of ratio and proportion.

Learning Objectives

1. Convert ratios of one quantity to another quantity.
2. Solve word problems involving ratios and proportions.

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Topic 5 Equations and Transposition

Learning Outcome

Transpose equations in order to find values for different variables in a formula.

Learning Objectives

1. Solve equations and word problems.

Topic 6 Length, Lines, and Simple Plane Figures

Learning Outcome

Describe measurement of length, types of lines and angles, and calculate perimeters and areas of simple plane figures.

Learning Objectives

1. Describe linear measurement systems and convert measurement units from one system to another.
2. Define parallel and perpendicular lines and types of angles.
3. Describe types of simple plane figures, including triangles and quadrilaterals.
4. Describe the components of a circle, circumference, area, and diameter.

Topic 7 Length, Lines, and Simple Plane Figures

Learning Outcome

Calculate the volumes of rectangular objects, cylinders, and spheres and the surface areas of cylinders and spheres.

Learning Objectives

1. Convert between commonly used volume units.
2. Calculate the volume of a rectangular prism.
3. Calculate the surface area and volume of a cylinder.
4. Calculate the surface area and volume of a sphere.

Major Topic: Elementary Physical, Chemical, and Thermodynamic Principles

Topic 1 Introduction to Matter and Chemistry

Learning Outcome

Identify basic types of matter, their properties, and the associated chemical principles.

Learning Objectives

1. Differentiate among the physical states of matter.
2. Differentiate between chemical and physical changes in matter.
3. Classify matter as either a type of mixture or a pure substance.
4. Describe the purpose and uses of the periodic table using the parts of an atom.
5. Describe the three main ways atoms bond together: covalent, ionic, and metallic bonding.
6. Discuss chemical equations and their purpose.
7. Perform simple stoichiometric calculations.
8. Demonstrate how unstable compounds are combined to make stable compounds.

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Topic 2 Introduction to Thermodynamics

Learning Outcome

Explain the principles and laws of thermodynamics.

Learning Objectives

1. Define the first two laws of thermodynamics.
2. Define heat and specific heat, and perform sensible heat calculations.
3. Describe the expansion of solids and liquids.

Topic 3 Introduction to Heat Transfer and Heat Exchangers

Learning Outcome

Explain the modes of heat transfer and the theory of heat exchanger operation.

Learning Objectives

1. Describe the three modes of heat transfer with reference to heat exchangers.
2. Discuss the general design and construction of typical heat exchangers.
3. Describe heat transfer fluids and how they affect the operation of a heat exchanger, including fouling, leakage, and vapor locking.
4. Describe heat exchanger inspection, maintenance, and operation, including placing them in service and removing them from service.

Topic 4 Thermodynamics of Steam

Learning Outcome

Apply the thermodynamics principles through practical applications using the steam tables and the temperature-enthalpy chart.

Learning Objectives

1. Describe heat as it relates to steam, water, and ice.
2. Explain the various columns of the steam tables.
3. Explain the thermodynamic principles of steam, using the steam tables.

Major Topic: Introduction to Power Engineering and its Governance

Topic 1 Introduction to Power Engineering

Learning Outcome

Describe the Power Engineer profession.

Learning Objectives

1. Describe steam, its uses and the basic steam cycle.
2. Describe the role and duties of a Power Engineer.
3. Describe how shift work affects sleep patterns, diet, and overall health.

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Topic 2 Jurisdictional Legislation for Power Engineers

Learning Outcome

Describe the application of Jurisdictional Acts and Regulations with respect to boilers and pressure vessels.

Learning Objectives

1. Describe how the Power Engineering profession is regulated in Canada.
2. Explain the purpose and scope of your Jurisdictional Act and Regulations pertaining to Power Engineering and Pressure Equipment.
3. Explain the purpose and intent of the Regulations governing Power Engineers and Pressure Welders.

Topic 3 Codes and Standards for Power Engineers and Pressure Vessels

Learning Outcome

Describe the purpose of boiler and pressure vessel Codes and Standards.

Learning Objectives

1. Discuss the history of how codes and standards became necessary in the pressure equipment field.
2. Explain the content and use of the CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code.
3. Explain the content and use of the CSA B52 Mechanical Refrigeration Code.
4. Explain the content and use of ASME Boiler and Pressure Vessel Code (ASME BPVC) Section I Power Boilers.
5. Explain the content and use of ASME BPVC Section VII - Recommended Guidelines for the Care of Power Boilers.
6. Explain the content and use of ASME BPVC Section IV - Rules for Construction of Heating Boilers.
7. Explain the content and use of ASME BPVC Section VI - Recommended Rules for Care and Operation of Heating Boilers.
8. Explain the purpose, intent, and limitation of ASME CSD-1 (Controls and Safety Devices) Standard.

Major Topic: Introduction to Plant and Fire Safety

Topic 1 Introduction to Plant Safety

Learning Outcome

Describe general plant safety as it related to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may be in an energy plant, and the basic Personal Protective Equipment that may be required.
3. Define, give examples of, and describe common power house hazards.
4. Describe Industrial health and safety management system.
5. Describe Hazard Assessment and Control programs.

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Topic 2 Plant Safety Programs

Learning Outcome

Describe common safety programs generally applied in plants.

Learning Objectives

1. Describe common occupational health and safety (OH&S) programs found in most plants.
2. Describe industrial safety programs in which Power Engineers may require additional training.
3. Discuss safe work permits.
4. Describe methods of equipment isolation and lock out.

Topic 3 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous materials.

Learning Objectives

1. Discuss the WHMIS system.
2. Discuss the essential components required in the WHMIS systems.
3. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
4. Discuss the safe handling of Hydrocarbons.

Topic 4 Plant Fire Safety

Learning Outcome

Explain fire safety in an industrial plant.

Learning Objectives

1. Discuss the theory, terminology, and the life safety issues associated with fires.
2. Explain the five classes of fires, and describe the types of fire extinguishing media and how they act on these fires.
3. Explain fire prevention.
4. Discuss fire prevention methods for the five types of fires.

Topic 5 Fire Extinguishing Methods and Equipment

Learning Outcome

Describe typical fire extinguishing equipment and its operation in plant environments.

Learning Objectives

1. Describe the construction and operation of various types of portable fire extinguishers.
2. Discuss the inspection and maintenance requirements of portable fire extinguishers.
3. Describe the types, layout, and operation of standpipe and sprinkler systems.
4. Discuss the maintenance requirements of standpipe and sprinkler system components.
5. Describe the purpose, operation, and maintenance of fire pumps.

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Major Topic: Introduction to Plant Operations and the Environment

Topic 1 Introduction to the Environment

Learning Outcome

Identify environmental considerations and how they relate to an operating plant.

Learning Objectives

1. Describe four important Biogeochemical Cycles that operate within the environment.
2. Describe typical interdependencies seen among elements within an "ecosystem."
3. List the types of impacts that operating facilities can have on the environment.
4. Describe the alert processes related to environmental problems of plants.
5. Explain the importance of "attitude" in limiting environmental impacts of plants.
6. Describe the long-term environmental impacts after the decommissioning and abandonment of plants.

Topic 2 Gas and Noise Emissions

Learning Outcome

Explain how gas and noise emissions affect plant operations.

Learning Objectives

1. Identify the sources and effects of common gases and vapours that have an adverse environmental impact.
2. Identify the common greenhouse and acid rain causing gases and describe their effects.
3. Describe the common methods for monitoring and reducing gaseous pollutants.
4. Describe the effects of noise pollution and methods of identifying, measuring, and controlling it.

Topic 3 Liquid and Solid Emissions

Learning Outcome

Explain how liquid and solid emissions affect plant operation.

Learning Objectives

1. Describe the sources and effects of solid pollutants from energy plants.
2. Describe the theory of operation of separators/collectors and monitoring of flue gas particulates.
3. Describe the disposal methods of solid waste from energy plants.
4. List sources and effects of liquid and thermal pollution.
5. Describe the preventive measures that can be taken to prevent liquid and thermal pollution.
6. Describe methods of liquid waste disposal.

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Major Topic: Elements of Material Science and Welding Technology

Topic 1 Energy Plant Construction and Operation Materials

Learning Outcome

Describe the mechanical properties of engineering materials used in engineering.

Learning Objectives

1. Describe the mechanical properties of materials.
2. Describe the various types of ferrous materials.
3. Describe the various types of non-ferrous materials.

Topic 2 Introduction to Welding

Learning Outcome

Describe welding processes relevant to the plant and Power Engineering.

Learning Objectives

1. Describe non-fusion welding process, equipment used, and methods.
2. Describe forge and oxy-fuel fusion welding processes and cutting processes.
3. Describe metal arc welding processes.
4. Describe heat treatment of welds.
5. Describe the types of weld joints used in pressure vessel construction.
6. Describe the additional construction components required for pressure vessels to ensure structural integrity and “access”.

Topic 3 Boiler and Pressure Vessel Inspection

Learning Outcome

Describe inspection processes and testing methods for welds and materials.

Learning Objectives

1. Describe common weld defects.
2. Describe the process of Visual Testing of welds.
3. Describe the process of Penetrant Testing for detecting weld or material defects.
4. Describe the process of radiographic weld testing.
5. Describe the process of ultrasonic weld testing.

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Major Topic: Introductory Fluid Handling Technology Topic 1

Introduction to Energy Plant Piping Systems Learning Outcome

Discuss the basic types of piping, piping connections, supports, and drainage devices used in industry.

Learning Objectives

1. State the applications for the most common materials and identify the sizes of commercial pipe.
2. Describe methods of connection for screwed, flanged, and welded pipe; identify fittings and their markings.
3. Describe methods and devices used to allow for pipe expansion and support.
4. Explain the methods used to promote good drainage of steam pipes, including the installation and maintenance of steam traps, to reduce the effects of water hammer.
5. Explain the requirements, materials, and methods for insulating pipe.

Topic 2 Introduction to Energy Plant Valves

Learning Outcome

Discuss the design and uses of the valve designs most commonly used in industry and on boilers.

Learning Objectives

1. Describe standard valve designs.
2. Describe design and operation of specialized boiler valves.
3. Describe a typical steam pressure reducing station, and the design and operation of steam system pressure-reducing valves.
4. Discuss valve details, including materials of construction and identification markings.
5. Describe typical valve maintenance requirements.

Major Topic: Basic Concepts in Electrotechnology

Topic 1 Basic Electricity

Learning Outcome

Apply the concepts of basic electricity while performing simple calculations using voltage, current, resistance, and power.

Learning Objectives

1. Describe the atomic structure of matter and its relationship to electricity.
2. Describe basic electrical circuits.
3. State Ohm's Law and apply it to single-resistor circuits.
4. Apply Ohm's Law to series resistance circuits.
5. Apply Ohm's Law to parallel resistance circuits.
6. Explain electrical conductors and insulators using examples.
7. Explain the factors that affect resistance mathematically.
8. Calculate the power developed in an electrical circuit.

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Topic 2 Magnetism and Electromagnetism

Learning Outcome

Describe the basic principles of magnetism.

Learning Objectives

1. Describe magnetism and the relationship between magnetism and electricity.
2. Describe the relationship between electricity and magnetism in an electrical generator.
3. Describe the relationship between electricity and magnetism in an electric motor.

Topic 3 Electrical Metering Devices

Learning Outcome

Describe the design and application of electrical metering devices.

Learning Objectives

1. Describe electrical meters and their uses.
2. Describe how voltage, current, and resistance are measured in an electric circuit.
3. Describe the construction and operation of a kilowatt hour meter.

Topic 4 Motors and Generators

Learning Outcome

Describe the operating principles of the various types of AC and DC motors and generators.

Learning Objectives

1. Describe the construction and operation of DC generators and motors.
2. Describe the construction and operation of AC generators (alternators) and motors.
3. Interpret the information on a motor nameplate.
4. Perform basic calculations relating to power factor and power factor correction.

Topic 5 Transformers

Learning Outcome

Describe the operating principles of electrical transformers.

Learning Objectives

1. Describe the principle of operation of transformers.
2. Perform basic transformer calculations as they relate to the construction and operation of single-phase transformers.
3. Describe the construction and operation of three-phase transformers.
4. Discuss special transformer types and their applications.
5. Discuss transformer cooling, safety, and maintenance.

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Topic 6 Electrical Distribution Circuits

Learning Outcome

Describe an electrical distribution system.

Learning Objectives

1. List and describe the standard types of electrical voltage systems.
2. Interpret electrical single-line diagrams and circuit symbols.
3. Describe the major components of an electrical distribution system.
4. Describe the function and operation of fuses and circuit breakers.
5. Describe the function and operation of alternate power supply system equipment.

Major Topic: Energy Plant Instrumentation and Controls

Topic 1 Introduction to Energy Plant Controls and Instrumentation

Learning Outcome

Describe the overall purpose and function of plant instrumentation systems.

Learning Objectives

1. Describe the concept and basic components of a control loop.
2. Describe the various means by which control signals are transmitted, and the function of transducers.
3. List and describe the types of instruments that are not control loop components.

Topic 2 Introduction to Process Measurement

Learning Outcome

Describe the construction and operation of common devices used to measure pressure, level, flow, temperature, humidity, and composition.

Learning Objectives

1. Describe the types of pressure sensing and measuring devices.
2. Describe the types of level sensing and measuring devices.
3. Describe the types of flow sensing and measuring devices.
4. Describe the types of temperature sensing and measuring devices.
5. Describe the types of humidity sensing and measuring devices.
6. Describe the types of gas sensing and measuring devices.

Topic 3 Basic Control and Instrumentation Components

Learning Outcome

Describe the basic types and functions of transmitters, recorders, controllers, and control actuators.

Learning Objectives

1. Describe the construction and operational principles of instrumentation transmitters.
2. Describe the construction and operational principles of instrumentation indicators and recorders.
3. Describe the construction and operational principles of instrumentation controllers.
4. Describe the construction and operational principles of final control elements.

Topic 4 Introduction to Programmable Controllers

Learning Outcome

Describe the operation of programming controls for boilers, including applicable testing and maintenance procedures.

Learning Objectives

1. Discuss how programmable controllers work and how they act as sequencers for equipment.
2. Describe applications of programmable controllers.
3. Explain the HMI (human machine interface) and purpose of touchscreen displays, functions, and alarm handling.

Topic 5 Electronic Control Systems and Computer Applications

Learning Outcome

Describe the design and operation of electronic control systems.

Learning Objectives

1. Discuss electronic process control systems.
2. Describe computers and how they operate within control systems.
3. Describe the applications of computerized control systems and plant computers.

Topic 6 Electrical Control Systems

Learning Outcome

Describe the design and operation of electrical control systems.

Learning Objectives

1. Describe the basic construction and operation of various electric control system components.
2. Describe the function of control devices in electric control systems.
3. Explain the operating sequence of basic electric control circuits.

Major Topic: Fundamental Industrial Communication Skills

Topic 1 Energy Plant Sketching

Learning Outcome

Create engineering equipment sketches.

Learning Objectives

1. Create sketches using center lines and dimensioning.
2. Recognize standard views of an object.
3. Recognize cross-hatching methods in sectional drawings.
4. Identify common symbols and lines used in plant system trace drawings.
5. Complete a plant line tracing.

Topic 2 Plant Diagrams and Drawings

Learning Outcome

Identify common types of diagrams used in plants.

Learning Objectives

1. Explain the layout of plant diagrams.
2. Explain the use of process flow diagrams (PFDs).
3. Explain the use of piping and instrumentation diagrams (P&IDs).
4. Explain the use of general arrangement, block plans and equipment diagrams.

Topic 3 Plant Communications

Learning Outcome

Describe the types and proper usage of plant communication systems.

Learning Objectives

1. Discuss effective written and verbal communication skills, including the use of two-way radios.
2. Describe the legal documentation requirements for Power Engineers, including log books and log sheets.
3. Discuss the elements of Maintenance Management Systems, including work requests, and work orders.
4. Discuss the purpose, revision, and control of Standard Operating Procedures.
5. Discuss updating procedures for piping and instrumentation diagrams.

Major Topic: Introduction to Boiler Designs

Topic 1 Introduction to Boilers

Learning Outcome

Describe the historical development of boilers, boiler design, components, and configuration.

Learning Objectives

1. Describe the history of boiler applications, boiler design, and modern boiler improvements.
2. Describe packaged boilers.
3. Describe the construction of shop-assembled and field-erected boilers.
4. Describe components and design aspects common to all boiler vessels.

Topic 2 Firetube Boilers

Learning Outcome

Describe the design, components, and characteristics of firetube boilers.

Learning Objectives

1. Differentiate the Scotch Boiler from the other firetube boilers, and describe its development history.
2. Describe circulation patterns in firetube boilers.
3. Discuss construction details of firetube boilers.

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Topic 3 Watertube Boilers

Learning Outcome

Describe the design, components, and characteristics of watertube boilers.

Learning Objectives

1. Describe the design and operating principles of watertube boilers.
2. Describe watertube boiler components.
3. Explain the design and application of packaged watertube boilers.
4. Describe the design, construction, and components of large-scale steam generating units.

Topic 4 Electric Boilers

Learning Outcome

Explain the general design and application of electric boilers.

Learning Objectives

1. Discuss the advantages and disadvantages of electric boilers.
2. Describe the construction and operating principle of electric boilers.

Topic 5 Special Boiler Designs for Heating Plants

Learning Outcome

Describe the special design considerations of boilers used in heating plants.

Learning Objectives

1. Describe the design of watertube and coil tube heating boilers.
2. Describe cast iron boilers and vertical firetube boilers.
3. Describe the construction and application of firetube heating boiler designs.

Topic 6 Differences between Power and Heating Boilers

Learning Outcome

Differentiate between ASME Section I and ASME Section IV boilers.

Learning Objectives

1. Discuss the differences between power boiler and heating boiler design and installation.
2. Discuss the differences between power boiler and heating boiler operation.

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Major Topic: Elements of Boiler Systems

Topic 1 Combustion

Learning Outcome

Discuss the basic theory of combustion, and the equipment used to provide proper combustion conditions within a boiler.

Learning Objectives

1. Discuss combustion, combustion equations, and the relationship between theoretical and excess air.
2. Discuss the characteristics of solid, liquid, and gaseous fuels.
3. Explain the effects of fuels and combustion on refractory materials.

Topic 2 Fuel Delivery and Firing Systems

Learning Outcome

Describe common fuel systems found in boiler systems.

Learning Objectives

1. Describe solid fuel delivery systems.
2. Describe the main types of solid fuel firing systems.
3. Describe gaseous fuel delivery systems.
4. Describe the main types of gaseous fuel firing systems.
5. Describe liquid fuel delivery systems.
6. Describe the main types liquid fuel firing systems.
7. Describe flue gas analysis and how it relates to boiler efficiency.

Topic 3 Draft

Learning Outcome

Describe basic concepts and equipment used to supply combustion air to boiler furnaces.

Learning Objectives

1. Describe the various air streams that deliver combustion air to a furnace.
2. Relate differential pressure to the creation of draft.
3. Describe forced, induced, and balanced mechanical draft.
4. Discuss common methods of controlling combustion airflow.
5. Discuss common methods of measuring furnace pressures.

Topic 4 Feedwater Systems

Learning Outcome

Describe feedwater systems used with boilers.

Learning Objectives

1. Describe the overall layout of feedwater, condensate, and make-up water systems.
2. Describe the valves used in feedwater systems.
3. Describe the control strategies for single-element, two-element, and three-element boiler feedwater systems.
4. Describe methods of supplying feedwater to steam heating boilers.
5. Explain the operation of condensate receiver make-up water controls.
6. Describe the return of condensate, and the supply of feedwater to high-pressure boilers.

Topic 5 Blowof f and Blowdown Systems

Learning Outcome

Describe the equipment, operation, and purpose of boiler blowoff and blowdown systems.

Learning Objectives

1. Describe blowoff, blowoff equipment and blowoff procedures.
2. Describe continuous blowdown, blowdown equipment, and blowdown procedures.
3. Describe the maintenance and repair of blowoff systems.

Topic 6 Boiler Fireside Cleaning Systems

Learning Outcome

Describe types of boiler fireside cleaning equipment, their purpose, and their operation.

Learning Objectives

1. Describe common options for in-service fireside cleaning.
2. Describe the construction and operation of retractable soot blowers.
3. Describe the construction and operation of stationary soot blowers.
4. Describe falling shot cleaning methods.

Major Topic: Lubrication and Bearings

Topic 1 Lubrication Principles

Learning Outcome

Describe the importance of lubrication and the principles concerned with lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and application.
3. List the properties of lubricating oils, the additives used, and their selection criteria.

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Topic 2 Types of Bearings and Lubrication

Learning Outcome

Describe bearing types, methods for care and maintenance of bearings, and bearing lubrication systems.

Learning Objectives

1. Define boundary and full fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of antifriction and thrust bearings.
4. Describe how to clean and replace roller and ball type bearings.
5. Explain the causes of bearing failure.

Major Topic: Pumps and Compressors

Topic 1 Types of Pumps

Learning Outcome

Describe the construction and operating principles of various types of pumps used in plants.

Learning Objectives

1. List common pump applications.
2. Define the terms associated with pump performance.
3. Describe the common pumps found in plants.

Topic 2 Pump Operation and Maintenance

Learning Outcome

Describe the major considerations and procedures for pump operation and maintenance.

Learning Objectives

1. Discuss the components of a driver and pump assembly.
2. Discuss pump shaft sealing, compression packing, and the replacement of compression packing.
3. Describe the standard types of mechanical seals.
4. Describe pump bearings, shaft alignment procedures, and the equipment used to align shafts.
5. Describe centrifugal pump startup and priming procedures.
6. Describe positive displacement pump operating characteristics, priming, startup, and routine checks.

Topic 3 Introduction to Compressors

Learning Outcome

Describe the operating principles of the different types of compressors.

Learning Objectives

1. Describe the main classifications and types of compressors.
2. Describe gaseous compression systems.

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Topic 4 Compressor Operation and Maintenance

Learning Outcome

Describe the major considerations and general procedures for compressor operation and maintenance.

Learning Objectives

1. Describe compressor parts and auxiliary equipment.
2. Describe the construction and operation of seals for compressors.
3. Describe the capacity control of compressors.
4. Describe preventative maintenance and routine procedures for compressors.

Major Topic: Boiler Safety Devices Topic 1

Pressure Relief Valves Learning Outcome

Explain the code requirements, design, and operation of pressure relief valves for power boilers, heating boilers, and pressure vessels.

Learning Objectives

1. Discuss the code requirements, construction, and operation of ASME Section I Pressure Relief Valves and Devices.
2. Discuss the code requirements, construction, and operation of ASME Section IV Pressure Relief Valves and Devices.
3. Describe the testing and repair of pressure relief valves.
4. Describe the construction and operation of temperature and pressure relief valves.

Topic 2 Combustion Safety

Learning Outcome

Explain the design and operation of combustion safety controls on burners and boilers.

Learning Objectives

1. Describe the operation of control and safety devices found on boiler fuel supplies.
2. Describe the construction and operation of flame detectors.
3. Describe the combustion safety controls for boilers and burner systems.
4. Describe burner management systems.
5. Interpret burner operating sequence charts, and provide a typical sequence of startup and shutdown events.

Topic 3 Water Level Safety Controls

Learning Outcome

Describe feedwater devices, and control methods used on boilers.

Learning Objectives

1. Describe the construction and operation of boiler low water level fuel cut-off equipment.
2. List the CSA and ASME code requirements regarding low water fuel cut-off devices.
3. Describe direct and indirect type boiler water level indicators.

Topic 4 Boiler Fittings

Learning Outcome

Relate the code, operation, and required fittings to the operating principles of fittings found on boilers.

Learning Objectives

1. Explain the code references for boiler fittings.
2. Describe the code requirements for pressure gauges on steam boilers.
3. Describe the code requirements for the boiler connections and valves on steam boilers.
4. Describe the code requirements for fittings on hot water heating boilers.
5. Describe the non-code fittings used on boilers.

Topic 5 Firing Rate Controls

Learning Outcome

Describe the operating and safety controls found on boilers.

Learning Objectives

1. Describe basic boiler firing rate controls.
2. Discuss various operating controls for steam and hot water boilers.

Major Topic: Boiler Plant Operation and Management

Topic 1 Boiler Plant Startup

Learning Outcome

Describe the operational procedures related to starting up auxiliary equipment in a boiler plant.

Learning Objectives

1. Describe the basic auxiliaries that need to be checked, prepared, or placed in service before starting a boiler plant.
2. Describe the general procedures for starting a plant for the first time, or restarting after an outage or turnaround.
3. Discuss basic operating practices for starting pumps and fans.
4. Describe the general preparation for a hot water boiler startup.
5. Describe the general preparation for a steam boiler startup.
6. Describe the safety and housekeeping preparation requirements for boiler plant startup.

Topic 2 Boiler Startup

Learning Outcome

Describe procedures for safely starting boiler systems.

Learning Objectives

1. Describe operating considerations when warming a cold boiler.
2. Describe how to start and cut-in a hot water boiler.
3. Describe how to start a single boiler steam plant.
4. Describe how to cut-in a steam boiler in a multiple boiler plant.
5. Describe semi-automatic burner ignition systems.
6. Discuss the post startup inspection for boilers returning to service after a major outage.

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Topic 3 Boiler Operation

Learning Outcome

Describe operational procedures related to operating boilers.

Learning Objectives

1. Describe the operation of a hot water heating boiler under routine conditions.
2. Describe routine steam boiler operating duties.
3. Describe emergency conditions in boiler plants and the required responses.
4. Describe basic boiler troubleshooting activities.

Topic 4 Operational Checks

Learning Outcome

Describe operational checks for operating boiler plants.

Learning Objectives

1. Describe the shift based operator responsibilities for boiler plants.
2. Describe the safety device operational checks carried out on boilers.
3. Describe routine maintenance activities for boiler plant operation.
4. Describe the use of Standard Operating Procedures (SOPs).
5. Describe the need for boiler operating and maintenance logs, and the type of information that should be recorded.

Topic 5 Shutdown Procedures

Learning Outcome

Describe generic shutdown and layup procedures for different boiler types.

Learning Objectives

1. Describe hot water boiler shutdown procedures.
2. Describe steam boiler shutdown and lockout procedures.
3. Describe extended period layup requirements for steam boilers.

Topic 6 Boiler Plant Monitoring and Reporting

Learning Outcome

Describe the points and readings that need to be monitored and recorded in a plant.

Learning Objectives

1. Discuss recording requirements for operating and performance conditions.
2. Discuss the various systems required to conduct equipment repairs, and to manage the related maintenance records.
3. Describe the operational causes, consequences, and prevention of water hammer.
4. Describe the consequences and actions required for various equipment failures.
5. Describe the consequences, and actions required, in the event of boiler accidents.

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Major Topic: Energy Plant Maintenance

Topic 1 Energy Plant Maintenance I

Learning Outcome

Describe the safe use of common hand tools in the powerhouse.

Learning Objectives

1. Describe the types and proper use of hacksaws, files, chisels, hammers, screwdrivers, and wrenches.
2. Describe the types and proper use of hand threading tools.
3. Describe the types and proper use of measuring tools.
4. Describe the proper layout of work and the use of layout tools.
5. Describe the types and proper use of portable and fixed grinders, hand drills, drill presses, and the care of drill bits.

Topic 2 Energy Plant Maintenance II

Learning Outcome

Discuss and describe the safe and proper setup of equipment for hoisting and working above ground.

Learning Objectives

1. Describe the requirements for setting up work platforms in general and ladders and scaffolding in particular.
2. Describe the general safety precautions and calculations used when rigging equipment.
3. Describe the general safety precautions used when hoisting equipment.
4. Discuss the correct use and limitations of wire cable and rope, including cable attachments and rope knots.
5. List and describe common types of metal fasteners, such as screws, bolts, studs, nuts, and washers.

Topic 3 Boiler Maintenance

Learning Outcome

Describe the service and maintenance required for boilers.

Learning Objectives

1. Describe the general maintenance and service of packaged firetube and cast iron sectional boilers.
2. Identify the operational procedures for wet and dry boiler layups.
3. Describe ways of detecting firetube and tubesheet leaks.
4. Describe the general procedure for the removal and replacement of defective firetubes.

Topic 4 Boiler Cleaning

Learning Outcome

Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical and chemical boiler cleaning methods.

Learning Objectives

1. List the steps and precautions to prepare a boiler for inspection.
2. Describe the internal inspection of a boiler.
3. Describe the methods and tools used to mechanically clean boilers.
4. Describe two methods used to chemically clean boilers.

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Major Topic: Water Treatment

Topic 1 External Boiler Water Treatment

Learning Outcome

Describe the general principle, methods, and equipment used in preparing raw feedwater for steam production.

Learning Objectives

1. Describe typical impurities and their effects on plant and boiler water pre-treatment systems, and their treatment process.
2. Describe the equipment requirements for pre-treatment of plant water systems.
3. Describe water filtration and the removal of suspended solids.
4. Describe the purpose, processes, and equipment used in water softening.
5. Describe the theory, process, and equipment used in deaeration.

Topic 2 Internal Boiler Water Treatment

Learning Outcome

Describe the general principles, methods, and equipment used for internal boiler water treatment.

Learning Objectives

1. Describe the types of problems, and associated treatments, related to internal boiler water contamination.
2. Describe internal boiler feedwater chemical feed systems.
3. Describe standard boiler water testing.

Topic 3 Condensate Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condensate.

Learning Objectives

1. Describe condensate treatment and the effects of non-treatment.
2. Describe the tests conducted on condensate.

Topic 4 Cooling Tower and Condenser Water Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condenser water, and their effects on the cooling tower.

Learning Objectives

1. Describe the effects of water on condensers and cooling tower materials.
2. Describe condenser and cooling tower water treatment.
3. Describe cooling tower and condenser water tests for common treatment methods.

Topic 5 Recirculating System Water Treatment

Learning Outcome

Describe recirculating water systems, their effects, treatment, and tests.

Learning Objectives

1. Describe recirculating water system corrosion and deposition.
2. Describe the use of sacrificial anodes, and measurement techniques to determine corrosion.
3. Describe glycol system testing requirements.
4. Discuss the monitoring tools, procedures, and tests used in recirculating water systems.

Major Topic: Types of Prime Movers and Heat Engines

Topic 1 Heat Engines and Prime Movers

Learning Outcome

Discuss the historical conversion of heat energy into mechanical energy.

Learning Objectives

1. Differentiate between the terms "heat engine" and "prime mover."
2. Discuss the history of the steam engine and the expansive power of steam.

Topic 2 Steam Turbines

Learning Outcome

Describe the construction and operation of steam turbines.

Learning Objectives

1. Describe the principle of operation and major components of a steam turbine.
2. Describe the lubrication and sealing of steam turbine shafts.
3. Describe how the rotational speed of a steam turbine is governed and controlled.
4. List the steps to follow in a typical steam turbine start-up and shut-down.

Topic 3 Condensers and Cooling Towers

Learning Outcome

Describe the operation and maintenance of condensers and cooling towers.

Learning Objectives

1. Explain the construction and operation of condensers, and how they relate to the operation of cooling towers.
2. Explain the principle of operation, the purpose, and the major components of cooling towers.
3. Describe the construction and operation of natural draft cooling towers.
4. Describe the construction and operation of mechanical draft cooling towers.
5. Discuss cold climate operation for cooling towers.
6. Explain typical problems and resolutions required within the operation of cooling towers.

Topic 4 Gas Turbines

Learning Outcome

Describe the application, startup, operation, and maintenance required for gas turbines.

Learning Objectives

1. Describe the principle of construction and operation of gas turbines.
2. Identify the operational characteristics of gas turbines.
3. Describe regeneration and combined steam-gas turbine operating cycles.
4. Describe the key elements of gas turbine startup, operation, and auxiliaries.

Topic 5 Internal Combustion Engines

Learning Outcome

Describe the application, construction, and operation of internal combustion engines.

Learning Objectives

1. Discuss the fuels used in internal combustion engines.
2. Describe the working cycles of the 4-stroke and 2-stroke spark ignition engines.
3. Describe the working cycle of the 4-stroke compression ignition (diesel) cycle.
4. Describe the construction of basic spark and compression engines.
5. Explain the basic operating considerations for diesel engines.

Major Topic: Plant Auxiliary Systems

Topic 1 Lighting Systems

Learning Outcome

Explain the various lighting systems and some of the basic design considerations for lighting a space.

Learning Objectives

1. Describe the common types of lighting equipment and systems.
2. Discuss the different types of artificial light sources.
3. Explain the various methods of lighting control.
4. Describe the general requirements and criteria for emergency lighting in buildings.
5. Discuss the interrelationship between lighting, air conditioning, and energy conservation in buildings.

Topic 2 Building Water Systems

Learning Outcome

Explain the various water supply systems used in buildings.

Learning Objectives

1. Describe the cold water distribution system in a building.
2. Describe the hot water distribution system in a building.
3. Describe the construction and operation of building system hot water heaters, including temperature regulation.
4. List and describe the construction and operation of water system protective devices in buildings.
5. Explain what is meant by “backflow prevention” and describe the common methods used.
6. Describe the maintenance requirements for the components in a building water distribution system.

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Topic 3 Drainage Systems

Learning Outcome

Describe the design and components of various drainage systems used in facilities.

Learning Objectives

1. Describe the overall layout of building drainage systems.
2. Describe storm water drainage systems for buildings.
3. Describe how surface runoff is managed in order to minimize environmental impact.

Major Topic: Basic Concepts of Compression and Absorption Refrigeration

Topic 1 Refrigeration Basics

Learning Outcome

Explain the basic concept of refrigeration and refrigerants.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the cycle of operations in a vapor compression refrigeration system.
3. Explain how the operating temperatures and pressures are selected and related for a vapor compression refrigeration system.
4. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.
5. Describe how refrigerants are classified.
6. Describe the thermodynamic properties of refrigerants.
7. Describe the properties of refrigerants relating to miscibility, leakage tendency, odor, moisture reaction, toxicity, and flammability.

Topic 2 Compression Refrigeration Systems

Learning Outcome

Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Distinguish between direct and indirect refrigeration systems.
3. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizer.
4. Describe the special types of refrigeration compressors, and how they are similar to and different from air compressors.
5. Describe the special designs of refrigeration system evaporators and condensers.

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Topic 3 Refrigeration System Control and Operation

Learning Outcome

Describe the purposes and operating principles of refrigeration system operational and safety controls.

Learning Objectives

1. Describe refrigeration system controls.
2. List the safety shutdown devices specific to centrifugal compressor water chillers.
3. Describe typical refrigeration system safety shutdown devices.
4. Describe the construction and operation of refrigerant metering devices.
5. Describe the different methods used to control evaporator capacity.
6. Describe the different methods used to control the capacity of refrigeration compressors.

Topic 4 Refrigeration System Operation and Maintenance

Learning Outcome

Describe the operating principles and maintenance of refrigeration systems.

Learning Objectives

1. Discuss refrigeration auxiliaries.
2. Describe refrigeration system leak test procedures.
3. Describe how a refrigeration system is dried and charged prior to start-up.
4. List the steps for adding oil to an in-service refrigeration compressor.
5. Describe the start-up and shut-down procedure for a compression refrigeration system.
6. Describe operational log sheets and preventative maintenance procedures for refrigeration systems.
7. Describe how a refrigeration system is purged of noncondensable gases.
8. Discuss refrigeration condenser operation and maintenance requirements.
9. Explain typical problems and resolutions related to refrigeration systems.

Topic 5 Absorption Refrigeration Systems

Learning Outcome

Describe the operating principle, maintenance, and operation of absorption refrigeration systems.

Learning Objectives

1. Describe the basic absorption system, comparing the differences to the compression system.
2. Describe the theory and operation of an ammonia absorption refrigeration system.
3. Describe the theory and operation of a lithium bromide absorption refrigeration system.
4. Explain the operation of absorption refrigeration systems with respect to crystallization and dilution.
5. Describe the major parts and systems of an absorption system, including: heat exchanger bypass system, pump motor lubrication and cooling system, and purging system.
6. Describe the startup and shutdown procedures for an absorption refrigeration system.
7. Describe the preventive maintenance that should be performed on an absorption refrigeration system.
8. Explain typical problems and resolutions related to an absorption refrigeration system.

Topic 6 Refrigeration Plant Safety

Learning Outcome

Outline the potential hazards inherent to refrigeration plants, the CSA requirements intended to mitigate hazards, and typical responses taken in the case of a significant leak.

Learning Objectives

1. Identify and provide a basic explanation of the CSA B52 Code requirements for refrigeration plant machinery rooms.
2. Identify safe practices for refrigeration plant operation and maintenance.
3. Describe the appropriate emergency response to a significant refrigerant leak.
4. Describe the Canadian Environmental Emergency Regulations and how they relate to refrigeration plants.

Major Topic: HVAC Fundamentals for Facility Operators

Topic 1 Conditioning the Air

Learning Outcome

Explain the methods and techniques for conditioning air in plants and buildings.

Learning Objectives

1. Discuss the process to condition air for human comfort and health.
2. List the categories and functions of HVAC systems.
3. Describe the operation of air-handling units.
4. Define the terms humidity, relative humidity, and dewpoint.
5. Define the terms dry-bulb temperature, wet-bulb temperature, wet-bulb depression, and how they relate to relative humidity.

Topic 2 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and warm air types of humidifiers.
3. Describe industrial and commercial types of humidifiers.

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Topic 3 Fans for Air Distribution Systems

Learning Outcome

Describe the airflow behavior and movement of air through distribution systems.

Learning Objectives

1. Discuss the theory of airflow and pressure conversions.
2. Describe the major types of air handling fans, their construction, and operation.
3. Interpret fan performance curves.
4. Describe fan motors, drives, and belt guards.
5. Describe fan volume controls.

Topic 4 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems, including various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the various contaminants found in air.
3. Describe the types of air cleaning devices used in industrial/commercial buildings.

Topic 5 HVAC Duct Systems

Learning Outcome

Describe the designs and components of duct systems used in HVAC applications.

Learning Objectives

1. Explain how air duct systems are classified.
2. Describe air duct materials, system layout, fabrication, and installation.
3. Describe air duct leakage.
4. List and describe the types of liners, dampers, and louvres used in air duct systems.
5. Discuss terminal air distribution devices, and the principles of diffusion, induction, entrainment, and aspiration.

Topic 6 Types of Coils and Operation

Learning Outcome

Describe the various types and operation of coils used in HVAC systems.

Learning Objectives

1. Explain how steam, hot water, and glycol coils are sized, configured, and operated to reduce the chance of freezing.
2. Describe the installation recommendations for coils, piping, steam traps, control valves, air vents, and vacuum relief devices.

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Major Topic: Building Environmental Systems and Control

Topic 1 Steam Heating

Learning Outcome

Describe the components, operating principles, and maintenance procedures of steam heating systems.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. Describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.
3. Describe standard types of piping and equipment layout for steam heating systems.
4. Describe the general operation and maintenance of steam heating systems.
5. Apply a steam heating system troubleshooting guide.

Topic 2 Hot Water Heating

Learning Outcome

Describe the various designs, equipment, and operation of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe various types of special hot water heating systems.
4. Describe the purpose and function of standard hot water heating system accessories.
5. Explain how the location of the hot water circulating pump and the expansion tank are determined.
6. Describe the routine operation of hot water heating systems, including cleaning, filling, starting, and use of glycol/antifreeze.
7. Apply a hot water heating troubleshooting guide.

Topic 3 Other Heating Systems

Learning Outcome

Describe common heating systems encountered by Power Engineers.

Learning Objectives

1. Describe natural gas fueled warm air heating systems.
2. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
3. Discuss the concept and application of infrared heating.
4. Describe the different methods of electric heating, and their advantages and disadvantages as compared to other types of systems.

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Topic 4 Cooling Systems and Combination Systems

Learning Outcome

Describe central, unitary and combined HVAC systems.

Learning Objectives

1. Describe the general layout and operation of unitary air conditioning systems.
2. Describe the general layout and operation of central air conditioning systems.
3. Describe the general layout and operation of combined air conditioning systems.
4. Discuss how HVAC systems should be operated under different situations.

Topic 5 Heat Gains and Losses, and Heat Recovery Methods

Learning Outcome

Describe heat gains and losses, and common methods for energy recovery.

Learning Objectives

1. Define heat transmission terminology.
2. Describe heat gain and heat loss analysis in a building or plant.
3. Describe the general principles of HVAC heat recovery.

Topic 6 HVAC Control Strategy

Learning Outcome

Describe the control systems strategies used in HVAC systems.

Learning Objectives

1. Describe a basic ventilation control strategy for HVAC systems.
2. Describe heating control strategies for HVAC systems.
3. Describe humidification, dehumidification, and cooling control strategies for HVAC systems.
4. Describe volume control with static pressure regulation for HVAC systems.

Major Topic: Typical Industrial Plant Configurations

Topic 1 Common Plant Configurations in Hydrocarbon Centric Industries

Learning Outcome

Identify steam-related processes employed in common types of plants.

Learning Objectives

1. Identify standard thermal system pathways and segments commonly used in plants.
2. Identify equipment and processes in heat transfer fluid (HTF) heating systems.
3. Identify the main thermal processes used in oil refining industries.
4. Describe the main processes used in steam assisted gravity drainage (SAGD) and cyclic steam stimulation (CSS).
5. Identify thermal processes used in gas separation and compression plants.

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Topic 2 Common Plant Configurations in Energy Intensive Industries

Learning Outcome

Identify steam related processes employed in common types of plants.

Learning Objectives

1. Identify the main steam/boiler processes used in wood and biomass processing plants.
2. Identify the important thermal processes used in food production and preservation.
3. Identify the common processes and equipment used in metallurgical processing plants.

Major Topic: Elementary Mechanics and Dynamics

Topic 1 Introduction to Basic Mechanics

Learning Outcome

Apply basic terms and calculations used in the study of mechanics.

Learning Objectives

1. Define mass, force, acceleration, velocity, and weight.
2. Perform simple calculations involving force, pressure, work, power, and energy.

Topic 2 Forces and Moments

Learning Outcome

Perform calculations involving forces and moments, and determine when a system of forces is in equilibrium.

Learning Objectives

1. Define the moment of a force and its units.
2. Determine the direction and calculate the magnitude of the moment of a force.

Topic 3 Simple Machines

Learning Outcome

Perform calculations relating to mechanical advantage, velocity ratio and efficiency.

Learning Objectives

1. Define the term simple machine and apply to calculations of mechanical advantage, velocity ratio and efficiency of simple machines.

Topic 4 Scalars and Vectors

Learning Outcome

Define and identify scalar and vector quantities and solve simple vector problems graphically.

Learning Objectives

1. Define scalar and vector quantities as they apply to drawing vector diagrams.

Topic 5 Linear Velocity and Acceleration

Learning Outcome

Solve simple problems involving linear velocity, time, and distance.

Learning Objectives

1. Solve distance, displacement, speed, and velocity problems.
2. Draw graphs of velocity as a function of time.
3. Define acceleration, state its units, and solve simple acceleration problems.
4. Apply mathematical formulae relating acceleration, velocity, distance and time to solve problems.

Topic 6 Force, Work, Pressure, Power, and Energy

Learning Outcome

Perform calculations involving force, work, pressure, power, and energy.

Learning Objectives

1. Perform calculations involving force and work.
2. Perform calculations involving gauge, atmospheric, and absolute pressure.
3. Perform calculations involving power and different forms of mechanical energy.

Topic 7 Friction

Learning Outcome

Solve problems involving friction.

Learning Objectives

1. Apply the laws governing the types of friction.
2. Apply the coefficient of friction to problems involving forces on a horizontal plane.

Topic 8 Stress and Strain

Learning Outcome

Explain physical properties of materials and how their behavior is affected when external forces are applied.

Learning Objectives

1. Describe the mechanical properties of materials, including elasticity, stiffness, plasticity, ductility, toughness, brittleness, and hardness.
2. Calculate stress including tensile, compressive, and shear stresses within rigid bodies due to external loads.
3. Calculate the strain of members under load.

Topic 9 Power Transmission

Learning Outcome

Perform calculations pertaining to common power transmission systems.

Learning Objectives

1. Calculate pulley speeds, transmitted power, and efficiency of belt drive systems.
2. Calculate gear speeds for gear and chain drive systems.

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REFERENCE CURRICULUM

For

Thermal Power Plant Engineer
(1st Class)

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Introduction

This Curriculum is intended to assist candidates studying for the Thermal Power Plant Engineer (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Thermal Power Plant Engineer (1st Class) Examination Candidates

Major Topic: Applied Engineering Technologies

Topic 1 Metallurgy

Learning Outcome

Describe the design, components, and implementation of a loss control program.

Learning Objectives

1. Describe the structure of metals.
2. Explain the nature and significance of phase changes in iron and steel due to temperature change.
3. Explain how alloying elements affect phase changes in steel and state the major alloying elements used in steel.
4. Explain the effect of temperature on the tensile strength of steel.
5. Explain the criteria for the assessment of materials.
6. Explain what creep is, and why it is important to monitor its effects on equipment.
7. Explain the methods of stress analysis.
8. Explain failure analysis.

Topic 2 Corrosion Chemistry and Processes

Learning Outcome

Explain the chemistry and processes of corrosion mechanisms.

Learning Objectives

1. Explain how atomic and molecular structures affect corrosion.
2. Explain the anodic and cathodic processes of corrosion.
3. Explain the electromotive force series and galvanic series.
4. Explain the effect of polarization.
5. Explain corrosion of single metals.
6. Explain the processes of crevice corrosion and pitting corrosion.
7. Explain the process of microbiologically influenced corrosion.
8. Explain the process of stress induced corrosion.
9. Explain the processes of erosion-corrosion.

Topic 3 Boiler Corrosion

Learning Outcome

Discuss the mechanisms of corrosion in boilers.

Learning Objectives

1. Explain the impact of corrosion.
2. Explain the agents of corrosion found in water.
3. Explain the mechanisms and significance of magnetite formation and magnetite depletion on boiler tube surfaces.
4. Explain the mechanisms and significance of economizer and superheater corrosion.
5. Explain the mechanism, identification and significance of flue gas side corrosion of boiler components.
6. Explain the mechanism, identification and significance of low temperature corrosion of boiler components.
7. Explain the relationship between boiler water chemistry and corrosion of copper alloys in feedwater systems.
8. Explain the mechanisms and significance of deaerator cracking and corrosion.

Topic 4 Corrosion Monitoring and Prevention Techniques

Learning Outcome

Explain techniques used to monitor and prevent corrosion.

Learning Objectives

1. Describe the methods of monitoring and analyzing corrosion.
2. Explain the design, applications, and operation of cathodic protection systems.
3. Explain the use of protective coatings for corrosion control.
4. Describe the regulatory and safety requirements relating to corrosion monitoring.
5. Describe chemical control of corrosion.

Topic 5 Corrosion Prevention Programs

Learning Outcome

Explain corrosion prevention programs.

Learning Objectives

1. Explain the corrosion characteristics and susceptibility of engineering materials and their selection for various purposes.
2. Describe the chemical, mechanical, and operational factors that are considered in controlling corrosion in steels.
3. Describe the chemical, mechanical and operational factors that are considered in controlling corrosion in copper alloys.
4. Explain the risks and required precautions involved with chemical cleaning of boiler surfaces.
5. Explain the steps taken to reduce waterside and fireside corrosion during dry and wet storage of a boiler.
6. Explain the development, components and management of a corrosion prevention program for cooling water systems, including the selection, application and characteristics of biocides.
7. Explain the development, components and management of a corrosion prevention program for piping and pressure vessels.
8. Explain the development, components and management of a corrosion prevention program for rotating equipment.

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Topic 6 Fuel Types

Learning Outcome

Discuss the characteristics and applications of coal, oil, and non-conventional gaseous and liquid fuels.

Learning Objectives

1. Explain the factors involved in the selection of primary and secondary fuel for a new installation.
2. Describe the fuel handling considerations and fuel burning characteristics for non-conventional solid fuels, including municipal waste, petroleum coke and biomass.
3. Compare the fuel burning characteristics of non-conventional gaseous fuels, including refinery gas, landfill gas, digester gas, carbon monoxide, liquid petroleum gases (LPGs) and acid gases.
4. Compare the fuel burning characteristics of black liquor.
5. Compare the physical properties and fuel burning characteristics of different grades of oil.
6. Describe the considerations for coal cleaning and blending.
7. Describe the purpose and process of coal gasification.
8. Differentiate between low heating value and high heating value fuels.
9. Describe the design and operational considerations for the use of low heating value fuels.
10. Explain the economic considerations for fuel selection for multifuel burners.

Topic 7 Burner Design

Learning Outcome

Explain the criteria for burner design and selection.

Learning Objectives

1. Describe the general criteria for effective burner design.
2. Describe the classes of burner designs, based on the fuel in use.
3. Compare the design strategies for mixing fuel and air including: co-flow, cross-flow, flow stream disruption and entrainment.
4. Describe the design considerations for a duct burner.
5. Sketch a typical multi-nozzle duct burner layout.
6. Describe the relationship of burner selection to furnace design.
7. Describe the relationship between coal pulverizer selection and burner design.
8. Describe burner design methods to reduce noise.
9. Explain the principle, significance, application, and design of staged combustion burners, including staged fuel flow and staged airflow burners.

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Topic 8 Combustion Optimization

Learning Outcome

Explain the considerations for obtaining optimum efficiency and operation of burners.

Learning Objectives

1. Explain the inherent assumptions and factors considered when determining combustion efficiency.
2. Explain the methods and limitations for obtaining maximum efficiency from the combustion of gaseous fuels.
3. Explain the methods and limitations for obtaining maximum efficiency from the combustion of liquid fuels.
4. Explain the methods and limitations for obtaining maximum efficiency from the combustion of solid fuels.
5. Explain the economic and efficiency factors for fuel and burner management in real time operating conditions for a multifuel system.
6. Describe the use of electronic instruments to continuously monitor combustion efficiency.
7. Explain the significance of flame shape, color and temperature.
8. Explain the effect of excess air on combustion stability and boiler efficiency.
9. Explain the symptoms, significance and corrective action for common combustion problems.

Topic 9 Combustion Safety and Emissions

Learning Outcome

Discuss safety and environmental considerations in burner operation, including strategies for NO_X control.

Learning Objectives

1. Describe the requirements for safe operation of a combustion system.
2. Compare the significance of burner safety devices for different fuel types.
3. Explain the cause and prevention of furnace explosions in boilers and fired heaters.
4. Describe the processes for dust reduction in coal handling systems.
5. Describe the procedures for dealing with coal bunker and pulverizer fires.
6. Explain the effect of excess air and combustion efficiency on emissions parameters.
7. Explain pre-treatment as a strategy for NO_X reduction (fuel switching, additives and fuel pre-treatment).
8. Explain combustion and operational modification as a strategy for NO_X reduction (low NO_X burners, staged combustion, water/steam injection, burners out of service, low excess air and air preheat and furnace temperature reduction).
9. Explain process modification as a strategy for NO_X reduction (reduced production, electrical heating, improved thermal efficiency and product switching).
10. Explain post treatment as a strategy for NO_X reduction selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR).
11. Explain the effect on NO_X emissions of boiler design, boiler condition and boiler loading characteristics.
12. Explain the reasons for and significance of flue gas recirculation.

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Topic 10 Water Pre-Treatment

Learning Outcome

Describe the process used to treat raw water for power plants, including detailed chemistry where applicable.

Learning Objectives

1. Describe the mechanisms of coagulation and flocculation.
2. Describe the chemical processes and reactions of oxidation of organic contaminants.
3. Describe the chemical processes and reactions of iron and manganese removal from raw water.
4. Describe the chemical processes and reactions in a lime/soda softener.
5. Describe the chemical processes and reactions in a sodium zeolite softener.
6. Describe the chemical processes and reactions in a hydrogen zeolite softener.
7. Describe the chemical processes and reactions in a demineralizer.
8. Describe the chemical processes and reactions in a dealkalizer.
9. Describe the mechanisms of membrane technology, including chemical and mechanical cleaning methods and clean-in-place design.
10. Describe the chemical processes and mechanisms of electrodialysis (ED) and electrodeionization (EDI).
11. Describe the chemical processes and reactions of oxygen scavenging and metal passivation.
12. Describe the methods by which silica is removed from feedwater and condensate.

Topic 11 Internal Water Treatment

Learning Outcome

Describe the processes used to treat boiler water and condensate, including detailed chemistry where applicable.

Learning Objectives

1. Explain the principles, reactions and control of chelation.
2. Explain the principles, reactions and control of a coordinated phosphate program.
3. Explain the phenomenon of phosphate hideout.
4. Explain the principles, reactions and control of a congruent phosphate program.
5. Explain the principles, reactions and control of an equilibrium phosphate program.
6. Explain the principles, reactions and control of an all-volatile treatment program.
7. Explain the principles, reactions and control of a polymer treatment program.
8. Explain the principles, reactions and control of an oxygenated water treatment program.
9. Describe the mechanism of sludge conditioning.
10. Describe the mechanism of antifoam conditioning.
11. Describe the chemical processes and reactions of condensate treatment, including corrosion prevention, deaeration and polishing.

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Topic 12 Water Treatment Management

Learning Outcome

Explain the monitoring, management, and maintenance of water treatment systems.

Learning Objectives

1. Explain the financial management of the costs and benefits of water treatment.
2. Apply raw water analysis to the selection of a water treatment system.
3. Explain monitoring and control of cycle chemistry.
4. Describe the troubleshooting process when a cycle chemistry parameter deviates from the acceptable range.
5. Describe the selection and maintenance of resins for zeolite, demineralizer, dealkalizer, and condensate polisher service.
6. Describe the procedures and interpretation for tube deposit analyses.
7. Explain the inspection procedure for internal boiler components in relation to water treatment.
8. Describe a typical maintenance program for the components of water treatment systems, including: water filters, clarifiers and lime-soda softeners, sodium zeolite softeners, demineralizers, mixed bed and condensate polishers, reverse osmosis units, microfiltration, electrodialysis and electrodeionization units and deaerators.
9. Describe the selection, responsibilities and management of water treatment consultants.

Topic 13 Non-Boiler Water Treatment

Learning Outcome

Explain the monitoring and management of potable water and cooling water treatment systems.

Learning Objectives

1. Describe the regulatory requirements for potable water quality and monitoring.
2. Describe the parameters and interpretation of potable water analyses.
3. Describe the selection and mechanism of oxidation agents.
4. Describe the mechanism of ultra-violet sterilization.
5. Explain the components and management of a cooling water treatment program.
6. Describe the use and chemistry of biocides in cooling water.
7. Describe the use and chemistry of corrosion inhibitors in cooling water.
8. Explain the use of chelants in cooling water.
9. Explain the use of threshold scale inhibitors in cooling water.
10. Explain the use of surfactants, dispersants and biodispersants in cooling water.

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Major Topic: Power Plant Operations Topic 1

Electrical Energy Management Learning Outcome

Discuss the concepts and techniques of electrical energy management.

Learning Objectives

1. Explain the concept of energy management and identify the operational factors that are included in an energy management program.
2. Describe the significance, components, responsibilities and procedure of an energy audit.
3. Explain the significance and application of power factor management, including the effects of: capacitor banks, synchronous motors, inductive and resistive loads, transformers, voltage regulation for synchronous generators and synchronous compensators.
4. Calculate capacitor ratings required for power factor correction.
5. Explain, using a sketch, the purpose, applications, design and operation of a static uninterruptible power supply (UPS).
6. Explain the concept and significance of distributed generation, including the design implications for electrical distribution systems.
7. Describe the benefits of UPS in a distributed generation system, including the use of UPS as a bridge between utility and internal power.
8. Explain the benefits of motor-generator sets, internal combustion engines, and microturbines in a distributed generation system.
9. Explain the design, operating principle, and benefits of a fuel cell in a distributed generation system.
10. Explain the purpose, components, and operation of emergency power systems, including the physical interconnection between emergency power and main power.
11. Explain the concept, significance, and management of peak load reduction, including utility contract obligations and use of internal generation.
12. Explain the concept and principles of generation load dispatch including contract obligations.

Topic 2 Plant and Equipment Efficiencies

Learning Outcome

Explain and calculate power plant and equipment efficiencies.

Learning Objectives

1. Describe methods used to maximize efficiency of steam power plants and minimize energy losses.
2. Calculate boiler gross efficiency using input-output method and heat loss method.
3. Calculate turbine performance and efficiency.
4. Calculate the condensate savings and heat gained through improvements in condenser efficiency.
5. Describe the components and significant parameters of a typical computerized plant performance management system, including a program to reduce controllable losses.
6. Describe the efficiencies of a simple cycle gas turbine and various cycle improvements that can be made.
7. Describe different methods for waste heat recovery and the resultant improvement of efficiency.
8. Compare the inherent efficiencies of Once-Through Steam Generators (OTSG) with Heat Recovery Steam Generators (HRSG).
9. Calculate the steam generated and efficiency of a combined cycle plant, given system data.

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Topic 3 Power Plant Construction

Learning Outcome

Explain the regulations, processes, and procedures pertaining to the design, construction, and modification of plant facilities.

Learning Objectives

1. Describe the general criteria, including economics, which must be considered in determining the need for additional facilities and in deciding between new plant construction and existing plant expansion.
2. Describe the general criteria to be considered in the design of a new plant.
3. Describe the regulatory permitting processes for a construction project, including environmental feasibility study.
4. Describe a Quality Assurance/Quality Control (QA/QC) program for pressure equipment, including the process for accepting, receiving, and approving new and used vessels.
5. Describe the major considerations and steps involved in the construction of a new plant, from design to completion.
6. Explain the role of the Chief Power Engineer and regulatory inspectors in a plant construction project.
7. Explain the components and management of a construction health and safety program.
8. Explain the process of coordinating plant expansion activities with the operation of the existing plant, including tie-in of the old and new facilities.
9. Interpret, in detail, the information provided in construction drawings.

Topic 4 Commissioning and De-Commissioning

Learning Outcome

Explain the regulations, processes, and procedures pertaining to the commissioning and de-commissioning of plant facilities.

Learning Objectives

1. Explain the sequence for commissioning a new plant.
2. Explain the detailed procedures for commissioning a boiler.
3. Explain the detailed procedures for commissioning a steam turbine.
4. Explain the detailed procedures for commissioning a gas turbine.
5. Explain the detailed procedures for commissioning a piping system.
6. Explain the detailed procedures for commissioning a large fan.
7. Describe the content and significance of a performance contract/guarantee for new equipment or a new plant.
8. Explain the specific procedures for re-commissioning a plant after a major outage.
9. Explain the obligations and liabilities of de-commissioning a plant, including regulatory requirements.
10. Explain the specific procedures for de-commissioning a plant.

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Topic 5 Retrofitting

Learning Outcome

Explain the benefits, applications, and processes of retrofitting power plant equipment.

Learning Objectives

1. Explain the considerations that are used to determine whether replacement, re-powering, retrofitting or upgrading should be undertaken.
2. Explain the regulatory requirements for modifications to equipment and systems, including pressure equipment, electrical systems and environmental impact.
3. Explain the overall process and responsibilities when modifying or retrofitting plant systems.
4. Describe the benefits of control system retrofitting with “smart” instrumentation.
5. Describe the retrofitting methods used to improve boiler efficiency and capacity including superheater upgrades, economizer upgrades, combustion system upgrades, improved air heater seals, improved waterwall design, environmental enhancements and control upgrades.
6. Describe the retrofitting methods used to improve steam turbine efficiency including improved turbine blades and diaphragms, turbine stage additions and improved blade tip sealing.
7. Describe the retrofitting methods used to improve gas turbine efficiency including upgrading inlet guide vanes, improved seals, tighter clearances, improved combustion liners, improved turbine blades and vanes, thermal barrier coatings, compressor blade coatings, compressor stage additions and compressor supercharging.

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Major Topic: Inspection, Maintenance, and Repair Practices

Topic 1 Project Management

Learning Outcome

Demonstrate the application of project management practices.

Learning Objectives

1. Define a project, the role of project management and the makeup of the project stakeholders.
2. Identify the roles and responsibilities of a typical project team.
3. Explain in detail the project planning step.
4. Describe the common tools that are used for project planning and management, including Work Breakdown Structure (WBS), Critical Path Method (CPM) and Gantt charts.
5. Explain in detail the project execution step, including control processes.
6. Explain in detail the project completion step, including assessment and reporting.

Topic 2 Maintenance Management Practices

Learning Outcome

Explain management practices for typical maintenance programs.

Learning Objectives

1. Describe how equipment is managed through the concept of asset management.
2. Explain the purpose, components, and management of a maintenance program including preventive, predictive and corrective maintenance approaches.
3. Explain the concepts and importance of reliability centred maintenance (RCM) in developing a maintenance program.
4. Describe the major steps in performing an RCM analysis.
5. Provide an example of how RCM is applied.
6. Explain the purpose and process of root cause failure analysis (RCFA).
7. Describe how maintenance can be optimized.
8. Describe how a plant turnaround is planned and effectively executed.
9. Explain the concept, process, and benefits of outsourcing maintenance.
10. Explain the setting up and management of short-term maintenance contracts and long-term service agreements.
11. Explain the purpose and process of maintenance planning and scheduling.

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Topic 3 Boiler Repairs

Learning Outcome

Explain quality control programs and specific boiler repair procedures.

Learning Objectives

1. Explain the National Board of Boiler Inspectors (NBBI) requirements for owner inspection and quality control programs.
2. Describe in detail the components of owner inspection and quality control programs, including roles and responsibilities, records and reporting procedures.
3. Describe the roles, responsibilities, and personnel qualifications regarding repairs to boilers.
4. Explain the detailed procedure for repairs to cracks in boiler parts, including drums and headers.
5. Explain the detailed procedure for repairs to ruptured boiler tubes.
6. Explain the management, responsibilities, and procedures for safety valve repairs.

Topic 4 Pressure Vessel and Piping Repairs

Learning Outcome

Explain specific pressure vessel and piping inspection and repair procedures.

Learning Objectives

1. Describe the management roles, responsibilities, and qualifications regarding repairs to pressure vessels and pressure piping.
2. Explain the concept for fitness for service.
3. Describe in detail a typical pressure vessel inspection, identifying typical problem areas.
4. Describe in detail a typical pressure piping inspection identifying common problem areas.
5. Explain the detailed procedure for typical repairs to cracks in pressure vessels.
6. Explain the methods and detailed procedures for typical repairs to corrosion in pressure vessels.
7. Explain the detailed procedure for typical repairs to cracks in pressure piping.
8. Explain the methods and detailed procedures for typical repairs to corrosion in pressure piping.

Topic 5 Non-Destructive Examination

Learning Outcome

Explain the methods, applications, and control of non-destructive examination.

Learning Objectives

1. Explain the significance and application of ASME Section V.
2. Describe radiographic examination.
3. Describe the process of ultrasonic examination.
4. Describe the process of dye penetrant examination.
5. Describe the process of magnetic particle examination.
6. Describe the process of eddy current examination.
7. Describe the process of acoustic emission examination.
8. Explain the selection, management, and control of a non-destructive examination contractor.

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Topic 6 Rotating Equipment Maintenance

Learning Outcome

Explain specific maintenance procedures for, and typical maintenance problems of, rotating equipment.

Learning Objectives

1. Explain the typical maintenance problems of a large steam turbine.
2. Explain the procedures for inspection and overhaul of a large steam turbine.
3. Explain the typical maintenance problems of a gas turbine.
4. Explain the procedures for inspection and overhaul of a gas turbine.
5. Explain the typical maintenance problems of a large multi-stage pump.
6. Explain the procedures for inspection and overhaul of a large multi-stage pump.
7. Explain the typical maintenance problems of a large generator.
8. Explain the procedures for inspection and overhaul of a large generator.

Topic 7 Rotating Equipment Monitoring

Learning Outcome

Describe the parameters and methods of turbine monitoring and oil analysis.

Learning Objectives

1. Describe the purpose, importance and types of rotating equipment monitoring.
2. Explain the concept and significance of turbine thermal expansion, the general principles and placement of measuring devices and the procedures to control.
3. Explain the concept and significance of turbine differential expansion, the general principle and placement of measuring devices and the procedures to control.
4. Explain the concept and significance of turbine eccentricity, the general principle and placement of measuring devices and the procedures to control.
5. Explain the concept of vibration, including typical causes, effects, and locations of vibration in rotating equipment and how it is measured.
6. Explain the concept and significance of turbine critical speed.
7. Explain the concept and significance of oil whirl, oil whip, and steam whirl and the design and operational considerations to counter oil whirl.
8. Describe common oil problems and their effects on rotating equipment and a typical oil sampling and testing program.

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REFERENCE CURRICULUM

For

Thermal Power Plant Engineer
(2nd Class)

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Introduction

This Curriculum is intended to assist candidates studying for the Thermal Power Plant Engineer (2nd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Thermal Power Plant Engineer (2nd Class) Examination Candidates

Major Topic: Boilers and Water Treatment

Topic 1 Boiler and Steam Generator Components and Design

Learning Outcome

Discuss the components and design considerations of a steam generator.

Learning Objectives

1. Explain how the ratings of boilers and steam generators are calculated.
2. Explain the factors to be considered in designing a steam generator.
3. Contrast the influence of solid fuel, liquid fuel, and gas fuel on steam generator design.
4. Explain the principles of natural water circulation in a steam generator. Explain why forced circulation is used in a steam generator and how it is attained.
5. Explain the design, placement, and installation considerations for water walls, superheaters, desuperheaters, reheaters, economizers, and air heaters.
6. Explain the purpose and placement of screen tubes, division walls, water-cooled stringer tubes in superheaters, and wall-mounted radiant superheaters.
7. Describe top and bottom support systems for a steam generator.
8. Describe furnace casing design considerations.
9. Describe the purpose and use of specialized steam generator duct arrangements, including air heater bypass, economizer bypass, and air heater recirculation.
10. Describe the methods used to insulate different parts of a steam generator.
11. Explain the general steps used to construct a steam generator.

Topic 2 Specialized Boiler Designs

Learning Outcome

Identify and discuss common specialized boiler designs.

Learning Objectives

1. Describe typical designs, components, and operating strategies for once-through steam-flood boilers.
2. Describe typical designs, components, and operating strategies for fluidized bed boilers (bubbling bed and recirculating bed types).
3. Describe typical designs, components, and operating strategies for heat recovery steam generators.
4. Compare different designs of heat recovery steam generators (HRSG): natural circulation, controlled circulation and once-through (OTSG).
5. Describe typical designs, components, and operating strategies for supercritical steam generators.
6. Describe typical designs, components, and operating strategies for black liquor recovery boilers.
7. Describe typical designs, components, and operating strategies for refuse boilers used in waste disposal.
8. Describe typical designs, components, and operating strategies for biomass boilers.
9. Describe typical designs, components, and operating strategies for waste-heat boilers (firetube and watertube types).

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Topic 3 Boiler and Steam Generator Operation

Learning Outcome

Describe in detail the typical procedures for operation of a large steam generator.

Learning Objectives

1. Describe the detailed hot and cold startup procedures for a steam generator including safety precautions.
2. Describe the detailed shutdown procedure for a steam generator including safety precautions.
3. Describe the detailed lay-up procedures for a steam generator including safety precautions.
4. Describe the detailed refractory dry out procedure for a new steam generator including safety precautions.
5. Describe the detailed boil out procedure for a new steam generator including safety precautions.

Topic 4 Boiler and Steam Generator Maintenance and Inspection

Learning Outcome

Describe in detail the typical procedures for boiler maintenance and inspection.

Learning Objectives

1. Describe the mechanical cleaning procedures for a boiler including safety precautions.
2. Describe the detailed chemical cleaning procedures for a watertube boiler including safety precautions.
3. Describe the detailed hydrostatic testing procedure for a boiler including safety precautions.
4. Describe standard shutdown activities and preventive maintenance procedures required for a boiler.
5. Describe the detailed procedure for complete inspection of a boiler including waterside, fireside, and auxiliary equipment.
6. Describe boiler inspection techniques and equipment.
7 Describe the required inspection records and reporting procedures.
8. Describe the roles and responsibilities for an inspection including engineering staff, operators, and boiler inspector.
9. Describe the safety requirements during a boiler inspection.

Topic 5 Pumps

Learning Outcome

Discuss the application of large centrifugal pumps.

Learning Objectives

1. Explain selection criteria for pump applications.
2. Interpret pump operating characteristics and performance curves.
3. Describe the procedure for the installation of a large multi-stage centrifugal pump.
4. Describe the typical repairs and preventive maintenance procedures required for a multi-stage centrifugal pump.
5. Describe the methods of control for a multi-stage centrifugal pump including recirculation control.
6. Describe the selection criteria for seal types and materials in a centrifugal pump.
7. Describe the methods of counteracting thrust in a large centrifugal pump.

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Topic 6 Water Chemistry and Analysis

Learning Outcome

Discuss the significance of common water impurities, and the application of water analyses.

Learning Objectives

1. Describe the sources of the impurities found in raw water.
2. Describe the effect of the listed water impurities on power plant equipment and processes.
3. Explain the significance and importance of standard methods of water analysis.
4. Describe which analyses are appropriate at given sampling points including the significance of the sampling point locations.
5. Interpret the results of a comprehensive standardized water analysis including the relationship of the various parameters.
6. Explain the purposes and principles of testing instruments, including embrittlement detector, total solids meter, and pH meter.
7. Explain the purpose of steam purity measurement and process of steam sampling.

Topic 7 Water Pre-Treatment I

Learning Outcome

Describe water pre-treatment processes for removal of suspended solids, oil, and gases.

Learning Objectives

1. Explain the purpose, equipment, operation, and limitations of sedimentation.
2. Explain the purpose, equipment, operation, and limitations of coagulation and flocculation.
3. Explain the purpose, equipment, operation, and limitations of filtration.
4. Explain the purpose, principles, equipment, operation, and limitations of microfiltration.
5. Describe how oil is removed from water.
6. Explain the purpose, equipment, operation, and limitations of mechanical deaeration.
7. Explain the purpose, equipment, operation, and limitations of evaporation.

Topic 8 Water Pre-Treatment II

Learning Outcome

Describe water pre-treatment processes for ion removal.

Learning Objectives

1. Explain the purpose, equipment, and operation of lime-soda softening.
2. Explain the purpose, equipment, operation, and limitations of hot process phosphate softening.
3. Explain the purpose, equipment, operation, and limitations of sodium zeolite softening.
4. Explain the purpose, equipment, and operation of hydrogen zeolite softening.
5. Describe how silica is removed from water.
6. Explain the purpose, equipment, and operation, of demineralization, including condensate polishing.
7. Explain the purpose, equipment, and operation of electrodialysis (ED) and electrodeionization (EDI).
8. Explain the purpose, equipment and operation of reverse osmosis (RO).

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Topic 9 Internal Water Treatment

Learning Outcome

Describe boiler internal water treatment processes.

Learning Objectives

1. Explain the causes, effects, and control of scale.
2. Explain the causes, effects, and control of foam in boiler water.
3. Explain the causes, effects, and control of caustic embrittlement.
4. Explain the causes, effects, and control of return line corrosion.
5. Explain the use of chelating agents in boiler water.
6. Explain the use of sludge conditioning in boiler water.
7. Explain the use of pH control in boiler water.
8. Explain the use of chemical deaeration in boiler water.
9. Explain the causes, effects, and control of carryover of boiler water.
10. Explain the use of blowdown from boiler water.
11. Explain the use and control of chemical feed systems for boiler water.
12. Explain the control of silica to avoid turbine blade deposits.

Topic 10 Non-Boiler Water Treatment

Learning Outcome

Discuss water treatment applications for cooling water, wastewater, and potable water.

Learning Objectives

1. List the water impurities of concern in a cooling water system and the effects caused by each one.
2. Describe control methods for a cooling water system for control of corrosion, fouling, and microbiological attack including chloride corrosion, and delignification.
3. Describe the potential effects of wastewater discharge.
4. Compare and contrast mechanical, chemical, and biological methods of wastewater treatment including the advantages and disadvantages of each.
5. Specify an appropriate method of wastewater treatment for a particular case study.
6. Describe the methods used for potable water treatment and analysis.

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Major Topic: Thermodynamics and Metallurgy

Topic 1 Corrosion of Metals

Learning Outcome

Discuss corrosion mechanisms and corrosion prevention methods.

Learning Objectives

1. Define corrosion and explain the electrochemical principles involved.
2. Explain how the environment can affect corrosion.
3. Explain the most common corrosion mechanisms.
4. Describe the predominant corrosion mechanisms that potentially affect various power plant systems and equipment.
5. Explain methods used to monitor and test for corrosion during plant operation.
6. Explain the methods used to control and prevent corrosion at the design stages and during operation.
7. Explain the main components of a corrosion failure analysis and a typical corrosion failure report.

Major Topic: Prime Movers

Topic 1 Steam Turbine Theory and Construction

Learning Outcome

Explain the design and components of a large steam turbine, and perform nozzle and steam velocity calculations.

Learning Objectives

1. Explain selection criteria for a turbine application.
2. Describe the design and components of steam turbine casings and casing drains.
3. Describe the design and components of steam turbine rotors, blading, and diaphragms.
4. Describe shaft seal designs, including stuffing boxes, carbon rings, labyrinth, and water seals.
5. Describe the design and components of steam turbine bearings.
6. Describe the ways in which steam turbines are designed to counteract thrust.
7. Describe the purpose and design of expansion and anchoring components.
8. Explain the principles of steam turbine nozzle design.
9. Explain a steam turbine blade velocity diagram.
10. Calculate the steam velocity and angle of entry for impulse and reaction turbine blading.
11. Calculate the work done on steam turbine blades and the resulting power developed.
12. Calculate steam turbine Rankine cycle thermal efficiency.

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Topic 2 Steam Turbine Auxiliaries and Control

Learning Outcome

Explain the purpose and design of steam turbine auxiliaries, control, and monitoring equipment.

Learning Objectives

1. Describe the purpose, design and components of a turning gear.
2. Describe the purpose, design and components of an adjusting gear.
3. Explain critical speed.
4. Describe the design and components of lubricating oil and jacking oil systems.
5. Describe the design of speed reducing gears.
6. Describe the design and components of flexible couplings.
7. Describe the purpose and design of steam turbine governors and governor systems.
8. Describe the purpose and design of steam turbine stop valves and control valves.
9. Describe the purpose and design of steam turbine grid type extraction valves.
10. Describe the purpose and design of steam turbine casing pressure relief systems including rupture diaphragms.
11. Describe the purpose and design of steam turbine overspeed trips.
12. Describe the purpose and design of steam turbine supervisory equipment.

Topic 3 Steam Turbine Operation and Maintenance

Learning Outcome

Discuss procedures for operation and maintenance of a large steam turbine.

Learning Objectives

1. Describe the detailed hot and cold start-up procedures for a large steam turbine, including safety precautions.
2. Describe the detailed shutdown procedure for a large steam turbine including safety precautions.
3. Explain what checks are performed on a large steam turbine during normal operation.
4. Sketch the flow of steam and condensate through a condensing steam turbine and a non-condensing steam turbine.
5. Explain the preventive maintenance requirements for a large steam turbine. Include shaft alignment, bearings, clearances for thrust, blades, shaft seals, correction of blade fouling, erosion and cleaning.
6. Describe the purpose of and procedure for static and dynamic balancing.

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Topic 4 Steam Condensers

Learning Outcome

Discuss condenser principles, performance, operation and auxiliaries.

Learning Objectives

1. Describe the principles and design of jet, air cooled, and surface condensers.
2. Describe the purpose, principle and design of surface condenser support and expansion systems.
3. Explain the significant parameters in condenser performance.
4. Calculate condenser thermal efficiency from the test data.
5. Explain the procedures used to troubleshoot condenser performance.
6. Explain the procedures used to backwash and clean a condenser.
7. Describe the purpose, principle and design of air ejectors and vacuum pumps.
8. Describe the purpose and flow of cooling water systems.
9. Describe the purpose, principle and design of cooling water intake screens, circulating pumps, cooling towers, and cooling ponds.
10. Describe the purpose, principle and design of condenser atmospheric exhaust (relief) valves.
11. Describe the purpose, principle and design of condensate pumps.

Topic 5 Internal Combustion Engines: Components and Auxiliaries

Learning Outcome

Explain the design, selection, and components of internal combustion engine installations, including auxiliaries.

Learning Objectives

1. Explain design, applications, and selection criteria for the different types of reciprocating internal combustion engines.
2. Explain fuels and combustion processes used by internal combustion engines.
3. Describe the design of internal combustion engine scavenging and supercharging arrangements.
4. Describe the design and components of internal combustion engine fuel conditioning systems, injection systems, and ignition systems.
5. Describe the design and components of internal combustion engine cooling systems and cooling water conditioning systems.
6. Describe the purpose, design and components of internal combustion engine lubricating oil systems.
7. State the purpose and describe the control of a typical internal combustion engine including the operation of safety devices.

Topic 6 Internal Combustion Engines: Operation and Maintenance

Learning Outcome

Describe general maintenance requirements, and detailed operating and troubleshooting procedures for internal combustion engines.

Learning Objectives

1. Describe the detailed startup procedures for an internal combustion engine.
2. Describe the detailed shutdown procedures for an internal combustion engine.
3. Explain the routine maintenance and monitoring requirements for an internal combustion engine.
4. Explain the major maintenance and overhaul requirements for an internal combustion engine.
5. Explain the troubleshooting of combustion and engine problems.

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Topic 7 Gas Turbine Design and Auxiliaries

Learning Outcome

Explain the design and components of a large gas turbine and related auxiliaries.

Learning Objectives

1. Explain applications and selection criteria for the different types of gas turbine engines.
2. Describe the principles and design of open and closed cycle gas turbine systems.
3. Describe the principles and design of combined cycle and cogeneration systems using gas turbines.
4. Describe the principles and design of gas turbine regeneration, intercooling, and reheating.
5. Describe the principles and design of gas turbine shaft arrangements.
6. Describe the design and components of gas turbine compressors, combustors (combustion chambers) and turbines.
7. Describe the design and operation of gas turbine air intake and exhaust systems.
8. Describe the design and operation of a gas turbine lubricating oil system.
9. Describe the design and operation of a gas turbine fuel system.
10. Describe the design and operation of a gas turbine steam or water injection system and a dry low NO_X system.

Topic 8 Gas Turbine Operation and Control

Learning Outcome

Discuss operating procedures, and control and monitoring components of a large gas turbine.

Learning Objectives

1. Describe the components and operation of gas turbine supervisory and control systems.
2. Describe the principles and design of gas turbine protection devices.
3. Describe the detailed hot and cold startup procedures for a gas turbine, including safety precautions.
4. Describe the detailed shutdown procedure for a gas turbine, including safety precautions.
5. Explain the routine maintenance and monitoring requirements for a gas turbine.
6. Describe the major maintenance and overhaul requirements for a gas turbine.
7. Explain the troubleshooting of gas turbine problems.

Topic 9 Lubrication

Learning Outcome

Explain the components of a lubrication application and maintenance program.

Learning Objectives

1. Describe the methods of manufacture and the different classifications of lubricants.
2. Describe the significance and measurement of lubricating oil characteristics, including viscosity, relative density, API (American Petroleum Institute) gravity, pour point, and dielectric strength.
3. Explain the typical causes of lubricating oil deterioration.
4. Describe the types of lubrication additives.
5. Describe a typical power plant lubrication program, including a lubrication survey.
6. Explain the different types of lubricating/governing/seal oil systems.
7. Describe the components and operation of a typical lubricating oil purification system.
8. Describe the various applications of ball-and-roller bearings and their lubrication, including bearing seals.

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Topic 10 Piping

Learning Outcome

Explain piping system design, inspection, and maintenance.

Learning Objectives

1. Explain selection criteria for piping materials.
2. Calculate the required thickness and the internal design pressure of piping.
3. Describe typical inspection procedures for piping installations and repairs.
4. Describe a typical routine inspection procedure and schedule for high-energy piping.
5. Explain the effects of high temperature on piping strength.
6. Describe the design and installation criteria for a piping system layout.
7. Explain the theory and effects of water hammer.

Major Topic: Combustion and Plant Systems

Topic 1 Power Plant Fuel Systems

Learning Outcome

Describe the design and operation of typical power plant systems.

Learning Objectives

1. Describe, using a sketch, the design and operation of fuel oil supply systems.
2. Describe, using a sketch, the design and operation of fuel gas supply systems.
3. Describe, using a sketch, the design and operation of solid fuel supply systems.

Topic 2 Power Plant Water and Steam Systems

Learning Outcome

Describe the design and operation of power plant systems.

Learning Objectives

1. Describe, using a sketch, the design and operation of feedwater systems.
2. Describe, using a sketch, the design and operation of steam distribution systems.
3. Describe, using a sketch, the design and operation of condensate systems.
4. Describe, using a sketch, the design and operation of cooling water systems.
5. Describe, using a sketch, the design and operation of waste handling systems.
6. Explain how different power plant water systems interconnect and what parameters are significant to each.

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Topic 3 Measurement and Control Components

Learning Outcome

Explain the design and application of measuring devices and final control elements.

Learning Objectives

1. Describe the design, use, and placement of electrical and electronic pressure measuring devices.
2. Describe the design, use, and placement of electrical and electronic temperature measuring devices.
3. Describe the design, use, and placement of Venturi tubes, orifice plates, flow nozzles, and Pitot tubes.
4. Describe the design and use of: manometers, ring balance, force balance, and electric flow indicating mechanisms.
5. Describe the design, use, and placement of the following liquid level measurement devices: ball-float, displacement-type, hydrostatic head, electric and pneumatic level transmission, electric and magnetic type level-limit devices, and remote water-level indicators.
6. Describe the types, construction, and flow characteristics of control valves.
7. Describe the design, operation, and application of the following valve operators: solenoid, pneumatic-diaphragm, power cylinder, and electric motor.

Topic 4 Control Instrumentation Systems

Learning Outcome

Explain and apply the theory of automatic boiler, distributed control, and programmable logic control systems.

Learning Objectives

1. Describe the principle, design, application, and limitations of the following automatic control methods: proportional, proportional-plus-reset, and proportional-plus-reset-plus-rate.
2. Describe the principle, design, application, and limitations of single, two, and three-element boiler feedwater control systems.
3. Describe the principle, design, application, and limitations of superheated and reheated steam temperature control systems.
4. Describe the principle, design, components, application, and limitations of Distributed Control Systems (DCS).
5. Describe the principle, design, application, and limitations of Programmable Logic Controllers (PLC).

Topic 5 Fuels and Combustion Calculations

Learning Outcome

Perform combustion and furnace draft calculations and explain flue gas analysis.

Learning Objectives

1. Describe the nature of combustion and the different types of fuels.
2. Calculate the mass and volumetric analysis of a fuel.
3. Describe proximate and ultimate analysis and calculate the heating value of fuel.
4. Given the results of a bomb calorimeter test, calculate the heating value of a fuel.
5. Calculate the amount of air and excess air required for combustion of fuel.
6. Explain flue gas analysis parameters and their significance.
7. Calculate theoretical draft, flue gas velocity, and stack diameter.
8. Calculate draft fan power and efficiency.

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Topic 6 Firing and Draf t Equipment

Learning Outcome

Explain the design, components, and auxiliary equipment of steam generator furnaces.

Learning Objectives

1. Describe steam generator furnace designs including cyclone furnaces and divided furnaces. Explain the purpose and placement of furnace arches.
2. Explain the purpose and design of separately fired superheat and reheat furnaces.
3. Explain the purpose, types, characteristics, and placement of refractory in a furnace.
4. Describe the principle, design, and application of oil, gas, and coal burners.
5. Describe the principle, design, and application of pulverizers.
6. Describe the principle, design, and application of ash and slag disposal systems.
7. Explain the significance, monitoring, and control of ash fusion temperature.
8. Describe the designs and applications of forced and induced draft fans.
9. Explain the methods which control furnace draft.

Topic 7 Combustion Control and Safeguards

Learning Outcome

Explain combustion control methods and safeguard components.

Learning Objectives

1. Describe, using a sketch, the combustion control arrangements in a steam generator.
2. Explain series, parallel, and series/parallel combustion control.
3. Explain turbine-following, boiler-following, and integrated combustion control systems.
4. Describe the operation of purge, fan failure, and flame failure interlock systems.
5. Describe the operation of flame detectors.
6. Describe, using a sketch, a typical programming sequence for a packaged boiler control system.
7. Describe the typical limiting devices and alarms for a packaged boiler combustion system.

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Major Topic: Electricity and Refrigeration

Topic 1 Alternating Current Theory

Learning Outcome

Explain characteristics and perform calculations involving AC circuits.

Learning Objectives

1. Explain the vector relationships between AC voltage and current.
2. Explain the significance of root mean square values for AC sine waves. Calculate root mean square and peak-to-peak values for AC sine waves.
3. Explain voltage/current relationships and calculate power in purely resistive circuits.
4. Explain voltage/current relationships in purely inductive circuits.
5. Explain voltage/current relationships in purely capacitive circuits.
6. Explain voltage and current relationships in circuits having resistance/inductance and resistance/capacitance combinations.
7. Calculate impedance, reactance, true and apparent power, and power factor in AC circuits.
8. Explain the significance of power factor and how it can be improved in AC circuits.
9. Explain the principle and significance of three-phase AC circuits, star, and delta connections in alternators, transformers and AC motors.
10. Calculate phase voltage, phase current and apparent and true power in a three-phase AC circuit.

Topic 2 Direct Current Machines

Learning Outcome

Explain the construction and operating principles of DC generators and motors.

Learning Objectives

1. Describe the construction and operating principles of a DC generator.
2. Explain the principle and application of compensating windings, interpoles, and lap and wave armature windings.
3. Explain the principles, applications, and load/voltage characteristics of generators.
4. Describe the parallel operation and voltage regulation of DC generators.
5. Review the principle of DC motor operation, including torque development and back EMF.
6. Calculate torque and speed of a DC motor.
7. Explain the principle and application of shunt, series, and compound-wound DC motors including speed control.
8. Explain the principle and application of counter-E, current limit and time limit DC motor automatic starters.
9. Explain the principle and application of dynamic and regenerative braking.
10. Calculate efficiency and discuss the reasons for power losses in a DC motor and generator.

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Topic 3 Alternating Current Generators

Learning Outcome

Explain the construction and operating principles of AC generators.

Learning Objectives

1. Explain the operating principles, design and construction of alternators with salient-pole and cylindrical rotors.
2. Explain the relationship between alternator speed, frequency, and number of pole pairs.
3. Describe the purpose and construction of an exciter.
4. Describe the purpose and design of alternator voltage regulators.
5. Describe alternator cooling systems, including circulating air cooling, hydrogen cooling, and stator winding cooling water systems.
6. Describe shaft sealing arrangements for an alternator.
7. Explain the theory and significance of alternator synchronization and parallel operation including the impact on power factor.
8. Explain efficiency and power losses in an AC generator.

Topic 4 Alternating Current Motors

Learning Outcome

Explain the construction and operating principles of AC motors.

Learning Objectives

1. Describe the principle of a pulsating magnetic field for single-phase AC motors and rotating magnetic field for three-phase AC motors. Describe general rotor and stator construction.
2. Describe the torque/speed characteristics of induction motors and the relationship between torque, slip and rotor speed.
3. Define full-load amps, locked rotor amps and service factor amps.
4. Describe the principles, applications, and operation of wound rotor motors.
5. Describe the principles, applications, and operation of single-phase AC motors. Include universal, shaded-pole, split-phase, capacitance-start, repulsion-start, and reluctance-start.
6. Describe the principles, applications, starting methods and operation of a synchronous motor.

Topic 5 Transformers

Learning Outcome

Explain the construction and operating principles of transformers.

Learning Objectives

1. Describe the construction of core type and shell type transformers.
2. Explain the factors that affect transformer rating.
3. Calculate load, power, iron and copper losses, and efficiency in a transformer.
4. Explain the purpose and procedures for transformer short and open circuit tests.
5. Describe the methods of cooling a transformer.
6. Describe the methods of connecting a transformer, including delta-delta, star-star, delta-star, and star-delta.
7. Explain the theory and significance of transformer paralleling.
8. Describe the applications of instrument transformers.
9. Describe the protective measures and devices used on transformers.

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Topic 6 Electrical System Protection

Learning Outcome

Describe the protective devices used on alternators, motors, and electrical circuits.

Learning Objectives

1. Describe the significance of fuses and circuit breakers for circuit protection including continuous rating, interrupting capacity, and inverse time principle.
2. Describe the purpose and designs of different types of fuses.
3. Describe the operation of circuit breakers used for different voltages, including moulded-case, oil-immersed, airblast, air-break, vacuum, and SF_6 switchgear.
4. Describe the operation of switches and contactors used for different voltages.
5. Explain the purpose, and significance of protection relaying as it applies to a large alternator.
6. Explain the purpose and significance of the protection devices for a large electric motor.

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REFERENCE CURRICULUM

For

Thermal Power Plant Operator

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Introduction

This Curriculum is intended to assist candidates studying for the Thermal Power Plant Operator Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Thermal Power Plant Operator Examination Candidates

Major Topic: Boiler Codes, Electrical and Instrumentation Theory

Topic 1 Fuels, Combustion, and Flue Gas Analysis

Learning Outcome

Explain the properties and combustion of common fuels and the analysis of combustion flue gas.

Learning Objectives

1. Explain/define complete combustion, incomplete combustion, combustion products, and write balanced combustion equations.
2. Explain the purpose and benefits of excess air and calculate the theoretical and excess air required for the complete combustion of a given fuel.
3. Explain proximate analysis, ultimate analysis, and heating value of a fuel and describe the use of calorimetry to determine heating value. Explain higher and lower heating values.
4. Given the ultimate analysis of a fuel, use Dulong's Formula to calculate the heating value of the fuel.
5. Describe the properties, classifications and combustion characteristics of coal.
6. Describe the properties, classifications and combustion characteristics of fuel oil.
7. Describe the properties and combustion characteristics of natural gas.
8. Explain the use and combustion characteristics of alternatives to traditional fossil fuels, including biomass, coke and oil emulsions.
9. Explain the analysis of flue gas for the measurement of O_2, CO, and CO_2 in relation to combustion efficiency. Describe typical, automatic flue gas analyzers.
10. Explain the formation, monitoring and control of nitrogen oxides (NO_X), sulfur dioxide, and particulates.

Topic 2 Piping Design, Connections, Support

Learning Outcome

Discuss the codes, designs, specifications, and connections for ferrous, non-ferrous and non-metallic piping and explain expansion and support devices common to piping systems.

Learning Objectives

1. Identify and explain the general scope of the ASME, ANSI, ASTM codes and standards with respect to piping and pipe fittings. Differentiate between power piping (Code B31.1) and pressure piping (Code B31.3).
2. Explain methods of pipe manufacture; size specifications and service ratings, and the material specifications and applications for ferrous pipe.
3. Using pipe specifications and the ASME code Sections I and II you will be able to identify the size of pipe required for a particular installation, process or operating condition.
4. Explain the materials, code specifications and applications of common, non-ferrous metal piping and cast iron.
5. Describe screwed, welded, and flanged methods of pipe connection and identify the fittings used for each method.
6. Describe the construction, designs, and materials of flange gaskets and explain the confined, semi-confined, and unconfined flange styles.
7. Explain the materials, construction and approved applications of common, non-metallic pipe.
8. Explain the effects of temperature on piping; explain the mechanisms and the dangers of expansion in piping systems, including attached equipment.
9. State the purpose and explain the designs, locations and applications of simple and offset U-bend expansion bends.
10. Describe designs, locations, care and maintenance of slip, corrugated, bellows, hinged, universal, pressure-balanced, and externally pressurized expansion joints.
11. Describe design, location, operation of pipe support components, including hangers, roller stands, variable spring hangers, constant load hangers, anchors, and guides.

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Topic 3 Steam Traps, Water Hammer, Insulation

Learning Outcome

Explain the designs and operation of steam trap systems, the causes and prevention of water hammer, and the designs and applications of pipe insulation.

Learning Objectives

1. Explain the dynamics, design, and components of steam/condensate return systems for steam lines and condensing vessels. Explain roles and locations of separators and traps.
2. Describe the design, operation and application of ball float, inverted bucket, thermostatic, bi-metallic, impulse, controlled disc, and liquid expansion steam traps.
3. Explain the selection, sizing and capacity of steam traps and explain the factors that determine efficient trap operation.
4. Explain the procedures for commissioning, testing, and maintenance of steam traps.
5. Explain and compare condensate-induced and flow-induced water hammer in steam and condensate lines. Explain the typical velocities, pressures and damage that can be created in steam/condensate lines due to water hammer.
6. Describe specific trap and condensate return arrangements that are designed to prevent water hammer in steam and condensate lines.
7. State precautions that must be observed to prevent water hammer and describe a typical steam system start-up procedure that will prevent water hammer.
8. State the purposes of insulation and explain the properties required for a good insulating material. Explain thermal conductivity, K-Factor and R-Value.
9. Identify the most common industrial insulating materials, describe the composition and characteristics of each, and explain in what service each would be used.
10. Describe common methods for applying insulation to piping and equipment, including wrap and clad, blanket, insulated covers and boxes. Explain the care of insulation and cladding and the importance of maintaining good condition.

Topic 4 Valves and Actuators

Learning Outcome

Describe the designs, configurations and operation of the common valve designs that are used in power and process piping.

Learning Objectives

1. Explain the factors that determine the suitability and applications of the major valve styles; gate, globe, ball, plug, butterfly and needle.
2. Explain the factors that determine the selection of valve materials, and describe examples of typical valve body and trim materials. How are common control valves identified?
3. Describe the configurations and applications for gate valves, including gate designs (solid, split, flexible, sliding), stem configurations (rising, non-rising, outside screw-and-yoke, inside screw), and bonnet designs (flanged, screwed, welded).
4. Describe the designs and applications of globe valves, including conventional disc, composition disc, plug-type disc, and angle valves. Describe high-pressure plug-type control valves.
5. Describe the designs, application and operation of single-seated and double-seated balance valves. Explain caged trim for balanced control valves.
6. Describe the designs and applications of typical plug valves, including tapered and cylindrical plug, four-way, eccentric, and jacketed.
7. Describe the designs and configurations for mixing and diverter valves.
8. Describe the designs and operation of diaphragm valves.
9. Describe designs and operation of butterfly valves, including vertical, horizontal, swing-through, lined, and high-performance.
10. Describe the design, application, and operation of gear, motor, air-diaphragm, and air-piston actuators for valves.

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Topic 5 Electrical Theory and DC Machines

Learning Outcome

Explain basic concepts in the production of electricity and the design, characteristics and operation of DC generators and motors.

Learning Objectives

1. Explain the production of electron flow in a circuit and define circuit voltage, amperage and resistance.
2. Explain electromagnetic induction and how it produces generator action and motor action.
3. Describe the design and operating principles of a DC generator or motor, clearly stating the purposes of the armature, brushes, windings and poles.
4. Explain how back EMF, armature reaction, and torque are created and their influence on a DC generator. Given the speed, flux, number of poles, and number of conductors, calculate the back EMF induced in a DC generator.
5. Explain separate and self excitation and describe the voltage/load characteristics of shunt, series and compound generators. State where the various types would be used. Explain how excitation of a DC generator is controlled.
6. Explain the speed/load characteristics of shunt, series and compound DC motors; define and calculate percent speed regulation and explain how speed is controlled in DC motors.
7. Explain DC motor torque characteristics and describe the starting mechanisms for DC motors.

Topic 6 AC Theory and Machines

Learning Outcome

Explain formation and characteristics of AC power, and describe the design, construction and operating principles of AC generators, motors and transformers.

Learning Objectives

1. Explain the creation of single phase and three-phase alternating power; define cycle, frequency and phase relationships (voltage/current) for AC sine waves.
2. Define the following terms and explain their relationships in an ac circuit: capacitance, inductance, reactance, impedance, power factor, alternator ratings (kVA and kW).
3. Describe the stator and rotor designs, operation, and applications for salient pole and cylindrical rotor alternators
4. Describe water, air and hydrogen cooling systems for large generators.
5. Explain parallel operation of alternators and state the requirements for synchronization. Describe manual and automatic synchronization.
6. Describe the design, applications and operating principles for large three-phase squirrel cage and wound rotor induction motors.
7. Describe the design and operating principle of synchronous motors.
8. Explain variable speed control, variable speed starting, and step starting for large induction motors.
9. Explain the principles and applications of power transformation. Perform transformer calculations.
10. Describe the designs and components of typical core and shell type transformers, including cooling components.

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Topic 7 AC Systems, Switchgear, Safety

Learning Outcome

Identify the components of typical AC systems and switchgear and discuss safety around electrical systems and equipment.

Learning Objectives

1. Using a one-line electrical drawing, identify the layout of a typical industrial AC power system with multiple generators, and explain the interaction of the major components.
2. Explain the function of the typical gages, meters, and switches on an AC generator panel.
3. Explain the purpose and function of the circuit protective and switching equipment associated with an AC generator: fuses, safety switches, circuit breakers, circuit protection relays, automatic bus switchover, grounding and lightning arrestors.
4. Explain the components and operation of a typical Uninterruptible Power Supply (UPS) system.
5. Explain safety procedures and precautions that must be exercised when working around and operating electrical system components. Explain grounding.

Topic 8 Electrical Calculations

Learning Outcome

Define terms and perform simple calculations involving DC and AC power circuits.

Learning Objectives

1. Use Ohm's Law and Kirchhoff's Laws to calculate current, resistance or voltage drop in series or parallel multi-resistor circuits.
2. Calculate unknown resistances using a Wheatstone Bridge circuit.
3. Explain and perform calculations involving electrical power, work and energy.
4. Calculate the frequency, period and phase angle for an AC sine wave.
5. Define terms and calculate the peak-to-peak, root mean square, and maximum values for AC voltage and current.
6. Given required parameters, calculate the inductive reactance, capacitive reactance, total reactance, and impedance for an AC circuit, plus circuit frequency and current flow.
7. Calculate real power, imaginary power and power factor for an AC circuit.
8. Given the load, voltage and power factor of a 3-phase generator, calculate the kVA and kW ratings of the generator.

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Topic 9 Control Loops and Strategies

Learning Outcome

Explain the operation and components of pneumatic, electronic and digital control loops, and discuss control modes and strategies.

Learning Objectives

1. Describe the operation, components and terminologies for a typical control loop.
2. Describe the operation and components of a purely pneumatic control loop. Explain the function of each component.
3. Describe the operation and components of an analog/electronic control loop. Explain the function of each component.
4. Describe the operation and components of a digital control loop. Explain the function of each component.
5. Explain the purpose, operation, and give examples of on-off, proportional, proportional-plus-reset, and proportional-plus-reset-plus-derivative control. Define proportional band and gain.
6. Describe and give typical examples of feed forward, feed back, cascade, ratio, split-range, and select control.
7. Explain, with examples, the purpose and incorporation of alarms and shutdowns into a control loop/ system.
8. Explain the interactions that occur and the interfaces that exist between an operator and the various components of a control loop/system, including the components of a controller interface.

Topic 10 Instrument and Control Devices

Learning Outcome

Explain the operating principles of various instrument devices that are used to measure and control process conditions.

Learning Objectives

1. Describe the design, operation and applications for the following temperature devices: bimetallic thermometer, filled thermal element, thermocouple, RTD, thermistor, radiation and optical pyrometers
2. Describe the design, operation and applications for the following pressure devices: bourdon tubes, bellows, capsules, diaphragms, and absolute pressure gage.
3. Describe the design, operation and applications for the following flow devices: orifice plate, venturi tube, flow nozzle, square root extractor, pitot tube, elbow taps, target meter, variable area, nutating disc, rotary meter and magnetic flowmeter.
4. Describe the design, operation and applications for the following level devices: atmospheric and pressure bubblers, diaphragm box, differential pressure transmitter, capacitance probe, conductance probes, radiation and ultrasonic detectors and load cells.

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Topic 11 Distributed and Logic Control

Learning Outcome

Explain the general purpose, design, components and operation of distributed and programmable logic control systems.

Learning Objectives

1. Explain distributed control and describe the layout and functioning of a typical distributed control system. Explain the function of each major component of the system.
2. Identify and explain the functions of the major components of the operator interface unit (OIU), including controller interfaces, displays, alarms and shutdown.
3. State typical applications and explain the purpose and functioning of a programmable logic controller, including the operator interfaces. Explain a ladder logic diagram.
4. State the purpose and explain the general functioning of a communication and data acquisition system (eg. SCADA) as it relates to process control.

Major Topic: Pumps and Boilers

Topic 1 Watertube Boiler Designs

Learning Outcome

Describe common designs, configurations and circulation patterns for modern bent-tube watertube boilers and steam generators and explain how boilers are rated.

Learning Objectives

1. Explain the difference between packaged, shop assembled, and field-erected watertube boilers. Explain how boilers are rated.
2. Explain the process of water circulation in a watertube boiler and the factors that influence circulation.
3. Identify examples of and describe the A, O, and D design configurations and explain the water and gas circulation patterns for each. Define integral furnace.
4. Define a steam-generating unit, identify oil and gas-fired units, and explain the components, heating surfaces, and flow patterns through a typical unit. State typical temperatures throughout the unit.
5. Differentiate between critical and super-critical boilers.
6. Explain the purpose and advantage of forced circulation and describe the flow through a typical controlled circulation boiler.
7. Explain the purpose and design of a once-through boiler.

Topic 2 Special Boiler Designs

Learning Outcome

Describe the designs, components, firing methods, and operating considerations for some special boilers used in industry.

Learning Objectives

1. Describe typical designs, components and operating strategies for once-through, steam flood boilers.
2. Describe typical designs, components and operating strategies for Fluidized Bed boilers.
3. Describe typical designs, components and operating strategies for Heat Recovery Steam Generators.
4. Describe typical designs, components and operating strategies for Black Liquor Recovery boilers used in pulp mills.
5. Describe typical designs, components and operating strategies for Refuse boilers used in waste disposal.
6. Describe typical designs, components and operating strategies for waste heat, biomass boilers.

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Topic 3 Boiler Construction

Learning Outcome

Explain Code requirements, in general terms, and describe construction and assembly methods for the major components of a large boiler.

Learning Objectives

1. Explain top and bottom support and describe the support techniques for various components of a large boiler, including lateral supports for furnace walls. Explain allowances for expansion.
2. Explain the purpose, design, locations and installation methods for boiler casing insulation, refractory, and cladding.
3. Describe the methods used to fabricate boiler tubes.
4. Describe the preparation, fabrication, and testing of boiler drums.
5. Describe methods of attaching tubes to drums and headers, including expanding and welding, and explain where each method would be used.
6. Explain code requirements/sizes for, and describe the designs and installation of, manholes and handholes, including welded handholes. Explain procedures for removing and installing covers.
7. Describe the field assembly of a large boiler or steam generating unit.

Topic 4 Boiler Heat Transfer Components

Learning Outcome

Explain the purpose, location, design and operating conditions for the major heat transfer components of a large watertube boiler or steam generator.

Learning Objectives

1. Describe baffle designs and locations and explain their significance to boiler heat transfer.
2. Describe the designs of integral furnace sidewall and header arrangements, including tube-and-tile, tangent tube, and membrane.
3. Define primary, secondary, convection, radiation, platen, and pendant as they apply to superheaters. Describe the locations of superheaters within a steam generator and state the operating characteristics of convection and radiant superheaters.
4. Explain the purpose and design of a separately-fired superheater.
5. Explain the purpose and describe the locations of reheaters. Explain the position of and flow through the reheater in relation to the superheaters.
6. Describe designs and locations for integral and separate economizers.
7. Describe the designs, operation, and location of plate, tubular, and rotary regenerative air heaters.
8. Explain operating care and considerations that must be given to the various heat transfer sections of the boiler.
9. Explain a typical water and gas temperature profile through a large steam generating unit.

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Topic 5 High Pressure Boiler Fittings

Learning Outcome

Describe the design and operation of common external and internal fittings attached to the pressure side of a high-pressure boiler.

Learning Objectives

1. Describe the design, installation, operation, and setting of a high-pressure pressure relief valve. Explain the Code requirements for size, capacity and locations of the pressure relief valves on a boiler.
2. Describe the code requirements for boiler pressure gages, including attachment and locations.
3. Describe common designs, connections and components of high-pressure water columns and flat gage glasses, including illumination and quick shut-off devices and bulls-eye glasses. Explain testing and maintenance of a high-pressure gage glass.
4. Describe the float and probe designs for low-water fuel cutoffs and explain how these are tested.
5. Describe boiler steam outlet arrangements and fittings including gate, angle, and globe stop valves and globe, Y, angle, and spring-cushioned non-return valves.
6. Describe manual blowoff piping arrangements. Describe the design and operation of sliding disc, seatless sliding plunger, seat and disc, and combination valves. Explain manual blowoff procedures. Describe the requirements for a blowoff tank.
7. Explain the components of the steam drum internals of a watertube boiler. Describe the design and operation of various steam separation devices, including baffles, primary and secondary separators, and scrubbers.

Topic 6 Burner Designs and Supply Systems

Learning Outcome

Describe the typical components of fuel supply systems and describe common burner/furnace designs for gas, oil, and coal-fired boilers.

Learning Objectives

1. Describe a complete fuel gas supply system from fuel gas header to burner and explain the function of each component, including control and shut-off valves, auto-vents, and instruments. State the typical operating pressures.
2. Describe the design and operation of spud and ring burners, and explain high-efficiency, low NO_X designs.
3. Describe a complete fuel oil supply system from storage tanks to burners and explain the function of each system component.
4. Describe the design and operation of air, steam, and mechanical atomizing burners.
5. Describe a coal supply system from stockpiles to burners for a typical pulverized coal furnace.
6. Describe the design and operation of a pulverized coal burner and explain turbulent vertical, tangential, and cyclone furnaces.
7. Describe the design and operation of ball, impact, ball-race, and bowl mill pulverizers.
8. Describe the designs and operation of underfeed, overfeed, and crossfeed stokers for furnaces burning solid fuels.

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Topic 7 Boiler Draft and Flue Gas Equipment

Learning Outcome

Explain boiler draft systems and fans and describe the equipment used to remove ash from flue gas.

Learning Objectives

1. Define and explain the applications and designs of natural, forced, induced and balanced draft.
2. Explain how draft is measured, monitored, and controlled in a large, balanced draft boiler. Explain the position of control dampers.
3. Describe typical draft fan designs, single and double inlet arrangements, and explain methods used to control fan output.
4. Explain the start-up and running checks that must be made on draft fans.
5. Describe typical windbox and air louver arrangements and distinguish between primary and secondary air.
6. Describe the design and operation of flue gas particulate clean-up equipment, including mechanical and electrostatic precipitators and baghouse filters.
7. Describe the design and operation of ash handling systems, including hydro and air systems, bottom ash systems, and scraper conveyor systems.
8. Describe the designs and operation of SO_2 recovery systems, including lime and wet gas scrubbing.

Topic 8 Boiler Control Systems

Learning Outcome

Explain the components and operation of automatic control systems for boiler water level, combustion, steam temperature, and start-up.

Learning Objectives

1. Describe on-off and single element control of boiler feedwater.
2. Explain swell and shrinkage in a boiler. Describe the components and operation of a two-element feedwater control system, explaining the interaction of the controllers.
3. Describe the components and operation of a three-element feedwater control system.
4. Describe the components and operation of a direct combustion control system.
5. Describe the components and operation of a ‘steam flow – airflow’ combustion control system.
6. Describe the components and operation of a ‘fuel flow – airflow’ combustion control system.
7. Describe the components and operation of an ‘airflow – fuel flow’ combustion control system.
8. Describe the components and operation of a multi-element combustion control system.
9. Describe steam temperature control methods and equipment, including attemperation (desuperheating), gas recirculation, gas bypass, and tilting burners.
10. Describe the automatic, programmed start-up sequence for a gas-fired boiler.

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Topic 9 Boiler Procedures

Learning Outcome

Describe common procedures in the operation and maintenance of high pressure boilers.

Learning Objectives

1. Explain the steps involved in the commissioning of a new boiler or before starting a boiler after major repairs, including:
   a) hydrostatic test
   b) external and internal inspections
   c) drying out refractory
   d) boiling out
   e) testing shutdowns and safety devices
2. Describe the wet and dry methods when laying up a boiler for an extended time, including nitrogen blanketing.
3. Describe the proper shut down and preparation of a boiler for internal inspection.
4. Describe a thorough inspection of the water and furnace sides of a boiler.
5. Describe typical equipment and procedures for cleaning the water side of a boiler:
   a) mechanically
   b) chemically
6. Explain routine tasks and visual monitoring that the operator must perform on a large operating boiler.
7. Explain the procedures and precautions that an operator must exercise to avoid furnace and pressure-side explosions.
8. Describe sootblowing systems and describe the procedures for operating sootblowers.

Topic 10 Internal Water Treatment for Boilers

Learning Outcome

Discuss internal water treatment methods and systems for the control of scale, corrosion, and carryover and explain testing and monitoring strategies.

Learning Objectives

1. Explain the causes and effects of boiler scale; explain the most common internal methods of scale control, including phosphate treatment, chelate treatment, sludge conditioning and dispersion.
2. Explain the causes and effects of boiler and condensate return line corrosion; explain treatment methods for acidic, caustic, oxygen, and carbon dioxide corrosion, including sulphite, hydrazine, and amine treatment.
3. Explain the mechanical and chemical causes, effects and types of carryover; explain methods of carryover control, including the use of antifoam and blowdown.
4. Describe the design and explain the operation of simple blowdown, heat recovery, and automatic blowdown systems.
5. Explain, in general terms, the sampling and testing strategies for boiler internal conditions; describe typical sampling and automatic monitoring equipment.
6. Describe typical chemical feed systems, including pot feeders, continuous feed with day tanks, and continuous feed with pump tanks.

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Topic 11 Boiler Water Pretreatment

Learning Outcome

Explain the purpose, principles, equipment, and monitoring of boiler water pretreatment processes.

Learning Objectives

1. Describe the design and explain the terms, purpose and operation of a clarifier, using coagulation, flocculation, and subsidence.
2. Describe the design and explain the terms, purpose and operation of gravity and pressure filters.
3. Describe the design and explain the terms, purpose and operation, including chemical reactions for a cold lime softener.
4. Describe the design and explain the terms, purpose and operation of a hot lime softener.
5. Explain the principles of ion exchange softening in general, identifying the common anions and cations in untreated water.
6. Describe the design, components, and operation of a sodium zeolite softening system including chemical reactions.
7. Describe the design, components, and operation of a hydrogen zeolite softening system including chemical reactions.
8. Describe the design, components, and operation of a dealkalization system including chemical reactions.
9. Describe the design, components, and operation of a demineralizer system, including mixed bed and degasification.
10. Explain the principle and operation of a reverse osmosis system.
11. Describe the design, principle, and operation controls of a typical deaerator.

Topic 12 Pump Designs and Operation

Learning Outcome

Describe the designs, principles, components and operating procedures for common industrial pumps.

Learning Objectives

1. Explain the principle of operation and describe the components of typical plunger, piston and diaphragm reciprocating pumps.
2. Explain the designs and operating principles of the external gear, internal gear, sliding vane, lobe, and screw type rotary pumps.
3. Explain the designs and operating principles of volute and diffuser centrifugal pumps, including impeller designs.
4. Describe centrifugal pump arrangements, including vertical, horizontal, single and double suction, opposed impellers, multi-staging, split and barrel casings.
5. Describe the design and applications of axial and mixed flow pumps.
6. Describe the design and components of a multistage centrifugal pump, clearly stating the purpose and general design of: wear rings, shaft sleeves, seals, bearings and lubrication components, vents and drains.
7. Explain design features that eliminate thrust in large centrifugal pumps.
8. Describe systems used to maintain minimum flow through a centrifugal pump.
9. Explain priming, start-up, capacity control and operating cautions for centrifugal pumps.

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Major Topic: Pumps and Boilers

Topic 1 Steam Turbine Principles and Design

Learning Outcome

Describe designs, operating principles and major components of steam turbines.

Learning Objectives

1. Explain impulse turbine operating principles. Describe convergent and divergent nozzles, and the pressure-velocity profiles through an impulse section.
2. Explain reaction turbine operating principles and describe the pressure-velocity profiles through reaction blading.
3. Explain pressure, velocity, and pressure-velocity compounding of impulse turbines. Describe the pressure-velocity profiles and the purpose and applications of each.
4. Explain the purpose, general operating principles and arrangement for each of the following turbine types: condensing, condensing-bleeder, backpressure, extraction, topping, mixed-pressure, cross-compounded, tandem compounded, double flow and reheat.
5. Describe the designs of typical turbine casings and state the purpose and location of casing fittings, including drains and sentinel valves. Describe the designs and principles of casing/shaft seals.
6. Describe the designs and applications of disc and drum rotors. Describe methods of rotor and casing blade attachment and explain blade-sealing arrangements.
7. Explain thrust in a large turbine and describe methods to offset thrust, including thrust bearings, dummy piston, and thrust-adjusting gear.
8. Identify typical designs and components for small and large industrial turbines. Explain typical size/ capacity rating specifications and explain typical applications.
9. Explain the use and design of reducing gears attached to steam turbines.

Topic 2 Steam Turbine Auxiliaries and Operation

Learning Outcome

Describe auxiliary support and control systems for steam turbines and explain start-up and shutdown procedures.

Learning Objectives

1. Describe typical lube oil systems for small and large steam turbines.
2. Explain the purpose and describe the design and operation of barring gear and jacking oil systems on a large turbine.
3. Describe a condensing turbine circuit and explain typical operating parameters.
4. Explain and state the applications, where applicable, of the following governor types: speed-sensitive, pressure-sensitive, nozzle, throttle, and bypass. Explain governor droop and isochronous control.
5. Explain the operation and the major components of the three main speed-sensitive governor systems: mechanical, mechanical-hydraulic, and electronic-hydraulic.
6. Explain the operation and describe the components of typical mechanical and electronic overspeed trip systems.
7. Explain the sequence followed for the cold start-up and the shutdown of a non-condensing steam turbine.
8. Explain the sequence followed for the cold start-up and the shutdown of a condensing and extracting steam turbine.

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Topic 3 Turbine Condenser Systems

Learning Outcome

Explain typical designs, components and operating principles of steam turbine condensers.

Learning Objectives

1. Explain the purposes of a turbine condenser in a steam plant cycle and describe a typical condensing circuit, with operating temperatures and pressures.
2. Explain the design, operation and applications of the jet condenser, including the ejector type.
3. Explain the design, operation and applications of the surface condenser, including air cooled and water-cooled, down flow and central flow.
4. Describe construction details for surface condensers, including shells, tube attachment, supports, and allowances for expansion.
5. Explain the effects of air in a condenser and describe the design and operation of single and two-stage air ejectors. Explain the detection of condenser air leaks. Explain vacuum pumps.
6. Explain the devices and operating considerations used to protect a condenser against high backpressure, high condensate level, and cooling water contamination. Describe a cooling water leak test.
7. Describe the operating conditions and corresponding design considerations for condensate extraction pumps and cooling water pumps.
8. Describe a feed water heater system in conjunction with a steam condenser and explain the designs of low-pressure and high-pressure feed water heaters.

Topic 4 Gas Turbine Principles and Designs

Learning Outcome

Explain common designs, major components, operating principles, and arrangements for industrial gas turbines.

Learning Objectives

1. Explain gas turbine advantages and disadvantages, background and industrial applications. Identify the types of gas turbines, their major components and describe the operating principles of a simple gas turbine.
2. Explain single and dual shaft arrangements for gas turbines. Describe open cycle and closed cycle operation.
3. Describe a typical open cycle gas turbine installation, including buildings or enclosures, intake and exhaust systems, auxiliary systems, and reducing gear.
4. Explain the efficiency and rating of gas turbines and describe the purpose and applications of gas turbine cycle improvements, including intercooling, regenerating, reheating and combined cycle.
5. Describe various aspects of compressor design and centrifugal and axial types of compressors.
6. Describe the types, operation, components and arrangements of combustors.
7. Describe turbine section design and operation especially with respect to blading and materials.
8. Explain the types and functions of the control systems and instrumentation needed for gas turbine operation.
9. Explain the typical operating parameters of a gas turbine; describe the effects of compressor inlet temperature, compressor discharge pressure, and turbine inlet temperature on gas turbine performance.

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Topic 5 Gas Turbine Auxiliaries and Operation

Learning Outcome

Describe the support auxiliaries for a gas turbine and explain common operational, control and maintenance procedures.

Learning Objectives

1. Describe the types of bearings used in a gas turbine and explain the components, operation, protective devices and routine maintenance of a typical lube oil system.
2. Describe and explain the operation and routine maintenance of a typical fuel gas supply system for a gas turbine.
3. Describe and explain the operation and routine maintenance of a typical fuel oil supply system for a gas turbine.
4. Explain the control of NO_X from a gas turbine and describe the purpose and operation of water/steam injection and dry low NO_X systems.
5. Explain the purpose, location and operation of the gas turbine starting motor and turning gear.
6. Describe the compressor intake and the turbine exhaust components.
7. Describe the preparation and complete start-up sequence for a gas turbine.
8. Describe the shutdown sequence and procedure for a gas turbine.
9. Explain the purpose and describe typical on-line and off-line waterwash procedures for gas turbine blades.

Topic 6 Internal Combustion Engines

Learning Outcome

Explain the operating principles, designs, support systems, and operation of industrial internal combustion engines (ICE).

Learning Objectives

1. Explain the principles of spark ignition and compression ignition; describe the operating cycles for two-stroke and four-stroke designs.
2. Identify and state the purpose of the major mechanical components of an internal combustion engine.
3. Describe carburetor, fuel injection, battery ignition, and magneto ignition systems for a spark ignition engine.
4. Describe individual pump, distributor, and common rail fuel injection systems for a diesel engine.
5. Explain the purpose and describe the operation of superchargers and turbochargers.
6. Describe and explain the operation of a typical cooling system for an industrial ICE.
7. Describe and explain the operation of a typical lubrication system for an industrial ICE.
8. Describe engine-starting devices/systems for diesel and gas engines.
9. Explain the monitoring, protection and control devices on a large industrial diesel or gas engine, including shutdowns and governing.
10. Explain a typical start-up procedure for a large industrial diesel engine, plus the routine monitoring requirements of a running engine.

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Topic 7 Cogeneration Systems and Operation

Learning Outcome

Explain cogeneration and describe common configurations, components and applications.

Learning Objectives

1. Define cogeneration and explain its purpose, advantages, and applications.
2. Explain the components and operation of simple-cycle cogeneration systems.
3. Explain the components and operation of combined-cycle, gas/steam turbine cogeneration systems.
4. Explain the components and operation of a fully fired, combined-cycle cogeneration system.
5. Explain single-shaft and dual-shaft combined-cycle power plants.
6. Explain the general control strategies and components, for both power and steam production, including diverter and duct burner operation.
7. Describe the various designs of heat recovery steam generators (HRSGs) and explain their industrial applications.
8. Explain the environmental considerations and techniques in the operation of a cogeneration system.
9. Describe typical cogeneration systems that use internal combustion engines (gas or diesel) and heat recovery water heaters (HRWHs).
10. Explain a typical start-up procedure for a combined cycle cogeneration system.

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REFERENCE CURRICULUM

For

Steam Turbine Operator (1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Steam Turbine Operator (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Steam Turbine Operator (1st Class) Examination Candidates

Topic 1 Steam Turbine Theory and Construction

Learning Outcome

Explain the design and components of a large steam turbine, and perform nozzle and steam velocity calculations.

Learning Objectives

1. Explain selection criteria for a turbine application.
2. Describe the design and components of steam turbine casings and casing drains.
3. Describe the design and components of steam turbine rotors, blading, and diaphragms.
4. Describe shaft seal designs, including stuffing boxes, carbon rings, labyrinth, and water seals.
5. Describe the design and components of steam turbine bearings.
6. Describe the ways in which steam turbines are designed to counteract thrust.
7. Describe the purpose and design of expansion and anchoring components.
8. Explain the principles of steam turbine nozzle design.
9. Explain a steam turbine blade velocity diagram.
10. Calculate the steam velocity and angle of entry for impulse and reaction turbine blading.
11. Calculate the work done on steam turbine blades and the resulting power developed.
12. Calculate steam turbine Rankine cycle thermal efficiency.

Topic 2 Steam Turbine Auxiliaries and Control

Learning Outcome

Explain the purpose and design of steam turbine auxiliaries, control, and monitoring equipment.

Learning Objectives

1. Describe the purpose, design and components of a turning gear.
2. Describe the purpose, design and components of an adjusting gear.
3. Explain critical speed.
4. Describe the design and components of lubricating oil and jacking oil systems.
5. Describe the design of speed reducing gears.
6. Describe the design and components of flexible couplings.
7. Describe the purpose and design of steam turbine governors and governor systems.
8. Describe the purpose and design of steam turbine stop valves and control valves.
9. Describe the purpose and design of steam turbine grid type extraction valves.
10. Describe the purpose and design of steam turbine casing pressure relief systems including rupture diaphragms.
11. Describe the purpose and design of steam turbine overspeed trips.
12. Describe the purpose and design of steam turbine supervisory equipment.

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Topic 3 Steam Turbine Operation and Maintenance

Learning Outcome

Discuss procedures for operation and maintenance of a large steam turbine.

Learning Objectives

1. Describe the detailed hot and cold start-up procedures for a large steam turbine, including safety precautions.
2. Describe the detailed shutdown procedure for a large steam turbine including safety precautions.
3. Explain what checks are performed on a large steam turbine during normal operation.
4. Sketch the flow of steam and condensate through a condensing steam turbine and a non-condensing steam turbine.
5. Explain the preventive maintenance requirements for a large steam turbine. Include shaft alignment, bearings, clearances for thrust, blades, shaft seals, correction of blade fouling, erosion and cleaning.
6. Describe the purpose of and procedure for static and dynamic balancing.

Topic 4 Steam Condensers

Learning Outcome

Discuss condenser principles, performance, operation and auxiliaries.

Learning Objectives

1. Describe the principles and design of jet, air cooled, and surface condensers.
2. Describe the purpose, principle and design of surface condenser support and expansion systems.
3. Explain the significant parameters in condenser performance.
4. Calculate condenser thermal efficiency from the test data.
5. Explain the procedures used to troubleshoot condenser performance.
6. Explain the procedures used to backwash and clean a condenser.
7. Describe the purpose, principle and design of air ejectors and vacuum pumps.
8. Describe the purpose and flow of cooling water systems.
9. Describe the purpose, principle and design of cooling water intake screens, circulating pumps, cooling towers, and cooling ponds.
10. Describe the purpose, principle and design of condenser atmospheric exhaust (relief) valves.
11. Describe the purpose, principle and design of condensate pumps.

Topic 5 Lubrication

Learning Outcome

Explain the components of a lubrication application and maintenance program.

Learning Objectives

1. Describe the methods of manufacture and the different classifications of lubricants.
2. Describe the significance and measurement of lubricating oil characteristics, including viscosity, relative density, API (American Petroleum Institute) gravity, pour point, and dielectric strength.
3. Explain the typical causes of lubricating oil deterioration.
4. Describe the types of lubrication additives.
5. Describe a typical power plant lubrication program, including a lubrication survey.
6. Explain the different types of lubricating/governing/seal oil systems.
7. Describe the components and operation of a typical lubricating oil purification system.
8. Describe the various applications of ball-and-roller bearings and their lubrication, including bearing seals.

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Topic 6 Piping

Learning Outcome

Explain piping system design, inspection, and maintenance.

Learning Objectives

1. Explain selection criteria for piping materials.
2. Calculate the required thickness and the internal design pressure of piping.
3. Describe typical inspection procedures for piping installations and repairs.
4. Describe a typical routine inspection procedure and schedule for high-energy piping.
5. Explain the effects of high temperature on piping strength.
6. Describe the design and installation criteria for a piping system layout.
7. Explain the theory and effects of water hammer.

Topic 7 Rotating Equipment Maintenance

Learning Outcome

Explain specific maintenance procedures for, and typical maintenance problems of, rotating equipment.

Learning Objectives

1. Explain the typical maintenance problems of a large steam turbine.
2. Explain the procedures for inspection and overhaul of a large steam turbine.
3. Explain the typical maintenance problems of a gas turbine.
4. Explain the procedures for inspection and overhaul of a gas turbine.
5. Explain the typical maintenance problems of a large multi-stage pump.
6. Explain the procedures for inspection and overhaul of a large multi-stage pump.
7. Explain the typical maintenance problems of a large generator.
8. Explain the procedures for inspection and overhaul of a large generator.

Topic 8 Rotating Equipment Monitoring

Learning Outcome

Describe the parameters and methods of turbine monitoring and oil analysis.

Learning Objectives

1. Describe the purpose, importance and types of rotating equipment monitoring.
2. Explain the concept and significance of turbine thermal expansion, the general principles and placement of measuring devices and the procedures to control.
3. Explain the concept and significance of turbine differential expansion, the general principle and placement of measuring devices and the procedures to control.
4. Explain the concept and significance of turbine eccentricity, the general principle and placement of measuring devices and the procedures to control.
5. Explain the concept of vibration, including typical causes, effects, and locations of vibration in rotating equipment and how it is measured.
6. Explain the concept and significance of turbine critical speed.
7. Explain the concept and significance of oil whirl, oil whip, and steam whirl and the design and operational considerations to counter oil whirl.
8. Describe common oil problems and their effects on rotating equipment and a typical oil sampling and testing program.

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REFERENCE CURRICULUM

For

Steam Turbine Operator (2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Steam Turbine Operator (2nd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Steam Turbine Operator (2nd Class) Examination Candidates

Topic 1 Introduction to Piping and Pipe Fittings

Learning Outcome

Discuss the basic types of piping, piping connections, supports and drainage devices used in industry.

Learning Objectives

1. State the applications for the most common materials and identify the sizes of commercial pipe.
2. Describe methods of connection for screwed, flanged and welded pipe and identify fittings and their markings.
3. Describe methods and devices used to allow for pipe expansion and support.
4. Explain the methods used to promote good drainage of steam piping, including the installation and maintenance of steam traps. Explain water hammer.
5. Explain the need for piping insulation and describe materials and methods of insulation.

Topic 2 Introduction to Valves

Learning Outcome

Discuss the design and uses of the valve designs most commonly used in industry and on boilers.

Learning Objectives

1. Describe standard valve designs.
2. Describe design and operation of specialized boiler valves.
3. Describe piping arrangements and the design and operation of steam system pressure-reducing valves.
4. Discuss valve details, including materials of construction and identification markings.
5. Describe typical valve maintenance requirements.

Topic 3 Introduction to Steam Turbines

Learning Outcome

Describe the construction and operation of steam turbines.

Learning Objectives

1. Describe the principle of operation and major components of a steam turbine.
2. Describe the lubrication and sealing of steam turbine shafts.
3. Describe the construction and operation of an overspeed trip.
4. Describe the general construction of a simple type of multistage steam turbine and an overall boiler-turbine cycle.
5. Describe how the rotational speed of a steam turbine is governed.
6. List the steps that are followed in a typical steam turbine start-up and shut-down.

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Topic 4 Steam Turbine Principles and Design

Learning Outcome

Describe designs, operating principles and major components of steam turbines.

Learning Objectives

1. Explain impulse turbine operating principles. Describe convergent and divergent nozzles, and the pressure-velocity profiles through an impulse section.
2. Explain reaction turbine operating principles and describe the pressure-velocity profiles through reaction blading.
3. Explain pressure, velocity, and pressure-velocity compounding of impulse turbines. Describe the pressure-velocity profiles and the purpose and applications of each.
4. Explain the purpose, general operating principles and arrangement for each of the following turbine types: condensing, condensing-bleeder, backpressure, extraction, topping, mixed-pressure, cross-compounded, tandem compounded, double flow and reheat.
5. Describe the designs of typical turbine casings and state the purpose and location of casing fittings, including drains and sentinel valves. Describe the designs and principles of casing/shaft seals.
6. Describe the designs and applications of disc and drum rotors. Describe methods of rotor and casing blade attachment and explain blade-sealing arrangements.
7. Explain thrust in a large turbine and describe methods to offset thrust, including thrust bearings, dummy piston, and thrust-adjusting gear.
8. Identify typical designs and components for small and large industrial turbines. Explain typical size/ capacity rating specifications and explain typical applications.
9. Explain the use and design of reducing gears attached to steam turbines.

Topic 5 Steam Turbine Auxiliaries and Operation

Learning Outcome

Describe auxiliary support and control systems for steam turbines and explain start-up and shutdown procedures.

Learning Objectives

1. Describe typical lube oil systems for small and large steam turbines.
2. Explain the purpose and describe the design and operation of barring gear and jacking oil systems on a large turbine.
3. Describe a condensing turbine circuit and explain typical operating parameters.
4. Explain and state the applications, where applicable, of the following governor types: speed-sensitive, pressure-sensitive, nozzle, throttle, and bypass. Explain governor droop and isochronous control.
5. Explain the operation and the major components of the three main speed-sensitive governor systems: mechanical, mechanical-hydraulic, and electronic-hydraulic.
6. Explain the operation and describe the components of typical mechanical and electronic overspeed trip systems.
7. Explain the sequence followed for the cold start-up and the shutdown of a non-condensing steam turbine.
8. Explain the sequence followed for the cold start-up and the shutdown of a condensing and extracting steam turbine.

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Topic 6 Turbine Condenser Systems

Learning Outcome

Explain typical designs, components and operating principles of steam turbine condensers.

Learning Objectives

1. Explain the purposes of a turbine condenser in a steam plant cycle and describe a typical condensing circuit, with operating temperatures and pressures.
2. Explain the design, operation and applications of the jet condenser, including the ejector type.
3. Explain the design, operation and applications of the surface condenser, including air-cooled and water-cooled, down flow and central flow.
4. Describe construction details for surface condensers, including shells, tube attachment, supports, and allowances for expansion.
5. Explain the effects of air in a condenser and describe the design and operation of single and two-stage air ejectors. Explain the detection of condenser air leaks. Explain vacuum pumps.
6. Explain the devices and operating considerations used to protect a condenser against high backpressure, high condensate level, and cooling water contamination. Describe a cooling water leak test.
7. Describe the operating conditions and corresponding design considerations for condensate extraction pumps and cooling water pumps.
8. Describe a feed water heater system in conjunction with a steam condenser and explain the designs of low-pressure and high-pressure feed water heaters.

Topic 7 Cooling Towers

Learning Outcome

Describe the operation and maintenance of cooling towers.

Learning Objectives

1. List the factors that determine rate of cooling in a cooling tower and the basic components of a cooling tower.
2. Describe the construction and operation of a natural draft cooling tower.
3. Describe the construction and operation of a mechanical draft cooling tower.
4. Discuss cold climate operation for cooling towers.
5. Describe the water treatment necessary for cooling water.
6. Apply a cooling tower troubleshooting guide.

Topic 8 Introduction to Instrumentation

Learning Outcome

Describe the overall purpose and function of plant instrumentation systems.

Learning Objectives

1. Describe the concept and basic components of a control loop.
2. Describe the various means by which control signals are transmitted.
3. Describe the function of transducers.
4. List and describe the types of instrumentation which are not necessarily part of a control loop.

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Topic 9 Introduction to Process Measurement

Learning Outcome

Describe the construction and operation of common devices used to measure pressure, level, temperature, flow, and composition.

Learning Objectives

1. Describe the standard types of pressure measuring devices.
2. Describe the standard types of level sensing and measuring devices.
3. Describe the standard types of flow sensing and measuring devices.
4. Describe the standard types of temperature sensing and measuring devices.
5. Describe the principle and basic operation of a chromatograph.

Topic 10 Basic Control Loop Components

Learning Outcome

Describe the basic types and functions of transmitters, recorders, controllers and control valves.

Learning Objectives

1. Describe the principle, construction and operation of instrumentation transmitters.
2. Describe the principle, construction and operation of instrumentation indicators and recorders.
3. Describe the principle, construction and operation of instrumentation controllers and control valves.

Topic 11 Lubrication Principles

Learning Outcome

Describe the importance of lubrication and the principles concerned with lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and application.
3. List the properties of lubricating oils, the additives used and their selection criteria.

Topic 12 Types of Bearing Lubrication

Learning Outcome

Describe the methods for simple care and maintenance of bearings and their related lubrication systems.

Learning Objectives

1. Define boundary and full fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of thrust bearings.
4. Describe how to clean and replace roller and ball type bearings.
5. List the causes of bearing failure.

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REFERENCE CURRICULUM

For

Gas Turbine Operator (1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Gas Turbine Operator (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Gas Turbine Operator (1st Class) Examination Candidates

Topic 1 Gas Turbine Design and Auxiliaries

Learning Outcome

Explain the design and components of a large gas turbine and related auxiliaries.

Learning Objectives

1. Explain applications and selection criteria for the different types of gas turbine engines.
2. Describe the principles and design of open and closed cycle gas turbine systems.
3. Describe the principles and design of combined cycle and cogeneration systems using gas turbines.
4. Describe the principles and design of gas turbine regeneration, intercooling, and reheating.
5. Describe the principles and design of gas turbine shaft arrangements.
6. Describe the design and components of gas turbine compressors, combustors (combustion chambers) and turbines.
7. Describe the design and operation of gas turbine air intake and exhaust systems.
8. Describe the design and operation of a gas turbine lubricating oil system.
9. Describe the design and operation of a gas turbine fuel system.
10. Describe the design and operation of a gas turbine steam or water injection system and a dry low NO_X system.

Topic 2 Gas Turbine Operation and Control

Learning Outcome

Discuss operating procedures, and control and monitoring components of a large gas turbine.

Learning Objectives

1. Describe the components and operation of gas turbine supervisory and control systems.
2. Describe the principles and design of gas turbine protection devices.
3. Describe the detailed hot and cold startup procedures for a gas turbine, including safety precautions.
4. Describe the detailed shutdown procedure for a gas turbine, including safety precautions.
5. Explain the routine maintenance and monitoring requirements for a gas turbine.
6. Describe the major maintenance and overhaul requirements for a gas turbine.
7. Explain the troubleshooting of gas turbine problems.

Topic 3 Lubrication

Learning Outcome

Explain the components of a lubrication application and maintenance program.

Learning Objectives

1. Describe the methods of manufacture and the different classifications of lubricants.
2. Describe the significance and measurement of lubricating oil characteristics, including viscosity, relative density, API (American Petroleum Institute) gravity, pour point, and dielectric strength.
3. Explain the typical causes of lubricating oil deterioration.
4. Describe the types of lubrication additives.
5. Describe a typical power plant lubrication program, including a lubrication survey.
6. Explain the different types of lubricating/governing/seal oil systems.
7. Describe the components and operation of a typical lubricating oil purification system.
8. Describe the various applications of ball-and-roller bearings and their lubrication, including bearing seals.

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Topic 4 Piping

Learning Outcome

Explain piping system design, inspection, and maintenance.

Learning Objectives

1. Explain selection criteria for piping materials.
2. Calculate the required thickness and the internal design pressure of piping.
3. Describe typical inspection procedures for piping installations and repairs.
4. Describe a typical routine inspection procedure and schedule for high-energy piping.
5. Explain the effects of high temperature on piping strength.
6. Describe the design and installation criteria for a piping system layout.
7. Explain the theory and effects of water hammer.

Topic 5 Rotating Equipment Maintenance

Learning Outcome

Explain specific maintenance procedures for, and typical maintenance problems of, rotating equipment.

Learning Objectives

1. Explain the typical maintenance problems of a large steam turbine.
2. Explain the procedures for inspection and overhaul of a large steam turbine.
3. Explain the typical maintenance problems of a gas turbine.
4. Explain the procedures for inspection and overhaul of a gas turbine.
5. Explain the typical maintenance problems of a large multi-stage pump.
6. Explain the procedures for inspection and overhaul of a large multi-stage pump.
7. Explain the typical maintenance problems of a large generator.
8. Explain the procedures for inspection and overhaul of a large generator.

Topic 6 Rotating Equipment Monitoring

Learning Outcome

Describe the parameters and methods of turbine monitoring and oil analysis.

Learning Objectives

1. Describe the purpose, importance and types of rotating equipment monitoring.
2. Explain the concept and significance of turbine thermal expansion, the general principles and placement of measuring devices and the procedures to control.
3. Explain the concept and significance of turbine differential expansion, the general principle and placement of measuring devices and the procedures to control.
4. Explain the concept and significance of turbine eccentricity, the general principle and placement of measuring devices and the procedures to control.
5. Explain the concept of vibration, including typical causes, effects, and locations of vibration in rotating equipment and how it is measured.
6. Explain the concept and significance of turbine critical speed.
7. Explain the concept and significance of oil whirl, oil whip, and steam whirl and the design and operational considerations to counter oil whirl.
8. Describe common oil problems and their effects on rotating equipment and a typical oil sampling and testing program.

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REFERENCE CURRICULUM

For

Gas Turbine Operator (2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Gas Turbine Operator (2nd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Gas Turbine Operator (2nd Class) Examination Candidates

Topic 1 Introduction to Piping and Pipe Fittings

Learning Outcome

Discuss the basic types of piping, piping connections, supports and drainage devices used in industry.

Learning Objectives

1. State the applications for the most common materials and identify the sizes of commercial pipe.
2. Describe methods of connection for screwed, flanged and welded pipe and identify fittings and their markings.
3. Describe methods and devices used to allow for pipe expansion and support.
4. Explain the methods used to promote good drainage of steam piping, including the installation and maintenance of steam traps. Explain water hammer.
5. Explain the need for piping insulation and describe materials and methods of insulation.

Topic 2 Introduction to Valves

Learning Outcome

Discuss the design and uses of the valve designs most commonly used in industry and on boilers.

Learning Objectives

1. Describe standard valve designs.
2. Describe design and operation of specialized boiler valves.
3. Describe piping arrangements and the design and operation of steam system pressure-reducing valves.
4. Discuss valve details, including materials of construction and identification markings.
5. Describe typical valve maintenance requirements.

Topic 3 Introduction to Instrumentation

Learning Outcome

Describe the overall purpose and function of plant instrumentation systems.

Learning Objectives

1. Describe the concept and basic components of a control loop.
2. Describe the various means by which control signals are transmitted.
3. Describe the function of transducers.
4. List and describe the types of instrumentation which are not necessarily part of a control loop.

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Topic 4 Introduction to Process Measurement

Learning Outcome

Describe the construction and operation of common devices used to measure pressure, level, temperature, flow, and composition.

Learning Objectives

1. Describe the standard types of pressure measuring devices.
2. Describe the standard types of level sensing and measuring devices.
3. Describe the standard types of flow sensing and measuring devices.
4. Describe the standard types of temperature sensing and measuring devices.
5. Describe the principle and basic operation of a chromatograph.

Topic 5 Basic Control Loop Components

Learning Outcome

Describe the basic types and functions of transmitters, recorders, controllers and control valves.

Learning Objectives

1. Describe the principle, construction and operation of instrumentation transmitters.
2. Describe the principle, construction and operation of instrumentation indicators and recorders.
3. Describe the principle, construction and operation of instrumentation controllers and control valves.

Topic 6 Lubrication Principles

Learning Outcome

Describe the importance of lubrication and the principles concerned with lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and application.
3. List the properties of lubricating oils, the additives used and their selection criteria.

Topic 7 Types of Bearing Lubrication

Learning Outcome

Describe the methods for simple care and maintenance of bearings and their related lubrication systems.

Learning Objectives

1. Define boundary and full fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of thrust bearings.
4. Describe how to clean and replace roller and ball type bearings.
5. List the causes of bearing failure.

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Topic 8 Gas Turbine Principles and Designs

Learning Outcome

Explain common designs, major components, operating principles, and arrangements for industrial gas turbines.

Learning Objectives

1. Explain gas turbine advantages and disadvantages, background and industrial applications. Identify the types of gas turbines, their major components and describe the operating principles of a simple gas turbine.
2. Explain single and dual shaft arrangements for gas turbines. Describe open cycle and closed cycle operation.
3. Describe a typical open cycle gas turbine installation, including buildings or enclosures, intake and exhaust systems, auxiliary systems, and reducing gear.
4. Explain the efficiency and rating of gas turbines and describe the purpose and applications of gas turbine cycle improvements, including intercooling, regenerating, reheating and combined cycle.
5. Describe various aspects of compressor design and centrifugal and axial types of compressors.
6. Describe the types, operation, components and arrangements of combustors.
7. Describe turbine section design and operation especially with respect to blading and materials.
8. Explain the types and functions of the control systems and instrumentation needed for gas turbine operation.
9. Explain the typical operating parameters of a gas turbine; describe the effects of compressor inlet temperature, compressor discharge pressure, and turbine inlet temperature on gas turbine performance.

Topic 9 Gas Turbine Auxiliaries and Operation

Learning Outcome

Describe the support auxiliaries for a gas turbine and explain common operational, control and maintenance procedures.

Learning Objectives

1. Describe the types of bearings used in a gas turbine and explain the components, operation, protective devices and routine maintenance of a typical lube oil system.
2. Describe and explain the operation and routine maintenance of a typical fuel gas supply system for a gas turbine.
3. Describe and explain the operation and routine maintenance of a typical fuel oil supply system for a gas turbine.
4. Explain the control of NO_X from a gas turbine and describe the purpose and operation of water/steam injection and dry low NO_X systems.
5. Explain the purpose, location and operation of the gas turbine starting motor and turning gear.
6. Describe the compressor intake and the turbine exhaust components.
7. Describe the preparation and complete start-up sequence for a gas turbine.
8. Describe the shutdown sequence and procedure for a gas turbine.
9. Explain the purpose and describe typical on-line and off-line waterwash procedures for gas turbine blades.

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REFERENCE CURRICULUM

For

Hot Water Generation Operator
(1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Hot Water Generation Operator (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Pittsburgh, PA 15242-0369

Reference Curriculum for Hot Water Generation Operator (1st Class) Examination Candidates

Major Topic: Heating Boilers

Topic 1 Cast Iron Sectional & Modular Boilers

Learning Outcome

Describe cast iron boilers and explain their uses.

Learning Objectives

1. Describe the general construction and the advantages of cast-iron sectional heating boilers over watertube and firetube boilers.
2. Describe the arrangement of equipment in a multiple, cast-iron sectional boiler heating plant.
3. Describe the construction and operation of cast-iron modular heating boilers.

Topic 2 Oil Burners for Heating Boilers

Learning Outcome

Describe the various oil burners used on heating boilers.

Learning Objectives

1. Describe air, steam and mechanical oil atomizing burners for boilers.
2. Describe the auxiliary equipment needed for an oil combustion system.
3. Describe the design and operation of fuel oil systems, including storage.

Topic 3 Gas Burners for Heating Boilers

Learning Outcome

Describe the operation of the various types of gas burners used on heating boilers.

Learning Objectives

1. Describe the operation of various types of gas burners.
2. Describe the construction and operation of automatic gas valves.

Topic 4 Basic Fittings for Hot Water Boilers

Learning Outcome

Describe the purpose and operating principles of basic boiler fittings on hot water boilers.

Learning Objectives

1. Describe the code requirements for the required fittings on hot water heating boilers.
2. Discuss the types of non-required fittings that are used on hot water heating boilers.

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Topic 5 Hot Water and Steam Heating Boiler Operation

Learning Outcome

Describe the specific safe and efficient operational procedures that relate to automatically-fired, low-pressure hot water and steam heating boilers.

Learning Objectives

1. Describe the general preparation and start-up of a hot water heating boiler.
2. Describe the operation of a hot water heating boiler under routine conditions, including removal from service.
3. Describe the preparation, start-up, routine operation and removal from service of a steam heating boiler.

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Pittsburgh, PA 15242-0369

REFERENCE CURRICULUM

For

Hot Water Generation Operator

(2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Hot Water Generation Operator (2nd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Hot Water Generation Operator (2nd Class) Examination Candidates

Major Topic: Heating Systems and Human Comfort

Topic 1 Hot Water Heating Systems

Learning Outcome

Describe the various designs of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe radiant panel and snow melting hot water systems.

Topic 2 Hot Water Heating System Equipment and Operation

Learning Outcome

Describe accessories, operation and troubleshooting of a hot water heating system.

Learning Objectives

1. Describe the purpose and function of standard hot water heating system components such as diverter fittings, air vents, air separators, flow control valves, balancing valves and fittings, riser stop valves, pressure reducing valves, circulating pumps, expansion tanks, and steam to hot water converters.
2. Explain how the location of the hot water circulating pump and the expansion tank are determined.
3. Describe the cleaning, filling, starting, routine operation, and troubleshooting of hot water heating systems.
4. Apply a hot water heating system troubleshooting guide.

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Pittsburgh, PA 15242-0369

REFERENCE CURRICULUM

For

HVAC Plant Operator (1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the HVAC Plant Operator (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for HVAC Plant Operator (1st Class) Examination Candidates

Major Topic: Heating Boilers

Topic 1 Cast Iron Sectional and Modular Boilers

Learning Outcome

Describe cast iron boilers and explain their uses.

Learning Objectives

1. Describe the general construction and the advantages of cast-iron sectional heating boilers over watertube and firetube boilers.
2. Describe the arrangement of equipment in a multiple, cast-iron sectional boiler heating plant.
3. Describe the construction and operation of cast-iron modular heating boilers.

Topic 2 Oil Burners for Heating Boilers

Learning Outcome

Describe the various oil burners used on heating boilers.

Learning Objectives

1. Describe air, steam and mechanical oil atomizing burners for boilers.
2. Describe the auxiliary equipment needed for an oil combustion system.
3. Describe the design and operation of fuel oil systems, including storage. 4.

Topic 3 Gas Burners for Heating Boilers

Learning Outcome

Describe the operation of the various types of gas burners used on heating boilers.

Learning Objectives

1. Describe the operation of various types of gas burners.
2. Describe the construction and operation of automatic gas valves.

Topic 4 Basic Fittings for Low Pressure Steam Boilers

Learning Outcome

Describe, and explain the operating principles of pressure gages and safety valves found on low-pressure steam boilers.

Learning Objectives

1. Describe the code requirements for pressure gages on low-pressure steam boilers.
2. Describe the code requirements for the boiler connections and valves on low-pressure steam boilers.

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Topic 5 Basic Fittings for Hot Water Boilers

Learning Outcome

Describe the purpose and operating principles of basic boiler fittings on hot water boilers.

Learning Objectives

1. Describe the code requirements for the required fittings on hot water heating boilers.
2. Discuss the types of non-required fittings that are used on hot water heating boilers.

Topic 6 Hot Water and Steam Heating Boiler Operation

Learning Outcome

Describe the specific safe and efficient operational procedures that relate to automatically-fired, low-pressure hot water and steam heating boilers.

Learning Objectives

1. Describe the general preparation and start-up of a hot water heating boiler.
2. Describe the operation of a hot water heating boiler under routine conditions, including removal from service.
3. Describe the preparation, start-up, routine operation and removal from service of a steam heating boiler.

Major Topic: Steam and Water Heating Systems

Topic 7 Steam Heating Equipment

Learning Outcome

Describe the components and operating principles of steam heating equipment.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. Describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.

Topic 8 Steam Heating Systems

Learning Outcome

Describe the operating principles and maintenance procedures of steam heating systems and the components of these systems.

Learning Objectives

1. Describe standard types of piping and equipment layout for steam heating systems.
2. Describe the general operation and maintenance of steam heating systems.
3. Apply a steam heating system troubleshooting guide.

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Topic 9 Hot Water Heating Systems

Learning Outcome

Describe the various designs of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe various types of special hot water heating systems.

Topic 10 Hot Water Heating System Equipment and Operation

Learning Outcome

Describe accessories, operation and troubleshooting of a hot water heating system.

Learning Objectives

1. Describe the purpose and function of standard hot water heating system accessories.
2. Explain how the location of the hot water circulating pump and the expansion tank are determined.
3. Describe the cleaning, filling, starting, use of antifreeze in, and routine operation of hot water heating systems.
4. Apply a hot water heating system troubleshooting guide.

Topic 11 Warm Air Heating System Equipment

Learning Outcome

Describe the operating principles of warm air heating systems.

Learning Objectives

1. Describe forced warm air heating systems and discuss common sources of warm air heat.
2. Describe the operational characteristics of direct fired space heaters.
3. Describe the various methods used to increase the heat transfer capabilities of furnaces.
4. Compare the advantages and disadvantages of forced and gravity warm air systems.

Topic 12 Warm Air Furnace Components and Maintenance

Learning Outcome

Describe the components and maintenance requirements of typical warm air heating and ventilating systems.

Learning Objectives

1. Describe the operation of various furnace components.
2. Discuss the relative merits of the various types of air ducts and outlet systems.
3. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
4. Apply a troubleshooting guide for forced warm air systems and components.

Topic 13 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems found in buildings, as well as describe the various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the various contaminants found in air.
3. Describe the types of air cleaning devices used in industrial/commercial buildings.

Topic 14 Infrared and Electric Heating

Learning Outcome

Describe infrared and electric heating systems.

Learning Objectives

1. Discuss the concept and application of infrared heating.
2. Describe the construction and operation of gas-fired and electric infrared heaters.
3. Describe the different methods of electric heating and the advantages and disadvantages of electric heating systems compared to other types.

Major Topic: Heating Boiler and Heating System Controls

Topic 15 Heating Boiler Feedwater Controls

Learning Outcome

Describe the various feedwater control methods and devices used on low-pressure steam boilers.

Learning Objectives

1. Describe the operation of a feedwater float switch operating a valve and a pump.
2. Describe how condensate is collected and returned to the boiler.
3. Explain the purpose and function of heating boiler feedwater and condensate piping connections.

Topic 16 Heating Boiler Operating Controls

Learning Outcome

Name and describe the various operating controls found on low-pressure heating boilers.

Learning Objectives

1. Discuss the various operating controls for low-pressure steam and hot water heating boilers.
2. Describe the operation of the control and safety switches found on the fuel supplies of low-pressure heating boilers.
3. Explain the required testing and maintenance of boiler controls.

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Topic 17 Heating Boiler Combustion Controls

Learning Outcome

Explain the design and operation of various combustion controls on heating boilers.

Learning Objectives

1. Describe the construction and operation of heating boiler flame failure detectors.
2. Describe the testing of hot water heating boiler flame failure safety devices.

Topic 18 Pneumatic Controls for Heating Systems

Learning Outcome

Explain the purpose of the various components found in a pneumatic control system.

Learning Objectives

1. Describe the layout of a pneumatic control system and the construction and operation of pneumatic controllers.
2. Describe the construction and operation of final control elements.
3. Explain the function of the various auxiliary devices associated with pneumatic control systems.
4. Describe a typical self-contained pneumatic control system.

Topic 19 Electric Controls for Heating Systems

Learning Outcome

Describe and explain the various components of an electric control circuit.

Learning Objectives

1. Discuss the various terms associated with electric control systems.
2. Describe the basic construction and operation of various electric control system components for heating systems.
3. Describe the function and operation of the controlled devices in electric control systems.
4. Explain the operating sequence of a basic electric control circuit.

Topic 20 Electronic Controls for Heating Systems

Learning Outcome

Describe and explain the function of the various components of an electronic control circuit.

Learning Objectives

1. Define the various terms associated with electronic control systems.
2. Describe a simple electronic control system.
3. Describe the common types of sensors used in HVAC electronic control systems.
4. Describe the types and functions of controllers used in HVAC electronic control systems.
5. Describe the output and indicating devices in an HVAC electronic control system, including interfacing with other systems.

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Major Topic: Auxiliary Building Systems

Topic 21 Lighting Systems

Learning Outcome

Explain the various lighting systems and some of the basic design considerations for lighting a space.

Learning Objectives

1. Describe the common types of lighting equipment and systems.
2. Explain the various methods of lighting control.
3. Describe the general requirements and criteria for emergency lighting in buildings.
4. Discuss the interrelationship between lighting, air conditioning and energy conservation in buildings.

Topic 22 Building Water Supply Systems

Learning Outcome

Explain the various water supply systems used in buildings.

Learning Objectives

1. Describe the cold water distribution system in a building.
2. Describe the hot water distribution system in a building.
3. Describe the construction and operation of building system hot water heaters, including temperature regulation.
4. Explain what is meant by "backflow prevention" and describe the common methods used.
5. List and describe the construction and operation of water system protective devices in buildings.

Topic 23 Sanitary Drainage Systems

Learning Outcome

Describe the design and components of various sanitary drainage systems used in buildings.

Learning Objectives

1. Describe the overall layout of building drainage systems.
2. Describe storm water drainage systems for buildings.
3. List the steps to take in the routine maintenance of building sanitary drainage system devices.
4. Apply a troubleshooting guide for flush valves in a sanitary drainage system.

Major Topic: Air Conditioning

Topic 24 Psychrometric Properties of Air

Learning Outcome

Describe the psychrometric properties of air.

Learning Objectives

1. Explain the composition of air and define the terms humidity, relative humidity and dewpoint.
2. Define the terms: dry bulb temperature, wet bulb temperature, wet bulb depression and psychrometer, and state the relationship between these terms and relative humidity.
3. Define the specific volume and enthalpy of air.
4. Identify and interpret the psychrometric properties of air on a psychrometric chart.

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Topic 25 Application of the Psychrometric Chart

Learning Outcome

Solve problems using a psychrometric chart.

Learning Objectives

1. Interpret the psychrometric chart to find values of specific properties.
2. Apply the psychrometric chart to the heating and cooling of air, and calculate heat added or removed.
3. Apply the psychrometric chart to the humidification and dehumidification of air and calculate moisture added or removed.
4. Apply the psychrometric chart to combined heating/cooling and humidification problems.
5. Discuss what is meant by “comfort conditions” with respect to the psychrometric chart.

Topic 26 Fans for Air Distribution Systems

Learning Outcome

Describe the air flow behavior and movement of air through distribution systems.

Learning Objectives

1. Discuss the theory of air flow and pressure conversions.
2. Describe the major types of air handling fans, their construction and operation.
3. Interpret fan performance curves.
4. Describe fan motors, drives and belt guards.
5. Describe fan volume controls.

Topic 27 Air Conditioning Duct Systems

Learning Outcome

Describe the designs and components of duct systems used in air conditioning.

Learning Objectives

1. Explain how air duct systems are classified.
2. Describe air duct materials, system layout, fabrication and installation.
3. Describe air duct leakage.
4. List and describe the types of liners, dampers, and louvers used in air duct systems.
5. Discuss terminal air distribution devices and the principles of diffusion, induction, entrainment and aspiration.

Topic 28 Coil Types

Learning Outcome

Describe the various types of coils used in air conditioning systems.

Learning Objectives

1. Describe the general construction of finned type heat exchanger coils.
2. Describe the detailed construction and operational principles of water coils.
3. Describe the detailed construction and operational principles of steam coils.

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Topic 29 Coil Operation

Learning Outcome

Describe the operation of the various types of coils used in air conditioning systems.

Learning Objectives

1. Explain the operational and equipment sizing issues and freezing problems associated with steam coils.
2. Explain the operational and equipment sizing issues and freezing problems associated with water coils.
3. Explain the operational and equipment sizing issues associated with glycol coils.
4. Describe the installation recommendations for coils, piping, steam traps, control valves, air vents and vacuum relief devices.

Topic 30 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and warm air types of humidifiers.
3. Describe industrial and commercial types of humidifiers.

Major Topic: Air Conditioning Systems

Topic 31 Air Conditioning Systems I

Learning Outcome

Describe the operation of various air conditioning systems.

Learning Objectives

1. List the functions and categories of air conditioning systems.
2. Describe the operation of air handling units.
3. Describe the general layout and operation of unitary air conditioning systems.
4. Describe the general layout and operation of central air conditioning systems.

Topic 32 Air Conditioning Systems II

Learning Outcome

Describe the design and operation of combined air conditioning systems and explain the factors to consider when selecting an air conditioning system.

Learning Objectives

1. Describe the general layout and operation of combined air conditioning systems.
2. Discuss the alternative arrangements of equipment for air conditioning systems.
3. Discuss the selection criteria for air conditioning systems.

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Topic 33 Air Conditioning Heat Recovery Systems

Learning Outcome

Explain the purpose, design and operation of heat recovery in air conditioning systems.

Learning Objectives

1. Describe the general principles of air conditioning heat recovery and the operation of “run-around” systems.
2. Describe the thermal wheel air conditioning heat recovery system.
3. Describe the heat pipe air conditioning heat recovery system.
4. Describe the heat pump system.

Topic 34 Air Conditioning System Controls

Learning Outcome

Describe the control systems used in air conditioning.

Learning Objectives

1. Describe various ventilation control strategies for air conditioning systems.
2. Describe preheat coil control strategies for air conditioning systems.
3. Describe heating coil control strategies for air conditioning systems.
4. Describe humidification control strategies for air conditioning systems.
5. Describe dehumidification and cooling control strategies for air conditioning systems.
6. Describe volume control with static pressure regulation for air conditioning systems.
7. Describe complete air conditioning control systems.

Topic 35 Heat Gains and Losses

Learning Outcome

Describe the various ways a building gains and loses heat.

Learning Objectives

1. Define heat transmission terminology.
2. Describe the heat gains that occur in a building due to conduction, infiltration, radiation and ventilation.
3. Describe the heat gains that occur in a building due to people, lighting, electric motors, appliances and cooking.
4. Describe the heat losses that occur in a building due to conduction, convection, radiation, infiltration and ventilation.

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REFERENCE CURRICULUM

For

HVAC Plant Operator (2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the HVAC Plant Operator (2nd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for HVAC Plant Operator (2nd Class) Examination Candidates

Major Topic: Heating Systems and Human Comfort

Topic 1 Heat Gains and Losses

Learning Outcome

Describe the various ways a building gains and loses heat.

Learning Objectives

1. Define heat transmission terminology and identify conversions or related units.
2. Describe the heat gains that occur in a building due to conduction, infiltration, ventilation, and radiation.
3. Describe the heat gains that occur in a building due to people, lighting, electric motors, appliances, and cooking.
4. Describe the heat losses that occur in a building due to conduction, convection, radiation, infiltration, and ventilation.

Topic 2 Steam Heating Equipment

Learning Outcome

Describe the operating principles of steam heating equipment and components.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. List and describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.

Topic 3 Steam Heating Systems

Learning Outcome

Describe the operating principles and maintenance procedures of steam heating systems and the components of these systems.

Learning Objectives

1. Describe standard types of piping and equipment layout for steam heating systems.
2. Describe the general operation and maintenance of steam heating systems.
3. Apply a steam heating system troubleshooting guide.

Topic 4 Hot Water Heating Systems

Learning Outcome

Describe the various designs of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe radiant panel and snow melting hot water systems.

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Topic 5 Hot Water Heating System Equipment and Operation

Learning Outcome

Describe accessories, operation and troubleshooting of a hot water heating system.

Learning Objectives

1. Describe the purpose and function of standard hot water heating system components such as diverter fittings, air vents, air separators, flow control valves, balancing valves and fittings, riser stop valves, pressure reducing valves, circulating pumps, expansion tanks, and steam to hot water converters.
2. Explain how the location of the hot water circulating pump and the expansion tank are determined.
3. Describe the cleaning, filling, starting, routine operation, and troubleshooting of hot water heating systems.
4. Apply a hot water heating system troubleshooting guide.

Topic 6 Warm Air Heating System Equipment

Learning Outcome

Describe the operating principles of warm air heating sources.

Learning Objectives

1. Compare the advantages and disadvantages of forced air and gravity warm air systems.
2. List and describe the common sources of warm air heat.
3. List and describe the operational characteristics of directly fired space heaters.

Topic 7 Warm Air Furnace Components and Maintenance

Learning Outcome

Describe the components and maintenance requirements of typical warm air heating and ventilating systems.

Learning Objectives

1. Describe the operation of furnace components.
2. Describe and discuss the relative merits of three types of air distribution and duct systems.
3. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
4. Apply a troubleshooting guide for forced warm air systems and components.

Topic 8 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems found in buildings, as well as describe the various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the types of contaminants found in air.
3. Describe the types of air cleaning devices used in buildings.

Topic 9 Infrared and Electric Heating

Learning Outcome

Describe infrared and electric heating systems.

Learning Objectives

1. Discuss the concept and application of infrared heating.
2. Describe the construction and operation of gas-fired and electric infrared heaters.
3. List the advantages of electric heating systems compared to other types of heating systems.
4. Describe the different methods of electric heating.

Topic 10 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and commercial types of humidifiers.
3. Describe industrial types of humidifiers.

Topic 11 Electric Controls for Heating Systems

Learning Outcome

Describe and explain the function of the various components of an electric control circuit.

Learning Objectives

1. Discuss the various terms associated with electric control systems.
2. Describe the basic construction and operation of electric thermostats, humidity controllers, and pressure controllers.
3. Describe the function and operation of the controlled devices in electric control systems.
4. Explain the operating sequence of a basic electric control circuit.

Major Topic: Plumbing and Auxiliaries

Topic 12 Building Water Supply Systems

Learning Outcome

Explain the various water supply systems in a building.

Learning Objectives

1. Describe the cold water distribution system in a building.
2. Describe the hot water distribution system in a building.
3. Describe the construction and operation of building system hot water heaters.
4. Explain what is meant by “backflow prevention” and describe the common methods used.
5. List and describe the construction and operation of water system protective devices in buildings.

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Topic 13 Sanitary Drainage Systems

Learning Outcome

Describe various sanitary drainage systems employed in buildings.

Learning Objectives

1. Describe the overall layout of building drainage systems.
2. Describe storm water drainage systems for buildings.
3. List the steps to take in the routine maintenance of building sanitary drainage system devices.
4. Apply a troubleshooting guide for sanitary drainage systems.

Major Topic: Lighting

Topic 14 Lighting Systems

Learning Outcome

Explain the various lighting systems and some of the basic design considerations for lighting a space.

Learning Objectives

1. Describe the common types of lighting equipment and systems.
2. Explain the various methods of lighting control.
3. Describe the general requirements and criteria for emergency lighting in buildings.
4. Discuss the interrelationship between lighting, air conditioning, and energy conservation in buildings.

Major Topic: Refrigeration

Topic 15 Refrigeration Theory

Learning Outcome

Explain the theory and terms associated with refrigeration.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the practical cycle of operations in a vapour compression refrigeration system.
3. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.

Topic 16 Refrigerants

Learning Outcome

Describe the different refrigerants used and explain the various properties of these refrigerants.

Learning Objectives

1. Describe the identification and classification of refrigerants.
2. Describe the characteristics and thermodynamic properties of refrigerants.
3. Describe the physical properties of refrigerants.

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Topic 17 Compression Refrigeration Systems

Learning Outcome

Describe the operating principle of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Distinguish between direct and indirect refrigeration systems.
3. Explain how compression refrigeration system temperatures and pressures are related.
4. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizer.

Topic 18 Refrigeration Compressors

Learning Outcome

Describe the operating principles and the components of refrigeration compressors and perform simple compressor calculations.

Learning Objectives

1. Describe the construction and operation of a reciprocating refrigeration compressor.
2. Describe the construction and operation of a rotary refrigeration compressor.
3. Describe the construction and operation of a centrifugal refrigeration compressor.
4. Describe the construction and operation of seals for refrigeration compressors.
5. Calculate the capacity, efficiency, and ratio of a refrigeration compressor.

Topic 19 Heat Exchangers for Refrigeration Systems

Learning Outcome

Describe the different types of heat exchangers used in refrigeration systems.

Learning Objectives

1. Describe the designs and construction of refrigeration system evaporators.
2. Describe the designs and construction of refrigeration system condensers.
3. Discuss refrigeration condenser operation and maintenance.

Topic 20 Refrigeration Accessories

Learning Outcome

Describe the various accessories used in refrigeration systems.

Learning Objectives

1. List and describe the operation of the gauges, separators, strainers, and indicators that are used as accessories in refrigeration systems.

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Topic 21 Cooling Towers

Learning Outcome

Describe the operation and maintenance of cooling towers.

Learning Objectives

1. List the factors that determine rate of cooling in a cooling tower and the basic components of a cooling tower.
2. Describe the construction and operation of a natural draft cooling tower.
3. Describe the construction and operation of a mechanical draft cooling tower.
4. Discuss cold climate operation for cooling towers.
5. Apply a cooling tower troubleshooting guide.

Topic 22 Air Conditioning Systems

Learning Outcome

Describe the operation of various air conditioning systems.

Learning Objectives

1. List the functional components and categories of air conditioning systems.
2. Describe the operation of air handling units.
3. Describe the general layout and operation of unitary air conditioning systems.
4. Describe the general layout and operation of central air conditioning systems.

Major Topic: Refrigeration and AC System Controls

Topic 23 Refrigeration Metering Devices and Capacity Controls

Learning Outcome

Describe the operating principles of refrigeration metering devices and capacity controls.

Learning Objectives

1. Describe the construction and operation of compression refrigeration cycle expansion valves.
2. Describe the types of evaporator and compressor capacity controls.

Topic 24 Refrigeration Cycle Controls

Learning Outcome

Describe the purposes and operating principles of the operational and safety controls on a refrigeration system.

Learning Objectives

1. Describe the operation of the various operating controls for refrigeration systems.
2. Describe the actuators used in refrigeration control systems.
3. Describe the typical refrigeration system safety shutdown devices.

Topic 25 Compression Refrigeration System Pre-Startup Procedures

Learning Outcome

Describe the various pre-startup procedures used on compression refrigeration systems.

Learning Objectives

1. Describe how to perform refrigeration system leak tests.
2. Describe how a refrigeration system is dried and charged prior to startup.
3. Describe how a refrigeration system is purged of noncondensable gases prior to startup.
4. List the steps for adding oil to a refrigeration compressor when it is in service.

Topic 26 Compression Refrigeration System Operations

Learning Outcome

Describe the various operation and maintenance procedures used on compression refrigeration systems.

Learning Objectives

1. Describe the steps in the startup and shutdown of a compression refrigeration system.
2. List the safety shutdown devices that are specific to centrifugal compressors.
3. Describe the routine operation and associated log sheets for compression refrigeration systems.
4. List and describe the standard preventive maintenance procedures for compression refrigeration systems.
5. Apply a compression refrigeration system troubleshooting guide.

Major Topic: Pumps and Air Compressors

Topic 27 Air Compression

Learning Outcome

Describe the operating principles of the different types of air compressors.

Learning Objectives

1. Describe the main classifications and types of air compressors.
2. Describe air compressor auxiliary equipment, including capacity control systems.
3. Discuss preventive maintenance for reciprocating air compressors.

Topic 28 Types of Pumps

Learning Outcome

Describe the various types of pumps found in buildings and industrial plants.

Learning Objectives

1. List the common applications of pumps in the power industry.
2. Define the terms associated with pump performance.
3. Describe the common types of pumps used in the power industry.

Topic 29 Pump Operation and Maintenance

Learning Outcome

Describe all details pertaining to pump operation and various maintenance procedures performed on pumps.

Learning Objectives

1. Describe the construction and function of pump wear rings.
2. Discuss pump shaft sealing and describe the process that is followed when replacing compression type packing.
3. Sketch and describe the standard types of mechanical seals.
4. Describe pump bearing and shaft alignment equipment and procedures.
5. Describe pump startup and priming procedures.
6. Identify pump troubles and their possible causes.

Topic 30 Lubrication

Learning Outcome

Describe the importance and the principles of lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and applications.
3. List the properties of lubricating oils and the additives used.

Topic 31 Types of Bearing Lubrication

Learning Outcome

Describe the methods for simple care and maintenance of bearings and their related lubrication systems.

Learning Objectives

1. Define boundary and fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of thrust bearings.
4. Describe how to clean and replace roller and ball bearings.
5. List the causes of bearing failure.

Major Topic: Distributed Generation

Topic 32 Microturbines

Learning Outcome

Describe the application and operation of microturbines.

Learning Objectives

1. Explain the application of microturbines in the generation of electricity and heat.

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Topic 33 Internal Combustion (IC) Engine Gen-Sets

Learning Outcome

Describe the application and operation of IC gen-sets.

Learning Objectives

1. Explain startup and shutdown procedures.
2. Explain the proper routine pre-start and operational checks.
3. Identify the three main methods of starting gen-sets.

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REFERENCE CURRICULUM

For

Compressor Plant Operator (1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Compressor Plant Operator (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Compressor Plant Operator (1st Class) Examination Candidates

Topic 1 Compressor Theory and Designs

Learning Outcome

Explain the classification, designs, and operating principles of industrial air and gas compressors.

Learning Objectives

1. Explain compressor terminologies, including compression ratio, capacity, staging, intercooling and aftercooling. Explain the effects of moisture in compressed gases. Explain the effects of altitude on the compression process.
2. Describe the operation and common arrangements of reciprocating compressors, including single-acting, double-acting, and tandem arrangements.
3. Identify the components of a reciprocating compressor and describe the operation of plate and channel valves.
4. Describe internal and external lubrication systems for reciprocating compressors.
5. Describe the design and explain the operating principles of rotary compressors, including sliding vane, rotary lobe, and rotary screw.
6. Identify the components and controls for a packaged industrial screw compressor.
7. Describe designs and principles of centrifugal compressors/blowers, including single and multi-stage designs.
8. Describe designs and principles of axial compressors/blowers.

Topic 2 Compressor Auxiliaries and Operation

Learning Outcome

Explain the controls and system auxiliaries for a typical instrument air system and explain startup procedures for air compressors.

Learning Objectives

1. Describe the control devices and strategies for air compressors, including start-and-stop, variable speed, constant speed; describe pilot and unloader devices.
2. Explain the design and operation of an anti-surge system for a dynamic compressor.
3. Describe the designs of water and air-cooled aftercoolers and intercoolers, with separators.
4. Describe the components, arrangement, and parameters of a typical, complete instrument air system, including wet and dry receivers, dryers.
5. Describe the components and operating principles and sequences of instrument air dryers. Explain dewpoint monitoring of air systems.
6. Describe the design, fittings, and operating consideration for air receivers.
7. Explain the start-up procedure for a positive displacement compressor.
8. Explain the start-up procedure for a dynamic compressor/blower.

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Topic 3 Air and Gas Compression

Learning Outcome

Explain the construction and operation of large air compressors and compressed air systems.

Learning Objectives

1. Describe the design and application of compressors, including prime mover selection.
2. Describe reciprocating compressor designs.
3. Describe rotary compressor designs.
4. Describe centrifugal and axial compressor designs.
5. Describe the types and operation of coolers and air dryers, including desiccant types.
6. Describe the installation of a compressed air system, including all ancillary equipment and typical instrumentation.
7. Describe the regulation and control of compressors.
8. Describe the monitoring and protection devices for a compressed air system.
9. Explain the effects of altitude, air temperature, and humidity on air compressor performance.
10. Describe the monitoring, troubleshooting, and typical preventive maintenance for a compressed air system.

Topic 4 Refrigeration Systems and Equipment

Learning Outcome

Explain the construction and operation of refrigeration systems.

Learning Objectives

1. Describe the types of refrigerants.
2. Describe the principles and operation of vapor compression refrigeration systems.
3. Describe the principles and operation of absorption refrigeration systems.
4. Describe the principles and operation of multi-stage and cascade refrigeration systems.
5. Describe the principles, applications, and operation of heat pump and thermoelectric systems.
6. Describe the design of hermetic refrigeration systems.
7. Describe the design and operation of refrigeration compressors.
8. Describe the design and operation of evaporators, condensers, receivers, scale traps and dehydrators.
9. Describe the design and operation of absorbers.
10. Describe the design and operation of valves and fittings.

Topic 5 Refrigeration Safety, Control, and Operation

Learning Outcome

Explain the procedures, standards, instrumentation, and controls for a refrigeration system.

Learning Objectives

1. Describe the codes and standards which apply to the design, installation, and operation of a refrigeration plant.
2. Describe the purpose and operation of the various operating, actuating, limiting and safety controls used in refrigeration systems.
3. Explain refrigeration metering devices.
4. Explain evaporator and compressor capacity controls.
5. Describe the detailed startup and shutdown procedures for a refrigeration system.
6. Explain absorption system startup and shutdown.
7. Explain leak testing, charging, purging, and compressor lubrication.
8. Describe the common operating problems and troubleshooting procedures for a refrigeration system.

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REFERENCE CURRICULUM

For

Compressor Plant Operator (2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Compressor Plant Operator (2nd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Compressor Plant Operator (2nd Class) Examination Candidates

Topic 1 Air Compression

Learning Outcome

Describe the operating principles of the different types of air compressors.

Learning Objectives

1. Describe the main classifications and types of air compressors.
2. Describe air compressor auxiliary equipment, including capacity control systems.
3. Discuss preventative maintenance for reciprocating air compressors.

Topic 2 Compressor Theory and Designs

Learning Outcome

Explain the classification, designs, and operating principles of industrial air and gas compressors.

Learning Objectives

1. Explain compressor terminologies, including compression ratio, capacity, staging, intercooling and aftercooling. Explain the effects of moisture in compressed gases. Explain the effects of altitude on the compression process.
2. Describe the operation and common arrangements of reciprocating compressors, including single-acting, double-acting, and tandem arrangements.
3. Identify the components of a reciprocating compressor and describe the operation of plate and channel valves.
4. Describe internal and external lubrication systems for reciprocating compressors.
5. Describe the design and explain the operating principles of rotary compressors, including sliding vane, rotary lobe, and rotary screw.
6. Identify the components and controls for a packaged industrial screw compressor.
7. Describe designs and principles of centrifugal compressors/blowers, including single and multi - stage designs.
8. Describe designs and principles of axial compressors/blowers.

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Topic 3 Compressor Auxiliaries and Operation

Learning Outcome

Explain the controls and system auxiliaries for a typical instrument air system and explain startup procedures for air compressors.

Learning Objectives

1. Describe the control devices and strategies for air compressors, including start-and-stop, variable speed, constant speed; describe pilot and unloader devices.
2. Explain the design and operation of an anti -surge system for a dynamic compressor.
3. Describe the designs of water and air-cooled aftercoolers and intercoolers, with separators.
4. Describe the components, arrangement, and parameters of a typical, complete instrument air system, including wet and dry receivers, dryers.
5. Describe the components and operating principles and sequences of instrument air dryers. Explain dewpoint monitoring of air systems.
6. Describe the design, fittings, and operating consideration for air receivers.
7. Explain the start-up procedure for a positive displacement compressor.
8. Explain the start-up procedure for a dynamic compressor/blower.

Topic 4 Air and Gas Compression

Learning Outcome

Explain the construction and operation of large air compressors and compressed air systems

Learning Objectives

1. Describe the design and application of compressors including a selection of prime movers.
2. Describe the design of reciprocating compressors.
3. Describe the design of rotary compressors.
4. Describe the design of centrifugal and axial compressors.
5. Describe the types and operation of coolers and air driers including types of desiccants.
6. Describe the installation of a compressed air system showing all ancillary equipment including typical instrumentation.
7. Describe the regulation and control of compressors.
8. Describe the monitoring and protection devices for a compressed air system.
9. Explain the effects of altitude, air temperature, and humidity on air compressor performance.
10. Describe the monitoring, troubleshooting, and typical preventive maintenance for a compressed air system.

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REFERENCE CURRICULUM

For

Diesel Plant Operator (1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Diesel Plant Operator (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

Reference Curriculum for Diesel Plant Operator (1st Class) Examination Candidates

Topic 1 Internal Combustion Engines: Components and Auxiliaries

Learning Outcome

Explain the design, selection, and components of internal combustion engine installations, including auxiliaries.

Learning Objectives

1. Explain design, applications, and selection criteria for the different types of reciprocating internal combustion engines.
2. Explain fuels and combustion processes used by internal combustion engines.
3. Describe the design of internal combustion engine scavenging and supercharging arrangements.
4. Describe the design and components of internal combustion engine fuel conditioning systems, injection systems, and ignition systems.
5. Describe the design and components of internal combustion engine cooling systems and cooling water conditioning systems.
6. Describe the purpose, design and components of internal combustion engine lubricating oil systems.
7. State the purpose and describe the control of a typical internal combustion engine including the operation of safety devices.

Topic 2 Internal Combustion Engines: Operation and Maintenance

Learning Outcome

Describe general maintenance requirements, and detailed operating and troubleshooting procedures for internal combustion engines.

Learning Objectives

1. Describe the detailed startup procedures for an internal combustion engine.
2. Describe the detailed shutdown procedures for an internal combustion engine.
3. Explain the routine maintenance and monitoring requirements for an internal combustion engine.
4. Explain the major maintenance and overhaul requirements for an internal combustion engine.
5. Explain the troubleshooting of combustion and engine problems.

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REFERENCE CURRICULUM

For

Diesel Plant Operator (2nd Class)

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Introduction

This Curriculum is intended to assist candidates studying for the Diesel Plant Operator (2nd Class) Examination.

Recommended Study Program:

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Reference Curriculum for Diesel Plant Operator (2nd Class) Examination Candidates

Topic 1 Internal Combustion Engines

Learning Outcome

Describe the application, construction, and operation of internal combustion engines.

Learning Objectives

1. Discuss the fuels used in internal combustion engines.
2. Describe the working cycles of the 4-stroke and 2-stroke spark ignition engines.
3. Describe the working cycle of the 4-stroke compression ignition (i.e., diesel) cycle.
4. Describe the construction of basic spark and compression cycle engines.
5. Explain the basic operating considerations for diesel engines.

Topic 2 Compressor Theory and Designs

Learning Outcome

Explain the classification, designs, and operating principles of industrial air and gas compressors.

Learning Objectives

1. Explain compressor terminologies, including compression ratio, capacity, staging, intercooling and aftercooling. Explain the effects of moisture in compressed gases. Explain the effects of altitude on the compression process.
2. Describe the operation and common arrangements of reciprocating compressors, including single-acting, double-acting, and tandem arrangements.
3. Identify the components of a reciprocating compressor and describe the operation of plate and channel valves.
4. Describe internal and external lubrication systems for reciprocating compressors.
5. Describe the design and explain the operating principles of rotary compressors, including sliding vane, rotary lobe, and rotary screw.
6. Identify the components and controls for a packaged industrial screw compressor.
7. Describe designs and principles of centrifugal compressors/blowers, including single and multi-stage designs.
8. Describe designs and principles of axial compressors/blowers.

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Topic 3 Compressor Auxiliaries and Operation

Learning Outcome

Explain the controls and system auxiliaries for a typical instrument air system and explain startup procedures for air compressors.

Learning Objectives

1. Describe the control devices and strategies for air compressors, including start-and-stop, variable speed, constant speed; describe pilot and unloader devices.
2. Explain the design and operation of an anti-surge system for a dynamic compressor.
3. Describe the designs of water and air-cooled aftercoolers and intercoolers, with separators.
4. Describe the components, arrangement, and parameters of a typical, complete instrument air system, including wet and dry receivers, dryers.
5. Describe the components and operating principles and sequences of instrument air dryers. Explain dewpoint monitoring of air systems.
6. Describe the design, fittings, and operating consideration for air receivers.
7. Explain the start-up procedure for a positive displacement compressor.
8. Explain the start-up procedure for a dynamic compressor/blower.

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REFERENCE CURRICULUM

For

International Power Engineer (1st Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
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Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the International Power Engineer (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for International Power Engineer (1st Class) Examination Candidates

Major Topic: Applied Thermodynamics and Plant Cycles

Topic 1 Rankine and Brayton Cycles

Learning Outcome

Discuss the application of the Rankine and Brayton cycles to a power plant.

Learning Objectives

1. Explain heat engines and their application to a steam power plant.
2. Explain the Rankine Cycle using a steam temperature-entropy diagram.
3. Evaluate a Rankine Cycle power plant in terms of efficiency, work ratio, specific steam consumption, isentropic efficiency and efficiency ratio.
4. Explain the Rankine Cycle improvements that can be incorporated into a power plant.
5. Explain the Brayton Cycle and its application to a gas turbine.
6. Explain the Brayton Cycle using pressure-volume and temperature-entropy diagrams.
7. Evaluate a Brayton Cycle power plant in terms of temperatures, work output, and efficiency.
8. Explain the Brayton Cycle improvements that can be incorporated into a power plant.
9. Describe the design, layout, and advantages of a gas turbine / steam turbine combined cycle plant.
10. Explain the total energy concept as it applies to a power plant.

Topic 2 Thermodynamics of Steam

Learning Outcome

Perform calculations for thermodynamic cycles of steam.

Learning Objectives

1. Describe the basis for non-flow processes of vapors.
2. Explain the constant volume process for steam and calculate heat supplied, work done and internal energy.
3. Explain the constant pressure process for steam and calculate heat supplied, work done and internal energy.
4. Explain the constant temperature process for steam and calculate heat supplied and work done.
5. Calculate steam entropy given the steam conditions.
6. Explain the significance of a Temperature-Entropy diagram for steam.
7. Explain the reversible adiabatic process for steam and calculate work done and internal energy.
8. Explain the significance of a Mollier chart for steam.

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Topic 3 Steady Flow Process Calculations

Learning Outcome

Perform steady flow process calculations for vapors and gases.

Learning Objectives

1. Describe the steady-flow energy equation and calculate the work done in a steady-flow process.
2. Calculate the power consumed in a steady-flow process.
3. Explain the principle of conservation of energy and supersaturation as they apply to a nozzle and calculate nozzle inlet and outlet velocities.
4. Calculate the initial dryness fraction of steam in a throttling process.
5. Determine, using a Mollier Chart, the quality, enthalpy, and entropy of steam entering a calorimeter.
6. Calculate energy transfer, work done, and power produced in a steam turbine.
7. Calculate the heat lost, surface area, required cooling water flow, and heat transfer coefficient in a steam condenser.
8. Define and calculate availability and effectiveness in the context of the steady-flow processes.

Topic 4 Thermodynamics of Perfect Gases

Learning Outcome

Perform calculations for thermodynamic cycles of perfect gases.

Learning Objectives

1. Review the behavior of perfect gases.
2. Explain Joule's law and its significance.
3. Calculate the heat added or rejected by a mass of perfect gas under changing temperature and pressure conditions.
4. Explain the isothermal cycle using a pressure-volume diagram and calculate heat rejected and work done using a perfect gas as the working fluid.
5. Explain the reversible adiabatic cycle using a pressure-volume diagram and calculate work done, final volume, and final temperature using a perfect gas as the working fluid.
6. Calculate work done in a polytropic cycle using a perfect gas as the working fluid.
7. Using the heat energy equation, calculate the efficiency of a polytropic compression process for a perfect gas.
8. Explain the Gibbs-Dalton law and calculate the work done and heat flow per kilogram when a gas mixture is expanded.

Topic 5 Expansion and Heat Transfer

Learning Outcome

Perform calculations for expansion and heat transfer.

Learning Objectives

1. Explain how thermal expansion and contraction is allowed for in boiler and piping design.
2. Calculate the linear and volumetric expansion of a header or pipe, given internal temperature conditions.
3. Calculate heat transfer by conduction.
4. Calculate the heat flow through a compound insulated wall.
5. Calculate the thickness of insulation required to maintain a given temperature gradient.

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Topic 6 Refrigeration Calculations

Learning Outcome

Perform thermodynamic calculations for a refrigeration system.

Learning Objectives

1. Explain the Carnot Cycle as it applies to refrigeration using temperature-entropy and pressure-enthalpy diagrams.
2. Calculate the Carnot coefficient of performance of a refrigeration system and a heat pump system.
3. Calculate the refrigerating effect of a refrigeration system.
4. Calculate the coefficient of performance of a refrigeration system and a heat pump system.
5. Demonstrate graphically, using temperature-enthalpy diagrams, the effect on refrigeration capacity of using a throttle valve in place of an expansion machine, of superheating at the compressor inlet, of undercooling the condensed refrigerant, and of using a flash chamber.
6. Calculate the mass flow of refrigerant in a system.
7. Calculate the swept volume of a compressor cylinder, given its volumetric efficiency.
8. Calculate the power requirement of a refrigerant compressor.

Major Topic: Principles of Applied and Fluid Mechanics

Topic 1 Lifting Machines

Learning Outcome

Perform calculations for lifting machines.

Learning Objectives

1. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load for lifting machines.
2. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a differential pulley block.
3. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a worm gear and worm wheel.
4. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a worm-driven screw jack.
5. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a turnbuckle.
6. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a hydraulic jack.

Topic 2 Energy and Momentum

Learning Outcome

Perform calculations involving potential energy, kinetic energy, and momentum of bodies in linear and rotating motion.

Learning Objectives

1. Define potential and kinetic energy.
2. Calculate the potential energy of a compressed spring.
3. Describe the behavior of a spring-mass system and calculate the maximum compression of a spring caused by contact with a moving mass.
4. Describe the effect of friction losses on potential and kinetic energy.
5. Define linear momentum and calculate the coefficient of restitution.
6. Calculate the kinetic energy and velocity of an elastic head-on collision.
7. Define angular momentum and calculate the changes in momentum of rotating shafts.
8. Calculate the kinetic energy and velocity of a rotating shaft.
9. Calculate the time required to change the rotational velocity of a shaft.

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Topic 3 Centripetal Force and Acceleration

Learning Outcome

Perform calculations involving centripetal and centrifugal forces.

Learning Objectives

1. Calculate the centripetal acceleration of a rotating body in uniform circular motion.
2. Calculate the centrifugal force on a rotating body in uniform circular motion.
3. Calculate the tension in an attachment cord for vertically revolving masses.
4. Calculate the speed and period of a conical pendulum.
5. Calculate the positions of balancing masses to equalize centrifugal forces.
6. Calculate the stress in a rotating flywheel rim.
7. Calculate the velocity, acceleration, and accelerating force of a reciprocating component such as a piston driving, or driven from, a crankshaft.

Topic 4 Torque and Torsion

Learning Outcome

Perform calculations involving torque and torsion.

Learning Objectives

1. Calculate angular velocity given the angular momentum of a rotating shaft.
2. Calculate strain in a solid bar under torsion load.
3. Calculate the stress at a given radius in a solid shaft.
4. Calculate torsional stress and strain in a hollow shaft.
5. Calculate modulus of rigidity and torsional resilience for a solid shaft.
6. Calculate the power consumed by torque acting on a rigid body rotating about a fixed axis.
7. Calculate maximum and mean torque for solid and hollow shafts of circular cross section.
8. Calculate the deflection of a closely coiled helical spring.

Topic 5 Stress and Strain

Learning Outcome

Perform calculations involving stress, strain, shear forces, and bending moments.

Learning Objectives

1. Explain the behavior of stress and strain in solids.
2. Calculate single and double shear stress in a solid bar subject to oblique loading.
3. Define the modulus of elasticity.
4. Calculate stress, strain, and the equivalent modulus of elasticity for a compound bar.
5. Calculate stress due to restricted thermal expansion.
6. Calculate the elastic strain energy of a solid bar.
7. Calculate the instantaneous compression and stress of a solid bar subjected to suddenly applied and shock loads.
8. Calculate stresses in pressure vessels due to internal pressure.
9. Using the fundamental bending equation, calculate bending moment, moment of inertia, modulus of elasticity, radius of curvature, maximum stress, and location of neutral axis.
10. Compare the strengths of beams using the modulus of section.
11. Calculate the deflection of a beam under load.

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Topic 6 Static Fluids

Learning Outcome

Perform calculations involving fluids at rest.

Learning Objectives

1. Calculate the relative density of a liquid mixture.
2. Calculate the pressure indicated by a manometer.
3. Calculate the energy transmitted by a pressurized liquid.
4. Calculate the pressure and force on the surfaces of a tank containing non-mixing liquids.
5. Calculate the position of the centre of pressure of a tank containing non-mixing liquids.
6. Explain Archimedes' principle.
7. Calculate the relative density from the buoyant force on a submerged body and its true and apparent weights.
8. Calculate the tension and stress in the cable or wire supporting a submerged solid body.
9. Calculate the density of a floating body, given the volume of liquid that it displaces.

Topic 7 Fluids in Motion

Learning Outcome

Perform calculations involving fluids in motion.

Learning Objectives

1. Explain the equation of continuity.
2. Calculate the fluid flow through a valve, given the valve diameter and lift.
3. Calculate flow through rectangular and triangular notches.
4. Calculate the total energy of a liquid in motion.
5. Calculate the pressure in a pipe given the cross-sectional area and liquid flow rate.
6. Calculate the diameter, velocity, and flow through an orifice given the coefficient of discharge.
7. Calculate flow through horizontal and vertical venturi given the discharge coefficient.
8. Compare the resistance to flow of various liquids due to their viscosity using the velocity gradient and coefficient of viscosity.
9. Explain the significance of steady and unsteady liquid flows with regard to Reynold's number.
10. Using Poiseuille's equation, calculate liquid flow in a pipe and the pressure required for the liquid flow to overcome viscosity.
11. Calculate the theoretical head imparted to water by a centrifugal pump.
12. Calculate the manometric head and efficiency, and power consumed by a centrifugal pump.
13. Calculate the power available from a hydraulic turbine.
14. Explain the design and significance of convergent and convergent-divergent nozzles and calculate the critical pressure of a steam nozzle.

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Major Topic: Applied Engineering Technologies

Topic 1 Metallurgy

Learning Outcome

Discuss the selection, properties, and stress effects of steel.

Learning Objectives

1. Describe the structure of metals.
2. Explain the nature and significance of phase changes in iron and steel due to temperature change.
3. Explain how alloying elements affect phase changes in steel and state the major alloying elements used in steel.
4. Explain the effect of temperature on the tensile strength of steel.
5. Explain the criteria for the assessment of materials.
6. Explain what creep is, and why it is important to monitor its effects on equipment.
7. Explain the methods of stress analysis.
8. Explain failure analysis.

Topic 2 Corrosion, Chemistry and Processes

Learning Outcome

Explain the chemistry and processes of corrosion mechanisms.

Learning Objectives

1. Explain how atomic and molecular structures affect corrosion.
2. Explain the anodic and cathodic processes of corrosion.
3. Explain the electromotive force series and galvanic series.
4. Explain the effect of polarization
5. Explain corrosion of single metals.
6. Explain the processes of crevice corrosion and pitting corrosion.
7. Explain the process of microbiologically influenced corrosion.
8. Explain the process of stress induced corrosion.
9. Explain the processes of erosion-corrosion.

Topic 3 Boiler Corrosion

Learning Outcome

Discuss the mechanisms of corrosion in boilers.

Learning Objectives

1. Explain the impact of corrosion
2. Explain the agents of corrosion found in water
3. Explain the mechanisms and significance of magnetite formation and magnetite depletion on boiler tube surfaces.
4. Explain the mechanisms and significance of economizer and superheater corrosion.
5. Explain the mechanism, identification, and significance of flue-gas side corrosion of boiler components.
6. Explain the mechanism, identification, and significance of low temperature corrosion of boiler components.
7. Explain the relationship between boiler water chemistry and corrosion of copper alloys in feedwater systems.
8. Explain the mechanisms and significance of deaerator cracking and corrosion.

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Topic 4 Corrosion Monitoring and Prevention Techniques

Learning Outcome

Explain techniques used to monitor and prevent corrosion.

Learning Objectives

1. Describe the methods of monitoring and analyzing corrosion.
2. Explain the design, applications, and operation of cathodic protection systems.
3. Explain the use of protective coatings for corrosion control.
4. Describe the regulatory and safety requirements relating to corrosion monitoring.
5. Describe chemical control of corrosion.

Topic 5 Corrosion Prevention Programs

Learning Outcome

Explain corrosion prevention programs.

Learning Objectives

1. Explain the corrosion characteristics and susceptibility of engineering materials and their selection for various purposes.
2. Describe the chemical, mechanical, and operational factors that are considered in controlling corrosion in steels.
3. Describe the chemical, mechanical, and operational factors that are considered in controlling corrosion in copper alloys.
4. Explain the risks and required precautions involved with chemical cleaning of boiler surfaces.
5. Explain the steps taken to reduce waterside and fireside corrosion during dry and wet storage of a boiler.
6. Explain the development, components, and management of a corrosion prevention program for cooling water systems, including the selection, application and characteristics of biocides.
7. Explain the development, components and management of a corrosion prevention program for piping and pressure vessels.
8. Explain the development, components and management of a corrosion prevention program for rotating equipment.

Topic 6 Fuel Types

Learning Outcome

Discuss the characteristics and applications of coal, oil, and non-conventional gaseous and liquid fuels.

Learning Objectives

1. Explain the factors involved in the selection of primary and secondary fuel for a new installation.
2. Describe the fuel handling considerations and fuel burning characteristics for non-conventional solid fuels including municipal waste, petroleum coke and biomass.
3. Compare the fuel burning characteristics of non-conventional gaseous fuels, including refinery gas, landfill gas, digester gas, carbon monoxide, liquid petroleum gases (LPGs) and acid gases.
4. Compare the fuel burning characteristics of black liquor.
5. Compare the physical properties and fuel burning characteristics of different grades of oil.
6. Describe the considerations for coal cleaning and blending.
7. Describe the purpose and process of coal gasification.
8. Differentiate between low heating value and high heating value fuels.
9. Describe the design and operational considerations for the use of low heating value fuels.
10. Explain the economic considerations for fuel selection for multifuel burners.

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Topic 7 Burner Design

Learning Outcome

Explain the criteria for burner design and selection.

Learning Objectives

1. Describe the general criteria for effective burner design.
2. Describe the classes of burner designs, based on the fuel in use.
3. Compare the design strategies for mixing fuel and air including: co-flow, cross-flow, flow stream disruption and entrainment.
4. Describe the design considerations for a duct burner.
5. Sketch a typical multi-nozzle duct burner layout.
6. Describe the relationship of burner selection to furnace design.
7. Describe the relationship between coal pulverizer selection and burner design.
8. Describe burner design methods to reduce noise.
9. Explain the principle, significance, application, and design of staged combustion burners, including staged fuel flow and staged air flow burners.

Topic 8 Combustion Optimization

Learning Outcome

Explain the considerations for obtaining optimum efficiency and operation of burners.

Learning Objectives

1. Explain the inherent assumptions and factors considered when determining combustion efficiency.
2. Explain the methods and limitations for obtaining maximum efficiency from the combustion of gaseous fuels.
3. Explain the methods and limitations for obtaining maximum efficiency from the combustion of liquid fuels.
4. Explain the methods and limitations for obtaining maximum efficiency from the combustion of solid fuels.
5. Explain the economic and efficiency factors for fuel and burner management in real time operating conditions for a multifuel system.
6. Describe the use of electronic instruments to continuously monitor combustion efficiency.
7. Explain the significance of flame shape, color and temperature.
8. Explain the effect of excess air on combustion stability and boiler efficiency.
9. Explain the symptoms, significance and corrective action for common combustion problems.

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Topic 9 Combustion Safety and Emissions

Learning Outcome

Discuss safety and environmental considerations in burner operation, including strategies for NO_X control.

Learning Objectives

1. Describe the requirements for safe operation of a combustion system.
2. Compare the significance of burner safety devices for different fuel types.
3. Explain the cause and prevention of furnace explosions in boilers and fired heaters.
4. Describe the processes for dust reduction in coal handling systems.
5. Describe the procedures for dealing with coalbunker and pulverizer fires.
6. Explain the effect of excess air and combustion efficiency on emissions parameters.
7. Explain pre-treatment as a strategy for NO_X reduction (fuel switching, additives and fuel pre-treatment).
8. Explain combustion and operational modification as a strategy for NO_X reduction (low NO_X burners, staged combustion, water/steam injection, burners out of service, low excess air and air preheat and furnace temperature reduction.
9. Explain process modification as a strategy for NO_X reduction (reduced production, electrical heating, improved thermal efficiency and product switching).
10. Explain post treatment as a strategy for NO_X reduction (SCR and SNCR).
11. Explain the effect on NO_X emissions of boiler design, boiler condition and boiler loading characteristics.
12. Explain the reasons for and significance of flue gas recirculation.

Topic 10 Water Pre-Treatment

Learning Outcome

Describe the processes used to treat raw water for power plants, including detailed chemistry where applicable.

Learning Objectives

1. Describe the mechanisms of coagulation and flocculation.
2. Describe the chemical processes and reactions of oxidation of organic contaminants.
3. Describe the chemical processes and reactions of iron and manganese removal from raw water.
4. Describe the chemical processes and reactions in a lime-soda softener.
5. Describe the chemical processes and reactions in a sodium zeolite softener.
6. Describe the chemical processes and reactions in a hydrogen zeolite softener.
7. Describe the chemical processes and reactions in a demineralizer.
8. Describe the chemical processes and reactions in a dealkalizer.
9. Describe the mechanisms of membrane technology, including chemical and mechanical cleaning methods and clean-in-place design.
10. Describe the chemical processes and mechanisms of electrodialysis (ED) and electrodeionization (EDI.)
11. Describe the chemical processes and reactions of oxygen scavenging and metal passivation.
12. Describe the methods by which silica is removed from feedwater and condensate.

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Topic 11 Internal Water Treatment

Learning Outcome

Describe the processes used to treat boiler water and condensate, including detailed chemistry where applicable.

Learning Objectives

1. Explain the principles, reactions and control of chelation.
2. Explain the principles, reactions and control of a coordinated phosphate program.
3. Explain the phenomenon of phosphate hideout.
4. Explain the principles, reactions and control of a congruent phosphate program.
5. Explain the principles, reactions and control of an equilibrium phosphate program.
6. Explain the principles, reactions and control of an all-volatile treatment program.
7. Explain the principles, reactions and control of a polymer treatment program.
8. Explain the principles, reactions and control of an oxygenated water treatment program.
9. Describe the mechanism of sludge conditioning.
10. Describe the mechanism of antifoam conditioning.
11. Describe the chemical processes and reactions of condensate treatment, including corrosion prevention, deaeration and polishing.

Topic 12 Water Treatment Management

Learning Outcome

Explain the monitoring, management, and maintenance of water treatment systems.

Learning Objectives

1. Explain the financial management of the costs and benefits of water treatment.
2. Apply raw water analysis to the selection of a water treatment system.
3. Explain monitoring and control of cycle chemistry.
4. Describe the troubleshooting process when a cycle chemistry parameter deviates from the acceptable range.
5. Describe the selection and maintenance of resins for zeolite, demineralizer, dealkalizer and condensate polisher service.
6. Describe the procedures and interpretation for tube deposit analyses.
7. Explain the inspection procedure for internal boiler components in relation to water treatment.
8. Describe a typical maintenance program for components of water treatment systems, including: water filters, clarifiers and lime-soda softeners, sodium zeolite softeners, demineralizers, mixed bed and condensate polishers, reverse osmosis units, microfiltration, electrodialysis and electrodeionization units and deaerators.
9. Describe the selection, responsibilities, and management of water treatment consultants.

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Topic 13 Non-Boiler Water Treatment

Learning Outcome

Explain the monitoring and management of potable water and cooling water treatment systems.

Learning Objectives

1. Describe the regulatory requirements for potable water quality and monitoring.
2. Describe the parameters and interpretation of potable water analyses.
3. Describe the selection and mechanism of oxidation agents.
4. Describe the mechanism of ultraviolet sterilization.
5. Explain the components and management of a cooling water treatment program.
6. Describe the use and chemistry of biocides in cooling water.
7. Describe the use and chemistry of corrosion inhibitors in cooling water.
8. Explain the use of chelants in cooling water.
9. Explain the use of threshold scale inhibitors in cooling water.
10. Explain the use of surfactants, dispersants and biodispersants in cooling water.

Major Topic: Power Plant Operations

Topic 1 Electrical Energy Management

Learning Outcome

Discuss the concepts and techniques of electrical energy management.

Learning Objectives

1. Explain the concept of energy management and identify the operational factors that are included in an energy management program.
2. Describe the significance, components, responsibilities and procedure of an energy audit.
3. Explain the significance and application of power factor management, including the effects of: capacitor banks, synchronous motors, inductive and resistive loads, transformers, voltage regulation for synchronous generators and synchronous compensators.
4. Calculate capacitor ratings required for power factor correction.
5. Explain, using a sketch, the purpose, applications, design and operation of a static uninterruptible power supply (UPS).
6. Explain the concept and significance of distributed generation, including the design implications for electrical distribution systems.
7. Describe the benefits of UPS in a distributed generation system, including the use of UPS as a bridge between utility and internal power.
8. Explain the benefits of motor-generator sets, internal combustion engines and micro-turbines in a distributed generation system.
9. Explain the design, operating principle, and benefits of a fuel cell in a distributed generation system.
10. Explain the purpose, components, and operation of emergency power systems, including the physical interconnection between emergency power and main power.
11. Explain the concept, significance, and management of peak load reduction, including utility contract obligations and use of internal generation.
12. Explain the concept and principles of generation load dispatch including contract obligations.

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Topic 2 Plant and Equipment Efficiencies

Learning Outcome

Explain and calculate power plant and equipment efficiencies.

Learning Objectives

1. Describe methods used to maximize efficiency of steam power plants and minimize energy losses.
2. Calculate boiler gross efficiency using input-output method and heat loss method.
3. Calculate turbine performance and efficiency.
4. Calculate the condensate savings and heat gained through improvements in condenser efficiency.
5. Describe the components and significant parameters of a typical computerized plant performance management system, including a program to reduce controllable losses.
6. Describe the efficiencies of a simple cycle gas turbine and various cycle improvements that can be made.
7. Describe different methods for waste heat recovery and the resultant improvement of efficiency.
8. Compare the inherent efficiencies of Once-Through Steam Generators (OTSG) with Heat Recovery Steam Generators (HRSG).
9. Calculate the steam generated and efficiency of a combined cycle plant, given system data.

Topic 3 Power Plant Construction

Learning Outcome

Explain the regulations, processes, and procedures pertaining to the design, construction, and modification of plant facilities.

Learning Objectives

1. Describe the general criteria, including economics, which must be considered in determining the need for additional facilities and in deciding between new plant construction and existing plant expansion.
2. Describe the general criteria to be considered in the design of a new plant.
3. Describe the regulatory permitting processes for a construction project, including environmental feasibility study.
4. Describe a quality assurance /quality control (QA/QC) program for pressure equipment, including the process for accepting, receiving, and approving new and used vessels.
5. Describe the major considerations and steps involved in the construction of a new plant, from design to completion.
6. Explain the role of the Chief Power Engineer and regulatory inspectors in a plant construction project.
7. Explain the components and management of a construction health and safety program.
8. Explain the process of coordinating plant expansion activities with the operation of the existing plant, including tie-in of the old and new facilities.
9. Interpret, in detail, the information provided in construction drawings.

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Topic 4 Commissioning and De-Commissioning

Learning Outcome

Explain the regulations, processes, and procedures pertaining to the commissioning and de-commissioning of plant facilities.

Learning Objectives

1. Explain the sequence for commissioning a new plant.
2. Explain the detailed procedures for commissioning a boiler.
3. Explain the detailed procedures for commissioning a steam turbine.
4. Explain the detailed procedures for commissioning a gas turbine.
5. Explain the detailed procedures for commissioning a piping system.
6. Explain the detailed procedures for commissioning a large fan.
7. Describe the content and significance of a performance contract/guarantee for new equipment or a new plant.
8. Explain the specific procedures for re-commissioning a plant after a major outage.
9. Explain the obligations and liabilities of de-commissioning a plant, including regulatory requirements.
10. Explain the specific procedures for de-commissioning a plant.

Topic 5 Retrofitting

Learning Outcome

Explain the benefits, applications, and processes of retrofitting power plant equipment.

Learning Objectives

1. Explain the considerations that are used to determine whether replacement, re-powering, retrofitting or upgrading should be undertaken.
2. Explain the regulatory requirements for modifications to equipment and systems, including pressure equipment, electrical systems and environmental impact.
3. Explain the overall process and responsibilities when modifying or retrofitting plant systems.
4. Describe the benefits of control system retrofitting with smart instrumentation.
5. Describe the retrofitting methods used to improve boiler efficiency and capacity including superheater upgrades, economizer upgrades, combustion system upgrades, improved air heater seals, improved waterwall design, environmental enhancements and control upgrades.
6. Describe the retrofitting methods used to improve steam turbine efficiency including improved turbine blades and diaphragms, turbine stage additions and improved blade tip sealing.
7. Describe the retrofitting methods used to improve gas turbine efficiency including upgrading inlet guide vanes, improved seals, tighter clearances, improved combustion liners, improved turbine blades and vanes, thermal barrier coatings, compressor blade coatings, compressor stage additions and compressor supercharging.

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Major Topic: Legislation and Codes for Industrial Equipment

Topic 1 Codes, Acts and Regulations

Learning Outcome

Explain the significance and application, at the Chief Engineer level, of boiler and pressure vessel legislation and regulations.

Learning Objectives

1. Describe the typical duties of the chief engineer as set out in boiler and pressure vessel legislation.
2. Describe the legal foundation for the boiler and pressure vessel legislation.
3. Define statutory delegation of powers as they apply to the *Boiler and Pressure Vessels Act*.
4. Describe the authority that safety officers (inspectors) have within their jurisdiction.
5. Determine what the offences and penalties are under the act and the appeal process.
6. Describe the typical regulations under the *Boiler and Pressure Vessels Act*.
7. Describe the typical codes and standards referenced by the *Boiler and Pressure Vessels Act*.

Topic 2 ASME Section I

Learning Outcome

Demonstrate familiarity with the content of A.S.M.E. Section I, and perform calculations involving cylindrical components, openings, compensations, safety and safety relief valves, and stays in boilers.

Learning Objectives

1. Describe the organization of ASME Section I and its application.
2. Calculate the required thickness or maximum allowable working pressure of a cylindrical shell.
3. Calculate the required thickness or maximum allowable working pressure of a seamless, unstayed dished head, flat head, and formed head.
4. Calculate the maximum dimensions of openings, and the strength of compensation required for reinforcement of openings in cylindrical shells, headers, or heads.
5. Calculate the requirements for braced surfaces and support stays.
6. Calculate the required tubesheet thickness and maximum allowable working pressure for firetube and watertube boilers.
7. Calculate required wall thicknesses of plain circular furnaces, circular flues, Adamson ring reinforced and corrugated furnaces.
8. Calculate the required size and capacity of pressure relief valves.

NOTE: The content of this chapter, including formulae and calculations, is based on the 2007 edition of the ASME codes. While studying, students should refer to the 2007 ASME "Academic Extract" or the complete 2007 codes

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Topic 3 ASME Section VIII and IX

Learning Outcome

Demonstrate familiarity with the content of A.S.M.E. Sections VIII and IX, and perform calculations involving cylindrical components, openings, compensations, safety and safety relief valves, and stays in pressure vessels.

Learning Objectives

1. Describe the organization of ASME Section VIII Division 1 and its application
2. Calculate the required thickness or maximum allowable working pressure of a cylindrical shell in a pressure vessel.
3. Calculate the required thickness or maximum allowable working pressure of a seamless dished head, flat head and formed head in a pressure vessel.
4. Calculate the reinforcement requirements of openings in a pressure vessel.
5. Calculate the minimum required thickness of a cylinder using ligament efficiency.
6. Calculate the required dimensions and locations of staybolts and braced surfaces in a pressure vessel.
7. Calculate the required size and capacity of pressure relief valves for a pressure vessel.
8. Explain the significance of A.S.M.E. Section IX.

NOTE: The content of this chapter, including formulae and calculations, is based on the 2007 edition of the ASME codes. While studying, students should refer to the 2007 ASME "Academic Extract" or the complete 2007 codes

Topic 4 CSA B-51 and B-52

Learning Outcome

Describe the content and requirements, and interactions with C.S.A. B-51 and C.S.A. B-52.

Learning Objectives

1. Describe the content and requirements of C.S.A. B-51
2. Describe the content and requirements of C.S.A. B-52
3. Explain the role and interactions of regulatory authorities and the Chief Engineer with regard to C.S.A. B-51 and B-52.

Topic 5 Piping and API Codes

Learning Outcome

Explain the significance and application, at the A.S.M.E. B31.1, A.S.M.E. B31.3, A.P.I. 510 and A.P.I. 570.

Learning Objectives

1. Explain the significance and applications of ASME B31.1 Power Piping.
2. Describe the general content of ASME B31.1 Power Piping.
3. Explain the significance and applications of ASME B31.3 Process Piping.
4. Describe the general content of ASME B31.3 Process Piping.
5. Explain the significance and applications of API 510 Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair and Alteration.
6. Describe the general content of API 510 Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair and Alteration.
7. Explain the significance and applications of API 570 Piping Code: In-service Inspection, Rating, and Alteration of Piping Systems.
8. Describe the general content of API 570 Piping Code: In-service Inspection, Rating, and Alteration of Piping Systems.
9. Explain the role and responsibilities of the chief engineer with regard to the ASME and API Codes.

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Major Topic: Safety, Loss, and Environmental Program Management

Topic 1 Loss Control

Learning Outcome

Describe the design, components, and implementation of a loss control program.

Learning Objectives

1. Explain the purpose, benefits, and typical components of a loss control program.
2. Explain the process of developing a comprehensive loss control program including the typical responsibilities and accountabilities of the program.
3. Describe the factors affecting insurance rates and the authority, role, and interaction of insurance inspectors with plant staff.
4. Describe the tools and techniques used to develop a positive attitude towards the components of a loss control program.
5. Describe the tools and techniques used to develop safety awareness in consumers.

Topic 2 Safety Legislation

Learning Outcome

Identify the authority and application of federal and state safety legislation to the work place.

Learning Objectives

1. Explain the ultimate responsibility and requirement, in the work place, to enforce all relevant safety legislation and regulations and to respond to regulatory directives.
2. Describe the legal and ethical obligations of managers, supervisors, and employees to personnel safety.
3. Explain the significance, components, and applications of Canada Labor Occupational Health and Safety legislation.
4. Explain the authority, significance, components, and applications of provincial safety regulations, including the role and interactions of the provincial safety inspectors with plant staff.
5. Explain the requirements for safety compliance training.
6. Explain right to refuse work legislation and its legal implications.
7. Explain the authority, significance, and applications of the Workers' Compensation Board regulations, including the role and interactions of the Board with plant staff.
8. Describe the function of, and roles and responsibilities for, a worksite health and safety committee.

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Topic 3 Safe Work Programs

Learning Outcome

Describe comprehensive safe work programs.

Learning Objectives

1. Identify the components and explain the management of a comprehensive safe work program.
2. Explain the components and management of a safety training program.
3. Explain the process of hazard identification, risk assessment and mitigation.
4. Explain the significance and procedure for safe work planning.
5. Explain the significance and procedure for safe work permits, including lockouts.
6. Explain the significance and procedure for confined space entry.
7. Explain the significance and procedure for hot work.
8. Explain the significance and procedure for excavations.
9. Explain the significance and procedure for working at heights.
10. Explain the significance and components of a contractor safety program.
11. Explain the components and management of a safety audit program, including roles and responsibilities.
12. Explain the purpose, components, and procedure for a hazard and operability study.

Topic 4 Emergency Response and Incident Investigation

Learning Outcome

Describe emergency response and incident investigation programs.

Learning Objectives

1. Identify the benefits and typical stakeholders of an emergency response program.
2. Explain the typical components of an emergency response program.
3. Explain the process of developing and maintaining an emergency response program, including typical responsibilities and accountabilities.
4. Explain the procedure for emergency response testing.
5. Explain the typical components of an incident reporting and investigation program.
6. Define categories of incidents.
7. Describe roles and responsibilities for incident initial reporting, investigation, final reporting, and corrective actions.
8. Explain the significance off and steps required in incident investigation.
9. Describe a system for managing incident report data, including the communication process and its significance.
10. Apply an incident reporting and investigation procedure to a case study.

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Topic 5 Environmental Legislation

Learning Outcome

Identify the authority and application of federal and provincial safety legislation and permits.

Learning Objectives

1. Explain the ultimate responsibility and requirements to enforce all relevant environmental legislation and regulations and to respond to regulatory directives.
2. Explain the authority, significance, components, and applications of provincial environmental legislation and regulations, including the role and interactions of the provincial inspectors with plant staff.
3. Explain the authority, significance, components, and applications of federal environmental legislation and regulations, including the role and interactions of the federal environmental inspectors with plant staff.
4. Explain the significance and process of identifying and working with typical stakeholders for environmental programs – the Environmental Impact Assessment (EIA) process.
5. Explain typical compliance requirements for an environmental monitoring program, including equipment calibration and uptime requirements.

Topic 6 Environmental Management

Learning Outcome

Explain environmental management programs, including reporting, clean-up, disposal, and reclamation.

Learning Objectives

1. Explain the purpose, significance and components of an Environmental Management System.
2. Describe the ISO 14000 - 14002 standards for an Environmental Management System.
3. Describe requirements for environmental routine, excursion and exceedance reporting.
4. Explain the compliance tests for Continuous Emission Monitoring Systems (CEMS) and the significance and procedures for Relative Accuracy Test Audits (RATA).
5. Explain the responsibilities and procedures for spill containment and cleanup.
6. Explain the components and development of an environmental audit program.
7. Explain the procedure for an environmental audit, including the roles and responsibilities for performing and responding to the audit.
8. Explain the significance, procedures, and regulatory requirements of waste segregation and disposal.
9. Identify waste streams that require special disposal procedures, including recognition of hazardous wastes.
10. Explain the significance and general components of Transportation of Dangerous Goods Acts.
11. Explain the significance and general requirements of hazardous waste transportation.
12. Describe the purpose, significance, requirements and general process of land reclamation.

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Major Topic: Inspection, Maintenance and Repair Practices

Topic 1 Project Management

Learning Outcome

Demonstrate the application of project management practices.

Learning Objectives

1. Define a project, the role of project management and the makeup of the project stakeholders.
2. Identify the roles and responsibilities of a typical project team.
3. Explain in detail the project planning step.
4. Describe the common tools that are used for project planning and management, including Work Breakdown Structure (WBS), Critical Path Method (CPM) and Gantt charts.
5. Explain in detail the project execution step, including control processes.
6. Explain in detail the project completion step, including assessment and reporting.

Topic 2 Maintenance Management Practices

Learning Outcome

Explain management practices for typical maintenance programs.

Learning Objectives

1. Describe how equipment is managed through the concept of asset management.
2. Explain the purpose, components, and management of a maintenance program including preventive, predictive and corrective maintenance approaches.
3. Explain the concepts and importance of reliability centred maintenance (RCM) in developing a maintenance program.
4. Describe the major steps in performing an RCM analysis.
5. Provide an example of how RCM is applied.
6. Explain the purpose and process of root cause failure analysis (RCFA).
7. Describe how maintenance can be optimized.
8. Describe how a plant turnaround is planned and effectively executed.
9. Explain the concept, process, and benefits of outsourcing maintenance.
10. Explain the setting up and management of short-term maintenance contracts and long-term service agreements.
11. Explain the purpose and process of maintenance planning and scheduling.

Topic 3 Boiler Repairs

Learning Outcome

Explain quality control programs and specific boiler repair procedures.

Learning Objectives

1. Explain the National Board of Boiler Inspectors (NBBI) requirements for owner inspection and quality control programs.
2. Describe in detail the components of owner inspection and quality control programs, including roles and responsibilities, records and reporting procedures.
3. Describe the roles, responsibilities, and personnel qualifications regarding repairs to boilers.
4. Explain the detailed procedure for repairs to cracks in boiler parts, including drums and headers.
5. Explain the detailed procedure for repairs to ruptured boiler tubes.
6. Explain the management, responsibilities, and procedures for safety valve repairs.

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Topic 4 Pressure Vessel and Piping Repairs

Learning Outcome

Explain specific pressure vessel and piping inspection and repair procedures.

Learning Objectives

1. Describe the management roles, responsibilities, and qualifications regarding repairs to pressure vessels and pressure piping.
2. Explain the concept for fitness for service.
3. Describe in detail a typical pressure vessel inspection, identifying typical problem areas.
4. Describe in detail a typical pressure piping inspection identifying common problem areas.
5. Explain the detailed procedure for typical repairs to cracks in pressure vessels.
6. Explain the methods and detailed procedures for typical repairs to corrosion in pressure vessels.
7. Explain the detailed procedure for typical repairs to cracks in pressure piping.
8. Explain the methods and detailed procedures for typical repairs to corrosion in pressure piping.

Topic 5 Non-Destructive Examination

Learning Outcome

Explain the methods, applications, and control of non-destructive examination.

Learning Objectives

1. Explain the significance and application of ASME Section V.
2. Describe radiographic examination.
3. Describe the process of ultrasonic examination.
4. Describe the process of dye penetrant examination.
5. Describe the process of magnetic particle examination.
6. Describe the process of eddy current examination.
7. Describe the process of acoustic emission examination.
8. Explain the selection, management, and control of a non-destructive examination contractor.

Topic 6 Rotating Equipment Maintenance

Learning Outcome

Explain specific maintenance procedures for, and typical maintenance problems of, rotating equipment.

Learning Objectives

1. Explain the typical maintenance problems of a large steam turbine.
2. Explain the procedures for inspection and overhaul of a large steam turbine.
3 Explain the typical maintenance problems of a gas turbine.
4. Explain the procedures for inspection and overhaul of a gas turbine.
5. Explain the typical maintenance problems of a large multi-stage pump.
6. Explain the procedures for inspection and overhaul of a large multi-stage pump.
7. Explain the typical maintenance problems of a large generator.
8. Explain the procedures for inspection and overhaul of a large generator.

Topic 7 Rotating Equipment Monitoring

Learning Outcome

Describe the parameters and methods of turbine monitoring and oil analysis.

Learning Objectives

1. Describe the purpose, importance and types of rotating equipment monitoring.
2. Explain the concept and significance of turbine thermal expansion, the general principles and placement of measuring devices and the procedures to control.
3. Explain the concept and significance of turbine differential expansion, the general principle and placement of measuring devices and the procedures to control.
4. Explain the concept and significance of turbine eccentricity, the general principle and placement of measuring devices and the procedures to control.
5. Explain the concept of vibration, including typical causes, effects, and locations of vibration in rotating equipment and how it is measured.
6. Explain the concept and significance of turbine critical speed.
7. Explain the concept and significance of oil whirl, oil whip, and steam whirl and the design and operational considerations to counter oil whirl.
8. Describe common oil problems and their effects on rotating equipment and a typical oil sampling and testing program.

Major Topic: Business and Workforce Management

Topic 1 Business Management

Learning Outcome

Explain general concepts in plant budgeting, finance, accounting, and inventory control.

Learning Objectives

1. Explain the concept and significance of the following accounting terms: accounting cycle, dual entry accounting, debits and credits, accrual accounting, revenue and expenses, assets and liabilities, and debt and equity.
2. Explain the concept and significance of financial statements, including Income Statement, Balance Sheet, Statement of Retained Earnings and Cash Flow Statement.
3. Explain budget development, control and reporting processes.
4. Explain typical types of budgets and their significance, including revenue, expense, capital expenditure and production budgets.
5. Explain the components of plant department budgets.
6. Explain the significance of a cost/benefit analysis.
7. Explain the “time value of money” concept and calculate the Net Present Value (NPV) and Internal Rate of Return (IRR) of a proposed investment.
8. Calculate the Return on Investment (ROI) of a proposed investment.
9. Explain depreciation, including straight-line and declining balance depreciation, and the concept and significance of Capital Cost Allowance (CCA).
10. Describe the components and use of a typical automated inventory system.
11. Explain the purpose and operation of typical inventory management systems, including fixed-point, fixed-interval, max/min, ABC, Just In Time (JIT) and Economic Order Quantity (EOQ).
12. Explain the concepts and significance of periodic and perpetual inventory systems, Last In First Out (LIFO) and First In First Out (FIFO).
13. Describe the role of a supplier and the use of strategic partnerships in an inventory management system.

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Topic 2 Contract Management

Learning Outcome

Explain general concepts and management of contracts.

Learning Objectives

1. Explain the content and significance of a typical code of ethics of a professional association.
2. Explain the importance and application of ethical practices in the work place.
3. Define and explain the legal significance of contract, offer and acceptance.
4. Explain the significance of contract documentation, and the rights and obligations of a contactor and contractee.
5. Compare contract types, including: fixed price; cost plus/shared risk; fixed price/cost plus incentive; bonus/penalty; time/material; product/service/resource; and enforceable/unenforceable contracts.
6. Describe methods of discharging a contract, including: agreement, performance, impossibility, operation of law, breach, failure to perform and specific performance.
7. Explain tort and its legal significance; the three basic types of torts, including: intentional, fault-based or negligent, and strict liability; the distinction between legal and ethical liability.
8. Explain due diligence and its legal and ethical significance.
9. Explain “force majeure” and its legal significance.
10. Explain what is involved in issuing and then completing a tendering process.

Topic 3 Problem Solving and Decision Making

Learning Outcome

Explain techniques for structured problem solving and decision making.

Learning Objectives

1. Explain the importance and application of a structured decision making process.
2. Describe the eight steps in a rational decision making process.
3. Compare analytic, conceptual, directive and behavioral decision making styles.
4. Explain the advantages and disadvantages of group decision making.
5. Describe the common methods of group decision making, including brainstorming, storyboarding, Nominal Group Technique (NGT) and the Delphi technique.
6. Apply a problem solving and decision making approach to a typical plant case study.

Topic 4 Leadership

Learning Outcome

Discuss models of leadership and motivation.

Learning Objectives

1. Explain leadership responsibilities and the significance of an effective leadership style.
2. Explain the Managerial Grid and its significance.
3. Explain Situational Leadership and its significance.
4. Compare the concept and significance of traditional objective setting and Management by Objectives (MBO).
5. Compare methods of communicating goals and objectives.
6. Explain the Motivation Process
7. Compare the basic models of individual motivation, including the Hierarchy of Needs, Motivation-Hygiene Theory, Goal-Setting Theory, Reinforcement Theory, Equity Theory, and Expectancy Theory.
8. Explain the concept and significance of the Social Styles Matrix.

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Topic 5 Communication and Conflict Resolution

Learning Outcome

Apply principles of communication and conflict resolution in the work place.

Learning Objectives

1. Compare linear, interactive, and transactive communications and their significance.
2. Explain the common communication shortcuts and their significance, including selectivity, assumed similarity, stereotyping, and the halo effect.
3. Explain the significance and effects of conflict in an organization.
4. Describe interpersonal and intergroup conflict.
5. Explain the lose/lose, lose/win, win/lose and win/win outcomes of conflict.
6. Explain assertiveness and cooperativeness and their significance.
7. Compare avoiding, accommodating, forcing, collaborating and compromising as conflict resolution strategies.
8. Explain the stages in assertive behavior for conflict resolution.
9. Describe the concept, significance, responsibilities and typical steps and tactics of a grievance process.
10. Explain the process of labor/management conflict resolution.
11. Describe the typical public stakeholders for an organization's business and the typical communication processes used in dealing with the public.
12. Explain the public concerns that an organization must address and the appropriate communication methods used in addressing them.

Topic 6 Labor Relations

Learning Outcome

Explain principles and models in the management of labor relations and change.

Learning Objectives

1. Explain management's right and responsibilities in the enforcement of federal and provincial labor legislation.
2. Compare management interactions between union and non-union work forces.
3. Explain the concept, preparation, and tactics of collective bargaining, including the use of a problem-solving approach.
4. Explain the concepts, significance, roles, and responsibilities during conciliation, arbitration, strike or lockout.
5. Compare the benefits and significance of permanent and contingent employees.
6. Explain the purpose and process of human resource planning and capacity planning.
7. Explain the facilitation of labor relations with a contractor's workforce.
8. Describe the types of changes that occur in the workplace, the relationship between workplace change and employee attitude, the psychological costs and benefits of change, and management's role and responsibilities.
9. Explain the concept and significance of homeostasis.
10. Describe the three types of resistance to change (logical, psychological, and sociological), the potential benefits of resistance to change, and the three basic steps to overcome resistance (unfreezing, changing, and refreezing).
11. Explain the typical strategies used to build support for change, including: use of group forces, leadership for change, participation, shared rewards, negotiation, employee security, and communication.
12. Explain the purposes and processes of benchmarking.

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Topic 7 Recruitment and Employee Development

Learning Outcome

Explain principles and models in the management of employee recruitment and development.

Learning Objectives

1. Explain the purpose and components of a human resource management process.
2. Explain the legal and ethical constraints on recruitment and selection.
3. Explain the types and processes of pre-employment testing.
4. Explain the purpose, procedure, and limitations of typical interviewing techniques, including behavioral descriptive interviews.
5. Explain the significance and components of a training and development program including training standard, roles and responsibilities.
6. Explain the significance and components of an orientation process.
7. Explain the purpose and proceeds of a needs assessment and gap analysis
8. Explain the purpose and process of competency profiling.
9. Explain the significance and selections of typical training methods, and their relationship to learning styles.
10. Explain the significance and progression and cross-training methods.
11. Explain the purpose and components of a performance management program, including coaching.
12. Explain typical models of performance reviews.
13. Explain the process of corrective and progressive discipline.

Topic 8 Management Structures and Organization

Learning Outcome

Discuss principles of organizational structure and the application of work teams.

Learning Objectives

1. Compare the design and benefits of typical organizational structures, including: scalar, functional, tall/ flat and matrix.
2. Explain the concept and significance of organizational culture.
3. Explain the significance of a team-based organizational structure and methods to develop and promote teamwork.
4. Compare the significance, benefits, and limitations of supervised and self-directed work teams.
5. Describe the characteristics and functioning of a successful work team.
6. Explain the concept and significance of cross-functional work teams.

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REFERENCE CURRICULUM

For

International Power Engineer (2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

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Introduction

This Curriculum is intended to assist candidates studying for the International Power Engineer (2nd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for International Power Engineer (2nd Class) Examination Candidates

Major Topic: Code Calculations and Legislation

Topic 1 A.S.M.E. Code Calculations - Cylindrical Components

Learning Outcome

Apply the appropriate formulae from ASME Sections I and VIII to calculations involving cylindrical components, openings, and compensations in boilers and pressure vessels.

Learning Objectives

1. Calculate the minimum required thickness or the maximum allowable working pressure of ferrous tubing, up to and including 125 mm O.D.
2. Using ASME Sections I and VIII, calculate the required minimum thickness or the maximum allowable working pressure of ferrous piping, drums, and headers.
3. Calculate the required thickness or maximum allowable working pressure of a seamless, unstayed dished head.
4. Calculate the minimum required thickness or maximum allowable working pressure of unstayed flat heads and welded covers.
5. Determine whether or not reinforcement is required for openings in a cylindrical shell, header, or head.
6. Using the ligament efficiency method, calculate the minimum required thickness of a cylindrical drum with two or more openings in the pressure boundary.

NOTE: The formulas, calculations, and code references found in this chapter are from the 2015 ASME BPVC, which is reproduced in part in the PanGlobal 2018 ASME Academic Extract Volumes 1 and 2.

Topic 2 ASME Code Calculations: Stayed Surfaces, Pressure Relief Valves and Furnaces

Learning Outcome

Apply the appropriate formulae from A.S.M.E. Sections 1 and 8 to calculations involving pressure vessel stayed surfaces, safety and safety relief valves, and firetube boilers.

Learning Objectives

1. Calculate the required thickness and maximum allowable working pressure for braced and stayed surfaces in pressure vessels.
2. Calculate the minimum required cross-sectional area of stays and staybolts in firetube boilers, including diagonal stays.
3. Calculate the required size and capacity of pressure relief valves.
4. Explain design considerations for various circular furnaces and calculate the required thickness of corrugated furnaces.

NOTE: The formulas, calculations, and code references found in this chapter are from the 2015 ASME BPVC, which is reproduced in part in the PanGlobal 2018 ASME Academic Extract Volumes 1 and 2.

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Topic 3 Boiler and Pressure Vessel Legislation

Learning Outcome

Describe the components and application of boiler and pressure vessel legislation within Canadian jurisdictions.

Learning Objectives

1. Identify the types and sources of Laws and the levels and scope of the Courts.
2. Define Statutory Delegation of Powers as they apply to the Boilers and Pressure Vessels Act.
3. Describe the authority that Safety Officers (Inspectors) have within their jurisdiction.
4. Determine what are the offences and penalties under the Act and the appeal process.
5. Describe the typical Regulations under the Boilers and Pressure Vessels Act.
6. Describe the typical Codes and Standards referenced by the Boilers and Pressure Vessels Act.

Topic 4 Plant Design and Installation

Learning Outcome

Explain the codes and procedures involved in the design and construction of a new plant.

Learning Objectives

1. State the codes and standards that must be followed when designing and building a new plant.
2. Describe the steps involved in developing specifications and contracts for new installations and modifications.
3. Explain the major steps involved in the design and construction of a new plant.
4. Explain the roles and responsibilities in the design and construction of a new plant.
5. Explain how the design and construction of a new plant are administered and controlled.

Topic 5 Management and Supervision

Learning Outcome

Describe the roles and basic competencies of a supervisor and manager.

Learning Objectives

1. Define management and explain the general functions of management.
2. Explain how management goals and objectives are developed through planning.
3. Describe how business decisions are made.
4. Describe methods of selecting new employees.
5. Explain how employees are trained.
6. Explain how to provide leadership and motivate employees.
7. Explain how to manage employee performance and behaviors.
8. Describe proper communication skills by writing a formal report.

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Topic 6 Plant Maintenance

Learning Outcome

Describe plant maintenance management systems.

Learning Objectives

1. Describe the major aspects of managing maintenance activities including management of maintenance, maintenance program development, planning, scheduling, performing maintenance, assessment and improvement.
2. Describe the different approaches to maintenance including preventive and corrective.
3. Describe how routine maintenance activities are planned, scheduled, and controlled.
4. Describe the use of Gantt and PERT charts and the critical path method to schedule major maintenance activities.
5. Describe the steps involved in preparing for and conducting a pressure vessel inspection.
6. Describe the use of computerized systems in managing maintenance, including a work order system.
7. Describe various methods of monitoring equipment, including log sheets and trending.
8. Describe the steps involved in developing a plant budget and controlling maintenance costs.

Topic 7 Safety

Learning Outcome

Explain the components and application of safety programs, safety audits, and safety training.

Learning Objectives

1. Describe the elements of a comprehensive safety program for a power plant.
2. Explain the purpose of and the process used for safety checklists, inspections, audits and reviews.
3. Explain the purpose of and the process used for safety orientation, education, and training.

Topic 8 Linear Motion

Learning Outcome

Apply the theory of applied mechanics to bodies at rest and in linear motion.

Learning Objectives

1. Calculate the displacement, velocity, and acceleration of bodies moving in a straight line.
2. Calculate the displacements and flight times of projectiles.
3. Describe the relationship between mass, force, acceleration and weight.
4. Explain inertia, momentum, and conservation of momentum and perform related calculations.
5. Demonstrate graphically the relationship between work, force, and distance.
6. Define and calculate the kinetic energy of moving objects.
7. Define and calculate the potential energy of stationary objects.
8. Explain the Law of Conservation of Energy.
9. Define and calculate indicated power and power cylinder dimensions.

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Topic 9 Angular Motion

Learning Outcome

Apply the theory of applied mechanics to bodies in angular motion.

Learning Objectives

1. Define and calculate angular displacement, angular velocity, and angular acceleration.
2. Define and calculate moment of inertia, radius of gyration and torque.
3. Define and calculate the kinetic energy of rotating masses, including flywheels.
4. Define rotational work and power. Calculate brake power and mechanical efficiency of a reciprocating engine.
5. Calculate the power transmitted by a belt drive.
6. Define centrifugal and centripetal force, centripetal acceleration, and perform calculations involving them.
7. Calculate the distance of movement of a governor due to centrifugal force.
8. Explain the balancing of masses about a center of rotation and perform simple balancing calculations for single and multiple masses.

Topic 10 Friction

Learning Outcome

Perform calculations related to frictional force.

Learning Objectives

1. Describe the concept, types, and laws of friction.
2. Define and calculate the coefficient of friction and applied forces for objects moved on a horizontal surface by forces parallel to the surface.
3. Define and calculate the applied forces for objects moved on a horizontal surface by forces not parallel to the surface.
4. Define and calculate the applied forces for objects moved on an inclined plane.
5. Define and calculate the frictional forces on a screw jack.
6. Define and calculate maximum torque on a belt drive.

Topic 11 Static and Dynamic Forces

Learning Outcome

Perform calculations related to static and dynamic forces acting on a body.

Learning Objectives

1. Define and evaluate forces in terms of moments and couples.
2. Define and calculate centroids and first and second moments of areas.
3. Define and calculate the different types of stress.
4. Define strain, modulus of elasticity, Poisson's ratio and perform calculations.

5 Define the thermal expansion of bars, including reactions, under conditions of restricted expansion and reactions of bars composed of dissimilar metals.

6. Define and calculate shear forces and bending moments for simply supported beams and cantilevers.
7. Perform calculations involving the fundamental torsion equation and explain the relationship between torque and stress.
8. Explain the relationship between torque and power, and calculate maximum and mean torque for solid shafts of circular cross section.
9. Calculate stress in coupling bolts due to torque.

Topic 12 Fluid Mechanics

Learning Outcome

Perform calculations related to fluid flows and pressure.

Learning Objectives

1. Describe the basics of fluid mechanics.
2. Perform calculations related to pressure in a fluid, including center of pressure.
3. Explain buoyancy and perform calculations involving buoyancy principles.
4. Define and calculate thermal expansion of a vessel and its liquid contents.
5. Describe flow in open channels and calculate fluid flow through a weir.
6. Describe liquid flow in a pipe using the continuity equation.
7. Apply the law of conservation of energy to fluid flow and define Bernoulli's equation.
8. Calculate fluid flow from a vessel orifice.
9. Calculate flow using a venturi meter.

Major Topic: Thermodynamics and Metallurgy

Topic 1 Heat, Expansion of Solids, and Heat Transfer

Learning Outcome

Perform calculations to determine the thermal expansion of solids and basic heat transfer properties.

Learning Objectives

1. Perform heat calculations on solids, liquids, and vapors.
2. Explain the theory of thermal expansion and solve problems using the formula for linear thermal expansion.
3. Calculate the change in the area of an object, including holes, due to a temperature change.
4. Describe the principle of volumetric expansion and perform calculations involving the change in volume of solids, due to a change in temperature.
5. Describe the three basic modes of heat transfer (convection, conduction, and radiation) and perform simple calculations.
6. Perform calculations involving heat transfer at a surface.

Topic 2 Thermodynamics of Gases

Learning Outcome

Perform calculations related to expansion and compression of perfect gases.

Learning Objectives

1. Explain the behaviors of a perfect gas and the laws that govern gas behavior, including Boyle's Law, Gay-Lussac's Law, Charles Law, the General Gas Law, and the Ideal Gas Law.
2. Explain Dalton's Law of Partial Pressures.
3. Define and calculate specific heats under constant volume and constant pressure conditions.
4. Explain the relationship between work and heat as expressed in the First and Second Laws of Thermodynamics.
5. Calculate the work done during expansion and compression under constant pressure and isothermal conditions.
6. Calculate the work done during adiabatic expansion and compression.
7. Calculate the work done during polytropic expansion and compression.

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Topic 3 Thermodynamics of Steam

Learning Outcome

Perform calculations related to properties of steam.

Learning Objectives

1. Describe the basic properties of water and steam.
2. Perform calculations involving specific enthalpy, dryness fraction, specific heat, and specific volume using steam tables.
3. Explain the principles and use of calorimeters to measure the dryness fraction of wet steam.
4. Calculate the dryness fraction of steam based on calorimeter data.
5. Calculate the internal energy of steam under given conditions.
6. Explain entropy and calculate the change in entropy for a particular water/steam process.
7. Determine steam properties using a Mollier Chart.
8. Calculate boiler thermal efficiency using test data.

Topic 4 Practical Thermodynamic Cycles

Learning Outcome

Explain the concepts and use of common thermodynamic cycles, using pressure-volume and temperature- entropy diagrams.

Learning Objectives

1. Explain the concept of a heat engine and describe the different types of heat engines.
2. Describe the Carnot cycle and calculate Carnot cycle efficiency.
3. Explain the Rankine cycle using pressure-volume and temperature-entropy diagrams and calculate Rankine cycle efficiency.
4. Explain the Otto cycle using pressure-volume and temperature-entropy diagrams and calculate Otto cycle efficiency.
5. Explain the Diesel cycle using pressure-volume and temperature-entropy diagrams and calculate Diesel cycle efficiency.
6. Explain the Brayton cycle using pressure-volume and temperature-entropy diagrams and calculate Brayton cycle efficiency.
7. Calculate the heat balance at different points in a Rankine cycle system using test data provided.

Topic 5 Metallurgy

Learning Outcome

Discuss the uses and structure of common metals.

Learning Objectives

1. Explain the study of metallurgy and the atomic and crystalline structure of metals.
2. Explain the significance of the iron-carbon equilibrium diagram.
3. Explain the purposes of, and processes used, in the heat treatment of steels.
4. Explain how to interpret metal specifications.
5. Explain typical selection of metals for process plant applications (what is selected and why).
6. Describe the composition, physical properties, and uses of copper, lead, and tin.
7. Describe the composition, physical properties, and uses of aluminum and aluminum alloys.

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Topic 6 Testing of Metals

Learning Outcome

Discuss the common procedures and parameters for testing of metals.

Learning Objectives

1. Differentiate between destructive and non-destructive testing and explain the procedures and interpretation of tensile, hardness, and impact tests.
2. Explain the purpose and procedure of a Proof (Hydrostatic Deformation) Test.
3. Explain the causes and significances of welding discontinuities.
4. Explain Non-Destructive Examination, along with its applications and benefits.
5. Explain visual inspection and the procedures used.
6. Explain magnetic particle inspection and the procedures used.
7. Explain liquid penetrant testing and the procedures used.
8. Explain ultrasonic testing and the procedures used.
9. Explain radiographic testing, including interpretation of results.
10. Explain acoustic emission testing and the procedures used.
11. Explain leak and pressure testing.
12. Explain how to monitor and test metals for creep, fatigue, and corrosion.

Topic 7 Corrosion of Metals

Learning Outcome

Discuss corrosion mechanisms and corrosion prevention methods.

Learning Objectives

1. Define corrosion and explain the electrochemical principles involved.
2. Explain how the environment can affect corrosion.
3. Explain the most common corrosion mechanisms.
4. Describe the predominant corrosion mechanisms that potentially affect various power plant systems and equipment.
5. Explain methods used to monitor and test for corrosion during plant operation.
6. Explain the methods used to control and prevent corrosion at the design stages and during operation.
7. Explain the main components of a corrosion failure analysis and a typical corrosion failure report.

Topic 8 Introduction to Welding Symbols

Learning Outcome

Describe how weld joints are constructed, using standard weld symbol terminology.

Learning Objectives

1. Explain the purpose of welding symbols.
2. Describe the common weld joints and weld types, including groove, fillet, plug and slot welds, with related weld terminology.
3. Recognize and describe symbols that identify weld types.
4. Identify and explain the meaning of the reference line, the arrow, and the tail in a welding symbol.
5. Identify and explain the meaning of supplemental welding symbols, not specific to the weld itself.
6. For groove and fillet welds, identify and explain welding symbols that relate to the weld configuration and joint preparation.

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Major Topic: Boilers and Water Treatment

Topic 1 Boiler and Steam Generator Components and Design

Learning Outcome

Discuss the components and design considerations of a steam generator.

Learning Objectives

1. Explain how the ratings of boilers and steam generators are calculated.
2. Explain the factors to be considered in designing a steam generator.
3. Contrast the influence of solid fuel, liquid fuel, and gas fuel on steam generator design.
4. Explain the principles of natural water circulation in a steam generator. Explain why forced circulation is used in a steam generator and how it is attained.
5. Explain the design, placement, and installation considerations for water walls, superheaters, desuperheaters, reheaters, economizers, and air heaters.
6. Explain the purpose and placement of screen tubes, division walls, water-cooled stringer tubes in superheaters, and wall-mounted radiant superheaters.
7. Describe top and bottom support systems for a steam generator.
8. Describe furnace casing design considerations.
9. Describe the purpose and use of specialized steam generator duct arrangements, including air heater bypass, economizer bypass, and air heater recirculation.
10. Describe the methods used to insulate different parts of a steam generator.
11. Explain the general steps used to construct a steam generator.

Topic 2 Specialized Boiler Designs

Learning Outcome

Identify and discuss common specialized boiler designs.

Learning Objectives

1. Describe typical designs, components, and operating strategies for once-through steam-flood boilers.
2. Describe typical designs, components, and operating strategies for fluidized bed boilers (bubbling bed and recirculating bed types).
3. Describe typical designs, components, and operating strategies for heat recovery steam generators.
4. Compare different designs of heat recovery steam generators (HRSG): natural circulation, controlled circulation and once-through (OTSG).
5. Describe typical designs, components, and operating strategies for supercritical steam generators.
6. Describe typical designs, components, and operating strategies for black liquor recovery boilers.
7. Describe typical designs, components, and operating strategies for refuse boilers used in waste disposal.
8. Describe typical designs, components, and operating strategies for biomass boilers.
9. Describe typical designs, components, and operating strategies for waste-heat boilers (firetube and watertube types).

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Topic 3 Boiler and Steam Generator Operation

Learning Outcome

Describe in detail the typical procedures for operation of a large steam generator.

Learning Objectives

1. Describe the detailed hot and cold startup procedures for a steam generator including safety precautions.
2. Describe the detailed shutdown procedure for a steam generator including safety precautions.
3. Describe the detailed lay-up procedures for a steam generator including safety precautions.
4. Describe the detailed refractory dry out procedure for a new steam generator including safety precautions.
5. Describe the detailed boil out procedure for a new steam generator including safety precautions.

Topic 4 Boiler and Steam Generator Maintenance and Inspection

Learning Outcome

Describe in detail the typical procedures for boiler maintenance and inspection.

Learning Objectives

1. Describe the mechanical cleaning procedures for a boiler including safety precautions.
2. Describe the detailed chemical cleaning procedures for a watertube boiler including safety precautions.
3. Describe the detailed hydrostatic testing procedure for a boiler including safety precautions.
4. Describe standard shutdown activities and preventive maintenance procedures required for a boiler.
5. Describe the detailed procedure for complete inspection of a boiler including waterside, fireside, and auxiliary equipment.
6. Describe boiler inspection techniques and equipment.
7 Describe the required inspection records and reporting procedures.
8. Describe the roles and responsibilities for an inspection including engineering staff, operators, and boiler inspector.
9. Describe the safety requirements during a boiler inspection.

Topic 5 Pumps

Learning Outcome

Discuss the application of large centrifugal pumps.

Learning Objectives

1. Explain selection criteria for pump applications.
2. Interpret pump operating characteristics and performance curves.
3. Describe the procedure for the installation of a large multi-stage centrifugal pump.
4. Describe the typical repairs and preventive maintenance procedures required for a multi-stage centrifugal pump.
5. Describe the methods of control for a multi-stage centrifugal pump including recirculation control.
6. Describe the selection criteria for seal types and materials in a centrifugal pump.
7. Describe the methods of counteracting thrust in a large centrifugal pump.

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Topic 6 Water Chemistry and Analysis

Learning Outcome

Discuss the significance of common water impurities, and the application of water analyses.

Learning Objectives

1. Describe the sources of the impurities found in raw water.
2. Describe the effect of the listed water impurities on power plant equipment and processes.
3. Explain the significance and importance of standard methods of water analysis.
4. Describe which analyses are appropriate at given sampling points including the significance of the sampling point locations.
5. Interpret the results of a comprehensive standardized water analysis including the relationship of the various parameters.
6. Explain the purposes and principles of testing instruments, including embrittlement detector, total solids meter, and pH meter.
7. Explain the purpose of steam purity measurement and process of steam sampling.

Topic 7 Water Pre-Treatment I

Learning Outcome

Describe water pre-treatment processes for removal of suspended solids, oil, and gases.

Learning Objectives

1. Explain the purpose, equipment, operation, and limitations of sedimentation.
2. Explain the purpose, equipment, operation, and limitations of coagulation and flocculation.
3. Explain the purpose, equipment, operation, and limitations of filtration.
4. Explain the purpose, principles, equipment, operation, and limitations of microfiltration.
5. Describe how oil is removed from water.
6. Explain the purpose, equipment, operation, and limitations of mechanical deaeration.
7. Explain the purpose, equipment, operation, and limitations of evaporation.

Topic 8 Water Pre-Treatment II

Learning Outcome

Describe water pre-treatment processes for ion removal.

Learning Objectives

1. Explain the purpose, equipment, and operation of lime-soda softening.
2. Explain the purpose, equipment, operation, and limitations of hot process phosphate softening.
3. Explain the purpose, equipment, operation, and limitations of sodium zeolite softening.
4. Explain the purpose, equipment, and operation of hydrogen zeolite softening.
5. Describe how silica is removed from water.
6. Explain the purpose, equipment, and operation, of demineralization, including condensate polishing.
7. Explain the purpose, equipment, and operation of electrodialysis (ED) and electrodeionization (EDI).
8. Explain the purpose, equipment and operation of reverse osmosis (RO).

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Topic 9 Internal Water Treatment

Learning Outcome

Describe boiler internal water treatment processes.

Learning Objectives

1. Explain the causes, effects, and control of scale.
2. Explain the causes, effects, and control of foam in boiler water.
3. Explain the causes, effects, and control of caustic embrittlement.
4. Explain the causes, effects, and control of return line corrosion.
5. Explain the use of chelating agents in boiler water.
6. Explain the use of sludge conditioning in boiler water.
7. Explain the use of pH control in boiler water.
8. Explain the use of chemical deaeration in boiler water.
9. Explain the causes, effects, and control of carryover of boiler water.
10. Explain the use of blowdown from boiler water.
11. Explain the use and control of chemical feed systems for boiler water.
12. Explain the control of silica to avoid turbine blade deposits.

Topic 10 Non-Boiler Water Treatment

Learning Outcome

Discuss water treatment applications for cooling water, wastewater, and potable water.

Learning Objectives

1. List the water impurities of concern in a cooling water system and the effects caused by each one.
2. Describe control methods for a cooling water system for control of corrosion, fouling, and microbiological attack including chloride corrosion, and delignification.
3. Describe the potential effects of wastewater discharge.
4. Compare and contrast mechanical, chemical, and biological methods of wastewater treatment including the advantages and disadvantages of each.
5. Specify an appropriate method of wastewater treatment for a particular case study.
6. Describe the methods used for potable water treatment and analysis.

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Major Topic: Prime Movers

Topic 1 Steam Turbine Theory and Construction

Learning Outcome

Explain the design and components of a large steam turbine, and perform nozzle and steam velocity calculations.

Learning Objectives

1. Explain selection criteria for a turbine application.
2. Describe the design and components of steam turbine casings and casing drains.
3. Describe the design and components of steam turbine rotors, blading, and diaphragms.
4. Describe shaft seal designs, including stuffing boxes, carbon rings, labyrinth, and water seals.
5. Describe the design and components of steam turbine bearings.
6. Describe the ways in which steam turbines are designed to counteract thrust.
7. Describe the purpose and design of expansion and anchoring components.
8. Explain the principles of steam turbine nozzle design.
9. Explain a steam turbine blade velocity diagram.
10. Calculate the steam velocity and angle of entry for impulse and reaction turbine blading.
11. Calculate the work done on steam turbine blades and the resulting power developed.
12. Calculate steam turbine Rankine cycle thermal efficiency.

Topic 2 Steam Turbine Auxiliaries and Control

Learning Outcome

Explain the purpose and design of steam turbine auxiliaries, control, and monitoring equipment.

Learning Objectives

1. Describe the purpose, design and components of a turning gear.
2. Describe the purpose, design and components of an adjusting gear.
3. Explain critical speed.
4. Describe the design and components of lubricating oil and jacking oil systems.
5. Describe the design of speed reducing gears.
6. Describe the design and components of flexible couplings.
7. Describe the purpose and design of steam turbine governors and governor systems.
8. Describe the purpose and design of steam turbine stop valves and control valves.
9. Describe the purpose and design of steam turbine grid type extraction valves.
10. Describe the purpose and design of steam turbine casing pressure relief systems including rupture diaphragms.
11. Describe the purpose and design of steam turbine overspeed trips.
12. Describe the purpose and design of steam turbine supervisory equipment.

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Topic 3 Steam Turbine Operation and Maintenance

Learning Outcome

Discuss procedures for operation and maintenance of a large steam turbine.

Learning Objectives

1. Describe the detailed hot and cold start-up procedures for a large steam turbine, including safety precautions.
2. Describe the detailed shutdown procedure for a large steam turbine including safety precautions.
3. Explain what checks are performed on a large steam turbine during normal operation.
4. Sketch the flow of steam and condensate through a condensing steam turbine and a non-condensing steam turbine.
5. Explain the preventive maintenance requirements for a large steam turbine. Include shaft alignment, bearings, clearances for thrust, blades, shaft seals, correction of blade fouling, erosion and cleaning.
6. Describe the purpose of and procedure for static and dynamic balancing.

Topic 4 Steam Condensers

Learning Outcome

Discuss condenser principles, performance, operation and auxiliaries.

Learning Objectives

1. Describe the principles and design of jet, air cooled, and surface condensers.
2. Describe the purpose, principle and design of surface condenser support and expansion systems.
3. Explain the significant parameters in condenser performance.
4. Calculate condenser thermal efficiency from the test data.
5. Explain the procedures used to troubleshoot condenser performance.
6. Explain the procedures used to backwash and clean a condenser.
7. Describe the purpose, principle and design of air ejectors and vacuum pumps.
8. Describe the purpose and flow of cooling water systems.
9. Describe the purpose, principle and design of cooling water intake screens, circulating pumps, cooling towers, and cooling ponds.
10. Describe the purpose, principle and design of condenser atmospheric exhaust (relief) valves.
11. Describe the purpose, principle and design of condensate pumps.

Topic 5 Internal Combustion Engines: Components and Auxiliaries

Learning Outcome

Explain the design, selection, and components of internal combustion engine installations, including auxiliaries.

Learning Objectives

1. Explain design, applications, and selection criteria for the different types of reciprocating internal combustion engines.
2. Explain fuels and combustion processes used by internal combustion engines.
3. Describe the design of internal combustion engine scavenging and supercharging arrangements.
4. Describe the design and components of internal combustion engine fuel conditioning systems, injection systems, and ignition systems.
5. Describe the design and components of internal combustion engine cooling systems and cooling water conditioning systems.
6. Describe the purpose, design and components of internal combustion engine lubricating oil systems.
7. State the purpose and describe the control of a typical internal combustion engine including the operation of safety devices.

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Topic 6 Internal Combustion Engines: Operation and Maintenance

Learning Outcome

Describe general maintenance requirements, and detailed operating and troubleshooting procedures for internal combustion engines.

Learning Objectives

1. Describe the detailed startup procedures for an internal combustion engine.
2. Describe the detailed shutdown procedures for an internal combustion engine.
3. Explain the routine maintenance and monitoring requirements for an internal combustion engine.
4. Explain the major maintenance and overhaul requirements for an internal combustion engine.
5. Explain the troubleshooting of combustion and engine problems.

Topic 7 Gas Turbine Design and Auxiliaries

Learning Outcome

Explain the design and components of a large gas turbine and related auxiliaries.

Learning Objectives

1. Explain applications and selection criteria for the different types of gas turbine engines.
2. Describe the principles and design of open and closed cycle gas turbine systems.
3. Describe the principles and design of combined cycle and cogeneration systems using gas turbines.
4. Describe the principles and design of gas turbine regeneration, intercooling, and reheating.
5. Describe the principles and design of gas turbine shaft arrangements.
6. Describe the design and components of gas turbine compressors, combustors (combustion chambers) and turbines.
7. Describe the design and operation of gas turbine air intake and exhaust systems.
8. Describe the design and operation of a gas turbine lubricating oil system.
9. Describe the design and operation of a gas turbine fuel system.
10. Describe the design and operation of a gas turbine steam or water injection system and a dry low NO_X system.

Topic 8 Gas Turbine Operation and Control

Learning Outcome

Discuss operating procedures, and control and monitoring components of a large gas turbine.

Learning Objectives

1. Describe the components and operation of gas turbine supervisory and control systems.
2. Describe the principles and design of gas turbine protection devices.
3. Describe the detailed hot and cold startup procedures for a gas turbine, including safety precautions.
4. Describe the detailed shutdown procedure for a gas turbine, including safety precautions.
5. Explain the routine maintenance and monitoring requirements for a gas turbine.
6. Describe the major maintenance and overhaul requirements for a gas turbine.
7. Explain the troubleshooting of gas turbine problems.

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Topic 9 Lubrication

Learning Outcome

Explain the components of a lubrication application and maintenance program.

Learning Objectives

1. Describe the methods of manufacture and the different classifications of lubricants.
2. Describe the significance and measurement of lubricating oil characteristics, including viscosity, relative density, API (American Petroleum Institute) gravity, pour point, and dielectric strength.
3. Explain the typical causes of lubricating oil deterioration.
4. Describe the types of lubrication additives.
5. Describe a typical power plant lubrication program, including a lubrication survey.
6. Explain the different types of lubricating/governing/seal oil systems.
7. Describe the components and operation of a typical lubricating oil purification system.
8. Describe the various applications of ball-and-roller bearings and their lubrication, including bearing seals.

Topic 10 Piping

Learning Outcome

Explain piping system design, inspection, and maintenance.

Learning Objectives

1. Explain selection criteria for piping materials.
2. Calculate the required thickness and the internal design pressure of piping.
3. Describe typical inspection procedures for piping installations and repairs.
4. Describe a typical routine inspection procedure and schedule for high-energy piping.
5. Explain the effects of high temperature on piping strength.
6. Describe the design and installation criteria for a piping system layout.
7. Explain the theory and effects of water hammer.

Topic 11 Mechanical Drawing

Learning Outcome

Interpret construction and process drawings.

Learning Objectives

1. Interpret the information provided in orthographic, isometric, and oblique projections.
2. Interpret the information provided in construction drawings with sectioning and dimensioning.
3. Interpret the information provided in Process Flow Diagrams.
4. Interpret the information provided in Piping and Instrumentation Diagrams (P&IDs).
5. Explain the use of isometric piping system and spool drawings in piping systems.

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Major Topic: Combustion and Plant Systems (344 pages)

Topic 1 Power Plant Fuel Systems

Learning Outcome

Describe the design and operation of typical power plant systems.

Learning Objectives

1. Describe, using a sketch, the design and operation of fuel oil supply systems.
2. Describe, using a sketch, the design and operation of fuel gas supply systems.
3. Describe, using a sketch, the design and operation of solid fuel supply systems.

Topic 2 Power Plant Water and Steam Systems

Learning Outcome

Describe the design and operation of power plant systems.

Learning Objectives

1. Describe, using a sketch, the design and operation of feedwater systems.
2. Describe, using a sketch, the design and operation of steam distribution systems.
3. Describe, using a sketch, the design and operation of condensate systems.
4. Describe, using a sketch, the design and operation of cooling water systems.
5. Describe, using a sketch, the design and operation of waste handling systems.
6. Explain how different power plant water systems interconnect and what parameters are significant to each.

Topic 3 Measurement and Control Components

Learning Outcome

Explain the design and application of measuring devices and final control elements.

Learning Objectives

1. Describe the design, use, and placement of electrical and electronic pressure measuring devices.
2. Describe the design, use, and placement of electrical and electronic temperature measuring devices.
3. Describe the design, use, and placement of Venturi tubes, orifice plates, flow nozzles, and Pitot tubes.
4. Describe the design and use of: manometers, ring balance, force balance, and electric flow indicating mechanisms.
5. Describe the design, use, and placement of the following liquid level measurement devices: ball-float, displacement-type, hydrostatic head, electric and pneumatic level transmission, electric and magnetic type level-limit devices, and remote water-level indicators.
6. Describe the types, construction, and flow characteristics of control valves.
7. Describe the design, operation, and application of the following valve operators: solenoid, pneumatic-diaphragm, power cylinder, and electric motor.

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Topic 4 Control Instrumentation Systems

Learning Outcome

Explain and apply the theory of automatic boiler, distributed control, and programmable logic control systems.

Learning Objectives

1. Describe the principle, design, application, and limitations of the following automatic control methods: proportional, proportional-plus-reset, and proportional-plus-reset-plus-rate.
2. Describe the principle, design, application, and limitations of single, two, and three-element boiler feedwater control systems.
3. Describe the principle, design, application, and limitations of superheated and reheated steam temperature control systems.
4. Describe the principle, design, components, application, and limitations of Distributed Control Systems (DCS).
5. Describe the principle, design, application, and limitations of Programmable Logic Controllers (PLC).

Topic 5 Fuels and Combustion Calculations

Learning Outcome

Perform combustion and furnace draft calculations and explain flue gas analysis.

Learning Objectives

1. Describe the nature of combustion and the different types of fuels.
2. Calculate the mass and volumetric analysis of a fuel.
3. Describe proximate and ultimate analysis and calculate the heating value of fuel.
4. Given the results of a bomb calorimeter test, calculate the heating value of a fuel.
5. Calculate the amount of air and excess air required for combustion of fuel.
6. Explain flue gas analysis parameters and their significance.
7. Calculate theoretical draft, flue gas velocity, and stack diameter.
8. Calculate draft fan power and efficiency.

Topic 6 Firing and Draf t Equipment

Learning Outcome

Explain the design, components, and auxiliary equipment of steam generator furnaces.

Learning Objectives

1. Describe steam generator furnace designs including cyclone furnaces and divided furnaces. Explain the purpose and placement of furnace arches.
2. Explain the purpose and design of separately fired superheat and reheat furnaces.
3. Explain the purpose, types, characteristics, and placement of refractory in a furnace.
4. Describe the principle, design, and application of oil, gas, and coal burners.
5. Describe the principle, design, and application of pulverizers.
6. Describe the principle, design, and application of ash and slag disposal systems.
7. Explain the significance, monitoring, and control of ash fusion temperature.
8. Describe the designs and applications of forced and induced draft fans.
9. Explain the methods which control furnace draft.

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Topic 7 Combustion Control and Safeguards

Learning Outcome

Explain combustion control methods and safeguard components.

Learning Objectives

1. Describe, using a sketch, the combustion control arrangements in a steam generator.
2. Explain series, parallel, and series/parallel combustion control.
3. Explain turbine-following, boiler-following, and integrated combustion control systems.
4. Describe the operation of purge, fan failure, and flame failure interlock systems.
5. Describe the operation of flame detectors.
6. Describe, using a sketch, a typical programming sequence for a packaged boiler control system.
7. Describe the typical limiting devices and alarms for a packaged boiler combustion system.

Topic 8 Environmental Monitoring

Learning Outcome

Explain the significance of environmental parameters and methods of monitoring.

Learning Objectives

1. Explain the significance of the following air quality parameters: particulates, stack opacity, SO_2 concentration, SO_2 mass flow, NO_X concentration, NO_X mass flow, mercury, O_2, CO_2, and hydrocarbons.
2. Explain the basic principles of operation for Continuous Emissions Monitoring System (CEMS) measurement instruments.
3. Explain the general requirements for Continuous Emissions Monitoring Systems (CEMS).
4. Explain the significance of the following water quality parameters: iron, phosphorous, biochemical oxygen demand (BOD), chemical oxygen demand (COD), hydrocarbons, temperature, flow, pH, and nitrogen.
5. Explain the general requirements for wastewater monitoring.
6. Explain how data received from environmental monitoring equipment is interpreted.
7. Explain the significance of environmental monitoring equipment failure.
8. Describe the procedures used for troubleshooting environmental monitoring equipment.

Topic 9 Environmental Control Methods

Learning Outcome

Explain the methods used to remove SO_2, NO_X, CO_2 and particulates from boiler flue gases.

Learning Objectives

1. Describe the purpose, design, operation, and application of Flue Gas Desulfurization (FGD) systems.
2. Describe the purpose, design, operation, and application of Selective Catalytic Reduction (SCR) systems.
3. Explain the significance of NO_X reduction in a power plant, and the procedures and equipment used to reduce NO_X emission from a boiler and from a gas turbine.
4. Explain the purpose, effects, and application of flue gas chemical conditioning in a power plant.
5. Explain the significance, procedures, and equipment for reduction of CO_2 emission from a boiler.
6. Describe the purpose, design, operation, and application of a baghouse.
7. Describe the purpose, design, operation, and application of an electrostatic precipitator.

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Major Topic: Electricity and Refrigeration

Topic 1 Alternating Current Theory

Learning Outcome

Explain characteristics and perform calculations involving AC circuits.

Learning Objectives

1. Explain the vector relationships between AC voltage and current.
2. Explain the significance of root mean square values for AC sine waves. Calculate root mean square and peak-to-peak values for AC sine waves.
3. Explain voltage/current relationships and calculate power in purely resistive circuits.
4. Explain voltage/current relationships in purely inductive circuits.
5. Explain voltage/current relationships in purely capacitive circuits.
6. Explain voltage and current relationships in circuits having resistance/inductance and resistance/capacitance combinations.
7. Calculate impedance, reactance, true and apparent power, and power factor in AC circuits.
8. Explain the significance of power factor and how it can be improved in AC circuits.
9. Explain the principle and significance of three-phase AC circuits, star, and delta connections in alternators, transformers and AC motors.
10. Calculate phase voltage, phase current and apparent and true power in a three-phase AC circuit.

Topic 2 Direct Current Machines

Learning Outcome

Explain the construction and operating principles of DC generators and motors.

Learning Objectives

1. Describe the construction and operating principles of a DC generator.
2. Explain the principle and application of compensating windings, interpoles, and lap and wave armature windings.
3. Explain the principles, applications, and load/voltage characteristics of generators.
4. Describe the parallel operation and voltage regulation of DC generators.
5. Review the principle of DC motor operation, including torque development and back EMF.
6. Calculate torque and speed of a DC motor.
7. Explain the principle and application of shunt, series, and compound-wound DC motors including speed control.
8. Explain the principle and application of counter-E, current limit and time limit DC motor automatic starters.
9. Explain the principle and application of dynamic and regenerative braking.
10. Calculate efficiency and discuss the reasons for power losses in a DC motor and generator.

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Topic 3 Alternating Current Generators

Learning Outcome

Explain the construction and operating principles of AC generators.

Learning Objectives

1. Explain the operating principles, design and construction of alternators with salient-pole and cylindrical rotors.
2. Explain the relationship between alternator speed, frequency, and number of pole pairs.
3. Describe the purpose and construction of an exciter.
4. Describe the purpose and design of alternator voltage regulators.
5. Describe alternator cooling systems, including circulating air cooling, hydrogen cooling, and stator winding cooling water systems.
6. Describe shaft sealing arrangements for an alternator.
7. Explain the theory and significance of alternator synchronization and parallel operation including the impact on power factor.
8. Explain efficiency and power losses in an AC generator.

Topic 4 Alternating Current Motors

Learning Outcome

Explain the construction and operating principles of AC motors.

Learning Objectives

1. Describe the principle of a pulsating magnetic field for single-phase AC motors and rotating magnetic field for three-phase AC motors. Describe general rotor and stator construction.
2. Describe the torque/speed characteristics of induction motors and the relationship between torque, slip and rotor speed.
3. Define full-load amps, locked rotor amps and service factor amps.
4. Describe the principles, applications, and operation of wound rotor motors.
5. Describe the principles, applications, and operation of single-phase AC motors. Include universal, shaded-pole, split-phase, capacitance-start, repulsion-start, and reluctance-start.
6. Describe the principles, applications, starting methods and operation of a synchronous motor.

Topic 5 Transformers

Learning Outcome

Explain the construction and operating principles of transformers.

Learning Objectives

1. Describe the construction of core type and shell type transformers.
2. Explain the factors that affect transformer rating.
3. Calculate load, power, iron and copper losses, and efficiency in a transformer.
4. Explain the purpose and procedures for transformer short and open circuit tests.
5. Describe the methods of cooling a transformer.
6. Describe the methods of connecting a transformer, including delta-delta, star-star, delta-star, and star-delta.
7. Explain the theory and significance of transformer paralleling.
8. Describe the applications of instrument transformers.
9. Describe the protective measures and devices used on transformers.

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Topic 6 Electrical System Protection

Learning Outcome

Describe the protective devices used on alternators, motors, and electrical circuits.

Learning Objectives

1. Describe the significance of fuses and circuit breakers for circuit protection including continuous rating, interrupting capacity, and inverse time principle.
2. Describe the purpose and designs of different types of fuses.
3. Describe the operation of circuit breakers used for different voltages, including moulded-case, oil-immersed, airblast, air-break, vacuum, and SF_6 switchgear.
4. Describe the operation of switches and contactors used for different voltages.
5. Explain the purpose, and significance of protection relaying as it applies to a large alternator.
6. Explain the purpose and significance of the protection devices for a large electric motor.

Topic 7 Air and Gas Compression

Learning Outcome

Explain the construction and operation of large air compressors and compressed air systems.

Learning Objectives

1. Describe the design and application of compressors, including prime mover selection.
2. Describe reciprocating compressor designs.
3. Describe rotary compressor designs.
4. Describe centrifugal and axial compressor designs.
5. Describe the types and operation of coolers and air dryers, including desiccant types.
6. Describe the installation of a compressed air system, including all ancillary equipment and typical instrumentation.
7. Describe the regulation and control of compressors.
8. Describe the monitoring and protection devices for a compressed air system.
9. Explain the effects of altitude, air temperature, and humidity on air compressor performance.
10. Describe the monitoring, troubleshooting, and typical preventive maintenance for a compressed air system.

Topic 8 Refrigeration Systems and Equipment

Learning Outcome

Explain the construction and operation of refrigeration systems.

Learning Objectives

1. Describe the types of refrigerants.
2. Describe the principles and operation of vapor compression refrigeration systems.
3. Describe the principles and operation of absorption refrigeration systems.
4. Describe the principles and operation of multi-stage and cascade refrigeration systems.
5. Describe the principles, applications, and operation of heat pump and thermoelectric systems.
6. Describe the design of hermetic refrigeration systems.
7. Describe the design and operation of refrigeration compressors.
8. Describe the design and operation of evaporators, condensers, receivers, scale traps and dehydrators.
9. Describe the design and operation of absorbers.
10. Describe the design and operation of valves and fittings.

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Topic 9 Refrigeration Safety, Control, and Operation

Learning Outcome

Explain the procedures, standards, instrumentation, and controls for a refrigeration system.

Learning Objectives

1. Describe the codes and standards which apply to the design, installation, and operation of a refrigeration plant.
2. Describe the purpose and operation of the various operating, actuating, limiting and safety controls used in refrigeration systems.
3. Explain refrigeration metering devices.
4. Explain evaporator and compressor capacity controls.
5. Describe the detailed startup and shutdown procedures for a refrigeration system.
6. Explain absorption system startup and shutdown.
7. Explain leak testing, charging, purging, and compressor lubrication.
8. Describe the common operating problems and troubleshooting procedures for a refrigeration system.

Topic 10 Refrigeration Calculations

Learning Outcome

Perform refrigeration system calculations.

Learning Objectives

1. Describe the general refrigeration cycle and the application of the Carnot cycle.
2. Describe the relationship between enthalpy and pressure for a refrigeration cycle.
3. Define and calculate the refrigerating effect and the mass of refrigerant circulated.
4. Calculate the coefficient of performance for a refrigeration system.
5. Calculate the capacity of a refrigeration machine.
6. Calculate the theoretical power of a refrigeration compressor.
7. Calculate the theoretical bore and stroke of a refrigeration compressor.

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REFERENCE CURRICULUM

For

International Power Engineer (3rd Class)

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Introduction

This Curriculum is intended to assist candidates studying for the International Power Engineer (3rd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for International Power Engineer (3rd Class) Examination Candidates

Major Topic: Applied Mechanics, Thermodynamics and Chemistry

Topic 1 Algebraic Operations, Logarithms and Problem Solving

Learning Outcome

Solve problems using algebraic operations, including equations and logarithms.

Learning Objectives

1. Apply the rules for addition, subtraction, multiplication and division of positive and negative quantities.
2. Simplify algebraic expressions and operations involving the removal or insertion of brackets.
3. Apply the rules for powers and roots to the multiplication and division of quantities and expressions.
4. Apply the rules of transposition to solve simple equations involving addition, subtraction, multiplication and division.
5. Solve equations involving powers, roots, and fractions.
6. Explain common and Naperian (natural) logarithms. Using a calculator, perform mathematical operations and solve equations that contain logarithms.
7. Apply an organized, systematic approach to solving a problem and presenting the solution.

Topic 2 Trigonometry

Learning Outcome

Explain trigonometric concepts and solve problems involving trigonometry.

Learning Objectives

1. Identify the types of angles and specify angle size in degrees and radians.
2. Identify right, obtuse, and acute triangles and apply the naming convention for sides and angles.
3. Use Pythagoras' Theorem to calculate the side lengths of a right angle triangle and solve simple problems involving right triangles.
4. Explain the sine, cosine, and tangent of an angle and determine the values of these functions for all angles between 0 and 360 degrees.
5. Using sine, cosine, and tangent, find the dimensions of right triangles and solve physical problems involving right triangles.
6. Define the Sine Rule and the Cosine Rule and use these rules to determine the unknown dimensions of oblique triangles.

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Topic 3 Mensuration

Learning Outcome

Solve problems involving the areas of plane figures and the surface areas and volumes of three-dimensional objects.

Learning Objectives

1. Convert between US Standard, Imperial and SI units of measure; convert unit magnitudes for area and volume within the SI system.
2. Calculate the areas of triangles given base and height, or the lengths of the sides.
3. Define the following quadrilaterals and calculate their areas: rectangle, square, rhomboid, rhombus, trapezoid, and trapezium.
4. Define the following polygons and calculate their areas: hexagon, octagon.
5. Define and calculate areas of: a circle, a segment of a circle, a sector of a circle, and an ellipse.
6. Solve problems involving the surface areas and volumes of cylinders and spheres.
7. Define terms and solve problems involving the surface areas and volumes of pyramids, cones, and frustums.

Topic 4 Forces and Friction

Learning Outcome

Explain concepts and solve problems involving vectors, force systems and friction.

Learning Objectives

1. Define, coplanar and concurrent vectors, and draw space diagrams for forces and displacements.
2. Draw a vector diagram and use it to graphically determine the resultant and equilibrant of a force system.
3. Use trigonometry to resolve forces into components and to calculate the resultant and equilibrant of a force system
4. Given a coplanar, concurrent force system, calculate any unknown forces.
5. Define static friction, sliding friction, and coefficient of friction; use the friction formula to calculate coefficient of friction
6. Explain friction angle and perform friction calculations for forces applied parallel to the horizontal plane.
7. Calculate the coefficient of friction, object weight, and applied forces for objects moved on a horizontal surface by forces that are NOT parallel to the plane.

Topic 5 Work, Power, Energy: Linear and Angular Motion

Learning Outcome

Explain concepts and solve problems involving velocity and acceleration, the Laws of Motion and work, power and energy.

Learning Objectives

1. Define force, force due to gravity, and work. Calculate the work done in moving objects horizontally and vertically.
2. Define power and mechanical efficiency. Calculate the power expended when work is done, plus the power developed and mechanical efficiency of a reciprocating engine.
3. Define potential and kinetic energy. Calculate the energies of stationary and moving objects.
4. Define, and show the relationships between, distance, displacement, speed, linear velocity, and linear acceleration.
5. Using linear motion relationships, calculate the displacements, velocities and accelerations of bodies moving in a straight line.
6. Define and calculate angular displacement, angular velocity and angular acceleration.

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Topic 6 Strength of Materials; Bending of Beams

Learning Outcome

Explain concepts and solve problems involving material stresses and bending of beams.

Learning Objectives

1. Define and explain, using appropriate formula, terms that apply to materials under load, including stress, tensile, compressive, shear, strain, elastic limit, ultimate load, ultimate strength, allowable working stress, factor of safety, Hooke's Law, Young's Modulus of Elasticity.
2. Calculate stress, strain, ultimate strength, factor of safety, and/or modulus of elasticity for materials under various load situations.
3. Explain the types of beams, beam supports, and beam loads and state the requirements for beam equilibrium.
4. Calculate the reaction forces for simple and cantilever beams, with point and distributed loads.
5. Explain the shear forces and bending moments in a beam and the compression/tension profile of a loaded beam.
6. Calculate the shear force at any given point in a simple or cantilever beam.
7. Calculate the bending moment at any given point in a simple or cantilever beam.

Topic 7 Simple Machines; Pressure, Density, Flow

Learning Outcome

Explain concepts and solve problems involving simple machines and fluids.

Learning Objectives

1. For simple machines in general, define and calculate mechanical advantage (MA), velocity ratio (VR), and efficiency.
2. Calculate the efforts, loads, MA, VR, and efficiencies of wheel and axle systems.
3. Calculate the efforts, loads, MA, VR, and efficiencies of various pulley systems.
4. Calculate the efforts, loads, MA, VR, and efficiencies of a screw jack.
5. Define and state the relationships between mass density, relative density, weight density, specific weight, and specific gravity.
6. Given unknowns, calculate the densities, relative densities, weights and/or volumes of substances.
7. Calculate pressures exerted by columns of fluids and convert between gage pressure, absolute pressure, millimetres of mercury, millimetres of water.
8. Calculate the pressure and force exerted by a liquid at various levels in a tank.
9. Explain flow continuity and calculate simple flows and velocities of liquids in a pipe.

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Topic 8 Heat, State Change, Calorimetry

Learning Outcome

Explain terminology regarding heat and perform calculations regarding heat during changes of state and calorimeter tests.

Learning Objectives

1. Define and explain internal energy, heat, specific heat, heat units, temperature and explain the relationship between the different temperature scales.
2. Define sensible heat and use the sensible heat equation to calculate the amount of heat required to change the temperature of a substance, the mass of the substance, and the temperature change, if no change of state occurs.
3. Explain the changes of state and define latent heat, latent heat of fusion, and latent heat of evaporation.
4. Given start and end conditions, calculate the heat required to change the states of water and other substances.
5. Determine the final temperatures and the original masses for mixtures of ice, water, steam, and other substances.
6. Explain the working principle of a simple calorimeter and use the calorimeter equation to determine specific heat and final temperature.
7. Explain water equivalent and perform calculations involving calorimetry and water equivalents.

Topic 9 Thermal Expansion and Heat Transfer

Learning Outcome

Explain concepts and perform calculations involving the thermal expansions of solids and liquids and heat transfer by conduction.

Learning Objectives

1. Explain the thermal conditions that cause expansion of solids and liquids and describe the relationship between linear, superficial (area) and volumetric expansion.
2. Given known conditions, calculate linear expansion or contraction, temperatures, and/or expansion coefficients for solids.
3. Given known conditions, calculate superficial expansion or contraction, temperatures, and/or expansion coefficients for solids.
4. Given known conditions, calculate volumetric expansion or contraction, temperatures, and/or expansion coefficients for solids or liquids.
5. Calculate the stress produced in a pipe or its supports when thermal expansion is restricted.
6. Explain the methods of heat transfer: conduction, convection, and radiation.
7. Define thermal conductivity and calculate the quantity of heat conducted, the temperature difference, or the material thickness when heat is transferred through flat walls and plates.

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Topic 10 Steam Properties and Calculations

Learning Outcome

Define properties of saturated and superheated steam and, using information from the steam tables, calculate the heat required to produce steam at various conditions; determine the equivalent and factor of evaporation for steam boilers.

Learning Objectives

1. Define and explain the following terms: saturation temperature, saturated steam, dry saturated steam, wet saturated steam, dryness fraction, superheated steam, enthalpy.
2. Identify, from the pressure-based and temperature-based steam tables, the properties of saturated steam at specified conditions.
3. Identify, from the superheated steam tables, the properties of superheated steam at specified conditions.
4. Calculate the heat required to produce dry saturated or superheated steam at given conditions, from feedwater at given conditions.
5. Calculate the dryness fraction of wet steam and/or the heat required to produce wet steam at a given dryness fraction.
6. Explain the properties of steam on a temperature-enthalpy diagram.
7. Define and calculate heat rate, equivalent evaporation and factor of evaporation for a boiler.

Topic 11 Gas Laws and Calculations

Learning Outcome

Explain the laws of perfect gases and perform calculations involving the expansion and compression of gases.

Learning Objectives

1. Explain Boyle's Law, Charles' Law, Gay-Lussac's Law, and the General Gas Law and use these to calculate pressure, temperature and/or volume changes for perfect gases.
2. Explain the Characteristic Gas Constant and use the Characteristic Gas Equation to determine the mass, the conditions, and the constant for a gas.
3. Explain isothermal, adiabatic, and polytropic processes (expansion and compression) for a gas, state the formula for each process, and compare the processes on a pressure/volume diagram.
4. Calculate unknown pressures, volumes and temperatures for gases during isothermal adiabatic, and polytropic processes.
5. Explain and calculate the work done in a cylinder under constant pressure.
6. Explain and calculate the work done in a cylinder during an isothermal expansion or compression.
7. Explain and calculate the work done in a cylinder during an adiabatic expansion or compression.
8. Explain and calculate the work done in a cylinder during a polytropic expansion or compression.

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Topic 12 Chemistry Fundamentals

Learning Outcome

Explain the fundamental principles in the structure, formation and interaction of chemical compounds and the importance of chemistry in industrial operations.

Learning Objectives

1. Define each term and explain the relationship between atoms, ions, elements, molecules, compounds, and mixtures.
2. Using the Periodic Table of the Elements, determine the atomic numbers and the atomic masses of elements.
3. Explain electronegativity and the bonding of ions.
4. Explain the formation of chemical compounds, explain typical reactions and apply fundamental principles to the balancing of simple chemical reactions.
5. Calculate the amount of reactants required or products produced in a chemical reaction.
6. Define acids, bases, and salts and explain their properties.
7. Define organic chemistry and explain, in general terms, the structure and applications of hydrocarbons and hydrocarbon derivatives.
8. Explain typical applications of chemistry in industry, including water treatment and testing, corrosion, combustion, hydrocarbon processing, petrochemical and pulp and paper processes.

Topic 13 Metallurgy and Materials

Learning Outcome

Explain the production, properties and applications of metallic and non-metallic materials.

Learning Objectives

1. Define and explain the importance and application of mechanical properties of materials, including brittleness, hardness, ductility, malleability, plasticity, elasticity, and toughness.
2. Describe material testing, including tension test, Brinell and Rockwell hardness tests, Charpy and Izod impact tests.
3. Describe the blast furnace and cupola furnace methods for iron production and compare the characteristics of gray, white, malleable, and ductile cast iron.
4. Define steel and explain the compositions and characteristics of low carbon, medium carbon and high carbon steels.
5. Define alloy steels, and explain the benefits of alloying elements, including nickel, chromium, molybdenum, vanadium, copper, lead, manganese and tungsten.
6. Explain the purposes of hot working, cold working and heat treating of metals.
7. Describe the production of carbon and alloy steel, using the open hearth, basic oxygen and electric-arc furnace processes.
8. Describe the properties and applications of non-ferrous metals and alloys.
9. Explain the basic structure, properties and applications of polymers, ceramics and composites.

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Topic 14 Corrosion Principles

Learning Outcome

Explain the mechanisms that cause corrosion and the methods used to monitor and control corrosion.

Learning Objectives

1. Define corrosion terms and explain the causes and characteristics of corrosion types, including galvanic, atmospheric, stray current, biological, stress cracking, hydrogen induced, sulphide stress cracking and chloride stress cracking.
2. Explain specifically the nature and sources of corrosion on the water side of boilers, including caustic corrosion, hydrogen damage, and pitting.
3. Explain the environmental factors that affect corrosion.
4. Explain the principles of corrosion inhibitor mechanisms, including adsorbed films, passivation, cathodic precipitates, and neutralization.
5. Describe the principles and applications of cathodic protection devices or systems, including sacrificial anodes, galvanic anodes, impressed current, and groundbeds.
6. Describe the principles and applications of corrosion monitoring devices, including coupons, electrical resistance probes, galvanic probes, and hydrogen probes.
7. Describe corrosion inspection procedures, including ultrasonics and radiography.

Topic 15 Industrial Drawings

Learning Outcome

Identify and interpret components of typical engineered drawings used in industry.

Learning Objectives

1. State the purpose of a Process Flow Diagram (PFD), and identify the major information available on a typical PFD.
2. State the purpose of a Piping & Instrumentation Diagram (P&ID), and identify the major information available on a typical P&ID. Explain the naming and symbol conventions for items found on a P&ID.
3. State the purpose and interpret information provided on a Material Balance Drawing.
4. Interpret information provided on a typical, approved Construction Drawing for a pressure vessel and other equipment.
5. State the purpose and identify the components of a typical Equipment Layout Drawing.

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Major Topic: Boiler Codes, Electrical and Instrumentation Theory

Topic 1 Legislation and Codes for Power Engineers

Learning Outcome

Explain the purpose of, general content of, and interaction with the legislation and codes that pertain to the design and operation of boilers and related equipment.

Learning Objectives

1. Explain Codes and Standards.
2. Explain the purpose and scope of the National Board of Boiler Inspectors (NBBI).
3. Explain the scope of the ASME and state the purpose and general content of the following sections of the ASME Codes: Section I, II, IV, V, VI, VII, VIII, IX.

Topic 2 Code Calculations - ASME Section I

Learning Outcome

Using the ASME Code - Section I, and ASME Section II D. Table 1A, calculate the design thickness and pressure of boiler tubes, drums, and piping, and calculate the capacities of pressure relief valves.

Learning Objectives

1. Given the tube material specification numbers, and other necessary parameters, use the formulae in PG-27.2.1 to calculate either the minimum required wall thickness or the maximum allowable working pressure for a boiler tube.
2. Given the material specification, construction method, and other necessary parameters, use the formulae in PG-27.2.2 to determine the minimum required thickness and or maximum allowable working pressure for boiler drums, headers, or piping.
3. Given the required specifications and operating conditions, use formula PG-29.1 to calculate the minimum required thickness of a seamless, unstayed dished head.
4. Given the required specifications and operating conditions, use formulae in paragraphs PG-29.11 and PG-29.12 to calculate the minimum required thickness of an unstayed, full-hemispherical head.
5. Using ASME Section I, Paragraphs PG-67 to PG-73, identify code information with respect to pressure relief valves and, using Table A-44, calculate the required pressure relief valve capacity for a given boiler.

Topic 3 Fuels, Combustion, and Flue Gas Analysis

Learning Outcome

Explain the properties and combustion of common fuels and the analysis of combustion flue gas.

Learning Objectives

1. Explain/define complete combustion, incomplete combustion, combustion products, and write balanced combustion equations.
2. Explain the purpose and benefits of excess air and calculate the theoretical and excess air required for the complete combustion of a given fuel.
3. Explain proximate analysis, ultimate analysis, and heating value of a fuel and describe the use of calorimetry to determine heating value. Explain higher and lower heating values.
4. Given the ultimate analysis of a fuel, use Dulong's Formula to calculate the heating value of the fuel.
5. Describe the properties, classifications and combustion characteristics of coal.
6. Describe the properties, classifications and combustion characteristics of fuel oil.
7. Describe the properties and combustion characteristics of natural gas.
8. Explain the use and combustion characteristics of alternatives to traditional fossil fuels, including biomass, coke and oil emulsions.
9. Explain the analysis of flue gas for the measurement of O_2, CO, and CO_2 in relation to combustion efficiency. Describe typical, automatic flue gas analyzers.
10. Explain the formation, monitoring and control of nitrogen oxides (NO_X), sulfur dioxide, and particulates.

Topic 4 Piping Design, Connections, Support

Learning Outcome

Discuss the codes, designs, specifications, and connections for ferrous, non-ferrous and non-metallic piping and explain expansion and support devices common to piping systems.

Learning Objectives

1. Identify and explain the general scope of the ASME, ANSI, ASTM codes and standards with respect to piping and pipe fittings. Differentiate between power piping (Code B31.1) and pressure piping (Code B31.3).
2. Explain methods of pipe manufacture; size specifications and service ratings, and the material specifications and applications for ferrous pipe.
3. Using pipe specifications and the ASME code Sections I and II you will be able to identify the size of pipe required for a particular installation, process or operating condition.
4. Explain the materials, code specifications and applications of common, non-ferrous metal piping and cast iron.
5. Describe screwed, welded, and flanged methods of pipe connection and identify the fittings used for each method.
6. Describe the construction, designs, and materials of flange gaskets and explain the confined, semi-confined, and unconfined flange styles.
7. Explain the materials, construction and approved applications of common, non-metallic pipe.
8. Explain the effects of temperature on piping; explain the mechanisms and the dangers of expansion in piping systems, including attached equipment.
9. State the purpose and explain the designs, locations and applications of simple and offset U-bend expansion bends.
10. Describe designs, locations, care and maintenance of slip, corrugated, bellows, hinged, universal, pressure-balanced, and externally pressurized expansion joints.
11. Describe design, location, operation of pipe support components, including hangers, roller stands, variable spring hangers, constant load hangers, anchors, and guides.

Topic 5 Steam Traps, Water Hammer, Insulation

Learning Outcome

Explain the designs and operation of steam trap systems, the causes and prevention of water hammer, and the designs and applications of pipe insulation.

Learning Objectives

1. Explain the dynamics, design, and components of steam/condensate return systems for steam lines and condensing vessels. Explain roles and locations of separators and traps.
2. Describe the design, operation and application of ball float, inverted bucket, thermostatic, bi-metallic, impulse, controlled disc, and liquid expansion steam traps.
3. Explain the selection, sizing and capacity of steam traps and explain the factors that determine efficient trap operation.
4. Explain the procedures for commissioning, testing, and maintenance of steam traps.
5. Explain and compare condensate-induced and flow-induced water hammer in steam and condensate lines. Explain the typical velocities, pressures and damage that can be created in steam/condensate lines due to water hammer.
6. Describe specific trap and condensate return arrangements that are designed to prevent water hammer in steam and condensate lines.
7. State precautions that must be observed to prevent water hammer and describe a typical steam system start-up procedure that will prevent water hammer.
8. State the purposes of insulation and explain the properties required for a good insulating material. Explain thermal conductivity, K-Factor and R-Value.
9. Identify the most common industrial insulating materials, describe the composition and characteristics of each, and explain in what service each would be used.
10. Describe common methods for applying insulation to piping and equipment, including wrap and clad, blanket, insulated covers and boxes. Explain the care of insulation and cladding and the importance of maintaining good condition.

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Topic 6 Valves and Actuators

Learning Outcome

Describe the designs, configurations and operation of the common valve designs that are used in power and process piping.

Learning Objectives

1. Explain the factors that determine the suitability and applications of the major valve styles; gate, globe, ball, plug, butterfly and needle.
2. Explain the factors that determine the selection of valve materials, and describe examples of typical valve body and trim materials. How are common control valves identified?
3. Describe the configurations and applications for gate valves, including gate designs (solid, split, flexible, sliding), stem configurations (rising, non-rising, outside screw-and-yoke, inside screw), and bonnet designs (flanged, screwed, welded).
4. Describe the designs and applications of globe valves, including conventional disc, composition disc, plug-type disc, and angle valves. Describe high-pressure plug-type control valves.
5. Describe the designs, application and operation of single-seated and double-seated balance valves. Explain caged trim for balanced control valves.
6. Describe the designs and applications of typical plug valves, including tapered and cylindrical plug, four-way, eccentric, and jacketed.
7. Describe the designs and configurations for mixing and diverter valves.
8. Describe the designs and operation of diaphragm valves.
9. Describe designs and operation of butterfly valves, including vertical, horizontal, swing-through, lined, and high-performance.
10. Describe the design, application, and operation of gear, motor, air-diaphragm, and air-piston actuators for valves.

Topic 7 Electrical Theory and DC Machines

Learning Outcome

Explain basic concepts in the production of electricity and the design, characteristics and operation of DC generators and motors.

Learning Objectives

1. Explain the production of electron flow in a circuit and define circuit voltage, amperage and resistance.
2. Explain electromagnetic induction and how it produces generator action and motor action.
3. Describe the design and operating principles of a DC generator or motor, clearly stating the purposes of the armature, brushes, windings and poles.
4. Explain how back EMF, armature reaction, and torque are created and their influence on a DC generator. Given the speed, flux, number of poles, and number of conductors, calculate the back EMF induced in a DC generator.
5. Explain separate and self excitation and describe the voltage/load characteristics of shunt, series and compound generators. State where the various types would be used. Explain how excitation of a DC generator is controlled.
6. Explain the speed/load characteristics of shunt, series and compound DC motors; define and calculate percent speed regulation and explain how speed is controlled in DC motors.
7. Explain DC motor torque characteristics and describe the starting mechanisms for DC motors.

Topic 8 AC Theory and Machines

Learning Outcome

Explain formation and characteristics of AC power, and describe the design, construction and operating principles of AC generators, motors and transformers.

Learning Objectives

1. Explain the creation of single phase and three-phase alternating power; define cycle, frequency and phase relationships (voltage/current) for AC sine waves.
2. Define the following terms and explain their relationships in an ac circuit: capacitance, inductance, reactance, impedance, power factor, alternator ratings (kVA and kW).
3. Describe the stator and rotor designs, operation, and applications for salient pole and cylindrical rotor alternators
4. Describe water, air and hydrogen cooling systems for large generators.
5. Explain parallel operation of alternators and state the requirements for synchronization. Describe manual and automatic synchronization.
6. Describe the design, applications and operating principles for large three-phase squirrel cage and wound rotor induction motors.
7. Describe the design and operating principle of synchronous motors.
8. Explain variable speed control, variable speed starting, and step starting for large induction motors.
9. Explain the principles and applications of power transformation. Perform transformer calculations.
10. Describe the designs and components of typical core and shell type transformers, including cooling components.

Topic 9 AC Systems, Switchgear, Safety

Learning Outcome

Identify the components of typical AC systems and switchgear and discuss safety around electrical systems and equipment.

Learning Objectives

1. Using a one-line electrical drawing, identify the layout of a typical industrial AC power system with multiple generators, and explain the interaction of the major components.
2. Explain the function of the typical gages, meters, and switches on an AC generator panel.
3. Explain the purpose and function of the circuit protective and switching equipment associated with an AC generator: fuses, safety switches, circuit breakers, circuit protection relays, automatic bus switchover, grounding and lightning arrestors.
4. Explain the components and operation of a typical Uninterruptible Power Supply (UPS) system.
5. Explain safety procedures and precautions that must be exercised when working around and operating electrical system components. Explain grounding.

Topic 10 Electrical Calculations

Learning Outcome

Define terms and perform simple calculations involving DC and AC power circuits.

Learning Objectives

1. Use Ohm's Law and Kirchhoff's Laws to calculate current, resistance or voltage drop in series or parallel multi-resistor circuits.
2. Calculate unknown resistances using a Wheatstone Bridge circuit.
3. Explain and perform calculations involving electrical power, work and energy.
4. Calculate the frequency, period and phase angle for an AC sine wave.
5. Define terms and calculate the peak-to-peak, root mean square, and maximum values for AC voltage and current.
6. Given required parameters, calculate the inductive reactance, capacitive reactance, total reactance, and impedance for an AC circuit, plus circuit frequency and current flow.
7. Calculate real power, imaginary power and power factor for an AC circuit.
8. Given the load, voltage and power factor of a 3-phase generator, calculate the kVA and kW ratings of the generator.

Topic 11 Control Loops and Strategies

Learning Outcome

Explain the operation and components of pneumatic, electronic and digital control loops, and discuss control modes and strategies.

Learning Objectives

1. Describe the operation, components and terminologies for a typical control loop.
2. Describe the operation and components of a purely pneumatic control loop. Explain the function of each component.
3. Describe the operation and components of an analog/electronic control loop. Explain the function of each component.
4. Describe the operation and components of a digital control loop. Explain the function of each component.
5. Explain the purpose, operation, and give examples of on-off, proportional, proportional-plus-reset, and proportional-plus-reset-plus-derivative control. Define proportional band and gain.
6. Describe and give typical examples of feed forward, feed back, cascade, ratio, split-range, and select control.
7. Explain, with examples, the purpose and incorporation of alarms and shutdowns into a control loop/ system.
8. Explain the interactions that occur and the interfaces that exist between an operator and the various components of a control loop/system, including the components of a controller interface.

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Topic 12 Instrument and Control Devices

Learning Outcome

Explain the operating principles of various instrument devices that are used to measure and control process conditions.

Learning Objectives

1. Describe the design, operation and applications for the following temperature devices: bimetallic thermometer, filled thermal element, thermocouple, RTD, thermistor, radiation and optical pyrometers
2. Describe the design, operation and applications for the following pressure devices: bourdon tubes, bellows, capsules, diaphragms, and absolute pressure gage.
3. Describe the design, operation and applications for the following flow devices: orifice plate, venturi tube, flow nozzle, square root extractor, pitot tube, elbow taps, target meter, variable area, nutating disc, rotary meter and magnetic flowmeter.
4. Describe the design, operation and applications for the following level devices: atmospheric and pressure bubblers, diaphragm box, differential pressure transmitter, capacitance probe, conductance probes, radiation and ultrasonic detectors and load cells.

Topic 13 Distributed and Logic Control

Learning Outcome

Explain the general purpose, design, components and operation of distributed and programmable logic control systems.

Learning Objectives

1. Explain distributed control and describe the layout and functioning of a typical distributed control system. Explain the function of each major component of the system.
2. Identify and explain the functions of the major components of the operator interface unit (OIU), including controller interfaces, displays, alarms and shutdown.
3. State typical applications and explain the purpose and functioning of a programmable logic controller, including the operator interfaces. Explain a ladder logic diagram.
4. State the purpose and explain the general functioning of a communication and data acquisition system (eg. SCADA) as it relates to process control.

Topic 14 Safety Management Systems

Learning Outcome

Discuss typical legislation and programs that manage safety in the industrial workplace.

Learning Objectives

1. Explain the general intent, power and scope of Occupational and Safety Health Act (OSHA) legislation.
2. Explain the intent and scope of a workplace OSHA program and state the responsibilities of company, employees, and the OH&S Committee within the program.
3. Define and give examples of typical workplace hazards and describe a system of hazard identification and control.
4. Explain the purpose of work permits and describe typical hot and cold work permit systems.
5. Explain the purpose of equipment lockout, describe lockout devices, and describe a typical equipment lockout procedure.
6. Define and identify a confined space and a permit-required confined space, describe a typical confined space permit and entry procedure.
7. Explain the hazards of excavation and describe typical excavation procedures and permits.
8. Explain the purpose and describe the typical components of an emergency response plan.
9. State the purpose of OSHA Hazard Communication Standard, explain the use of labels and material safety data sheets, and explain the responsibilities of employer and employee.
10. Explain the purpose, requirements, and procedures for incident and accident investigation and reporting.

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Topic 15 Fire Protection Systems

Learning Outcome

Discuss the classes and extinguishing media of fires, and explain systems that are used to detect and extinguish industrial fires.

Learning Objectives

1. Explain the classifications of fires and describe the extinguishing media that are appropriate for each classification.
2. Describe the components and operation of a typical fire detection and alarm system in an industrial setting.
3. Describe the design and operation of a typical standpipe system.
4. Describe the wet pipe, dry pipe, preaction and deluge designs for sprinkler systems.
5. Describe the layout, components and operation of a typical firewater system with fire pump and hydrants. Explain seasonal considerations for a firewater system.
6. Describe the construction and operation of a typical fire hydrant.
7. Explain the purpose and describe a typical deluge water system for hydrocarbon storage vessels.
8. Explain the purpose and describe a typical foam system for process buildings and tanks.
9. Describe a typical fire response procedure for an industrial setting.

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Major Topic: Pumps and Boilers

Topic 1 Watertube Boiler Designs

Learning Outcome

Describe common designs, configurations and circulation patterns for modern bent-tube watertube boilers and steam generators and explain how boilers are rated.

Learning Objectives

1. Explain the difference between packaged, shop assembled, and field-erected watertube boilers. Explain how boilers are rated.
2. Explain the process of water circulation in a watertube boiler and the factors that influence circulation.
3. Identify examples of and describe the A, O, and D design configurations and explain the water and gas circulation patterns for each. Define integral furnace.
4. Define a steam-generating unit, identify oil and gas-fired units, and explain the components, heating surfaces, and flow patterns through a typical unit. State typical temperatures throughout the unit.
5. Differentiate between critical and super-critical boilers.
6. Explain the purpose and advantage of forced circulation and describe the flow through a typical controlled circulation boiler.
7. Explain the purpose and design of a once-through boiler.

Topic 2 Special Boiler Designs

Learning Outcome

Describe the designs, components, firing methods, and operating considerations for some special boilers used in industry.

Learning Objectives

1. Describe typical designs, components and operating strategies for once-through, steam flood boilers.
2. Describe typical designs, components and operating strategies for Fluidized Bed boilers.
3. Describe typical designs, components and operating strategies for Heat Recovery Steam Generators.
4. Describe typical designs, components and operating strategies for Black Liquor Recovery boilers used in pulp mills.
5. Describe typical designs, components and operating strategies for Refuse boilers used in waste disposal.
6. Describe typical designs, components and operating strategies for waste heat, biomass boilers.

Topic 3 Boiler Construction

Learning Outcome

Explain Code requirements, in general terms, and describe construction and assembly methods for the major components of a large boiler.

Learning Objectives

1. Explain top and bottom support and describe the support techniques for various components of a large boiler, including lateral supports for furnace walls. Explain allowances for expansion.
2. Explain the purpose, design, locations and installation methods for boiler casing insulation, refractory, and cladding.
3. Describe the methods used to fabricate boiler tubes.
4. Describe the preparation, fabrication, and testing of boiler drums.
5. Describe methods of attaching tubes to drums and headers, including expanding and welding, and explain where each method would be used.
6. Explain code requirements/sizes for, and describe the designs and installation of, manholes and handholes, including welded handholes. Explain procedures for removing and installing covers.
7. Describe the field assembly of a large boiler or steam generating unit.

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Topic 4 Boiler Heat Transfer Components

Learning Outcome

Explain the purpose, location, design and operating conditions for the major heat transfer components of a large watertube boiler or steam generator.

Learning Objectives

1. Describe baffle designs and locations and explain their significance to boiler heat transfer.
2. Describe the designs of integral furnace sidewall and header arrangements, including tube-and-tile, tangent tube, and membrane.
3. Define primary, secondary, convection, radiation, platen, and pendant as they apply to superheaters. Describe the locations of superheaters within a steam generator and state the operating characteristics of convection and radiant superheaters.
4. Explain the purpose and design of a separately-fired superheater.
5. Explain the purpose and describe the locations of reheaters. Explain the position of and flow through the reheater in relation to the superheaters.
6. Describe designs and locations for integral and separate economizers.
7. Describe the designs, operation, and location of plate, tubular, and rotary regenerative air heaters.
8. Explain operating care and considerations that must be given to the various heat transfer sections of the boiler.
9. Explain a typical water and gas temperature profile through a large steam generating unit.

Topic 5 High Pressure Boiler Fittings

Learning Outcome

Describe the design and operation of common external and internal fittings attached to the pressure side of a high-pressure boiler.

Learning Objectives

1. Describe the design, installation, operation, and setting of a high-pressure pressure relief valve. Explain the Code requirements for size, capacity and locations of the pressure relief valves on a boiler.
2. Describe the code requirements for boiler pressure gages, including attachment and locations.
3. Describe common designs, connections and components of high-pressure water columns and flat gage glasses, including illumination and quick shut-off devices and bulls-eye glasses. Explain testing and maintenance of a high-pressure gage glass.
4. Describe the float and probe designs for low-water fuel cutoffs and explain how these are tested.
5. Describe boiler steam outlet arrangements and fittings including gate, angle, and globe stop valves and globe, Y, angle, and spring-cushioned non-return valves.
6. Describe manual blowoff piping arrangements. Describe the design and operation of sliding disc, seatless sliding plunger, seat and disc, and combination valves. Explain manual blowoff procedures. Describe the requirements for a blowoff tank.
7. Explain the components of the steam drum internals of a watertube boiler. Describe the design and operation of various steam separation devices, including baffles, primary and secondary separators, and scrubbers.

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Topic 6 Burner Designs and Supply Systems

Learning Outcome

Describe the typical components of fuel supply systems and describe common burner/furnace designs for gas, oil, and coal-fired boilers.

Learning Objectives

1. Describe a complete fuel gas supply system from fuel gas header to burner and explain the function of each component, including control and shut-off valves, auto-vents, and instruments. State the typical operating pressures.
2. Describe the design and operation of spud and ring burners, and explain high-efficiency, low NO_X designs.
3. Describe a complete fuel oil supply system from storage tanks to burners and explain the function of each system component.
4. Describe the design and operation of air, steam, and mechanical atomizing burners.
5. Describe a coal supply system from stockpiles to burners for a typical pulverized coal furnace.
6. Describe the design and operation of a pulverized coal burner and explain turbulent vertical, tangential, and cyclone furnaces.
7. Describe the design and operation of ball, impact, ball-race, and bowl mill pulverizers.
8. Describe the designs and operation of underfeed, overfeed, and crossfeed stokers for furnaces burning solid fuels.

Topic 7 Boiler Draf t and Flue Gas Equipment

Learning Outcome

Explain boiler draft systems and fans and describe the equipment used to remove ash from flue gas.

Learning Objectives

1. Define and explain the applications and designs of natural, forced, induced and balanced draft.
2. Explain how draft is measured, monitored, and controlled in a large, balanced draft boiler. Explain the position of control dampers.
3. Describe typical draft fan designs, single and double inlet arrangements, and explain methods used to control fan output.
4. Explain the start-up and running checks that must be made on draft fans.
5. Describe typical windbox and air louver arrangements and distinguish between primary and secondary air.
6. Describe the design and operation of flue gas particulate clean-up equipment, including mechanical and electrostatic precipitators and baghouse filters.
7. Describe the design and operation of ash handling systems, including hydro and air systems, bottom ash systems, and scraper conveyor systems.
8. Describe the designs and operation of SO_2 recovery systems, including lime and wet gas scrubbing.

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Topic 8 Boiler Control Systems

Learning Outcome

Explain the components and operation of automatic control systems for boiler water level, combustion, steam temperature, and start-up.

Learning Objectives

1. Describe on-off and single element control of boiler feedwater.
2. Explain swell and shrinkage in a boiler. Describe the components and operation of a two-element feedwater control system, explaining the interaction of the controllers.
3. Describe the components and operation of a three-element feedwater control system.
4. Describe the components and operation of a direct combustion control system.
5. Describe the components and operation of a ‘steam flow – airflow’ combustion control system.
6. Describe the components and operation of a ‘fuel flow – airflow’ combustion control system.
7. Describe the components and operation of an ‘airflow – fuel flow’ combustion control system.
8. Describe the components and operation of a multi-element combustion control system.
9. Describe steam temperature control methods and equipment, including attemperation (desuperheating), gas recirculation, gas bypass, and tilting burners.
10. Describe the automatic, programmed start-up sequence for a gas-fired boiler.

Topic 9 Boiler Procedures

Learning Outcome

Describe common procedures in the operation and maintenance of high pressure boilers.

Learning Objectives

1. Explain the steps involved in the commissioning of a new boiler or before starting a boiler after major repairs, including:
   a) hydrostatic test
   b) external and internal inspections
   c) drying out refractory
   d) boiling out
   e) testing shutdowns and safety devices
2. Describe the wet and dry methods when laying up a boiler for an extended time, including nitrogen blanketing.
3. Describe the proper shut down and preparation of a boiler for internal inspection.
4. Describe a thorough inspection of the water and furnace sides of a boiler.
5. Describe typical equipment and procedures for cleaning the water side of a boiler:
   a) mechanically
   b) chemically
6. Explain routine tasks and visual monitoring that the operator must perform on a large operating boiler.
7. Explain the procedures and precautions that an operator must exercise to avoid furnace and pressure-side explosions.
8. Describe sootblowing systems and describe the procedures for operating sootblowers.

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Topic 10 Internal Water Treatment for Boilers

Learning Outcome

Discuss internal water treatment methods and systems for the control of scale, corrosion, and carryover and explain testing and monitoring strategies.

Learning Objectives

1. Explain the causes and effects of boiler scale; explain the most common internal methods of scale control, including phosphate treatment, chelate treatment, sludge conditioning and dispersion.
2. Explain the causes and effects of boiler and condensate return line corrosion; explain treatment methods for acidic, caustic, oxygen, and carbon dioxide corrosion, including sulphite, hydrazine, and amine treatment.
3. Explain the mechanical and chemical causes, effects and types of carryover; explain methods of carryover control, including the use of antifoam and blowdown.
4. Describe the design and explain the operation of simple blowdown, heat recovery, and automatic blowdown systems.
5. Explain, in general terms, the sampling and testing strategies for boiler internal conditions; describe typical sampling and automatic monitoring equipment.
6. Describe typical chemical feed systems, including pot feeders, continuous feed with day tanks, and continuous feed with pump tanks.

Topic 11 Boiler Water Pretreatment

Learning Outcome

Explain the purpose, principles, equipment, and monitoring of boiler water pretreatment processes.

Learning Objectives

1. Describe the design and explain the terms, purpose and operation of a clarifier, using coagulation, flocculation, and subsidence.
2. Describe the design and explain the terms, purpose and operation of gravity and pressure filters.
3. Describe the design and explain the terms, purpose and operation, including chemical reactions for a cold lime softener.
4. Describe the design and explain the terms, purpose and operation of a hot lime softener.
5. Explain the principles of ion exchange softening in general, identifying the common anions and cations in untreated water.
6. Describe the design, components, and operation of a sodium zeolite softening system including chemical reactions.
7. Describe the design, components, and operation of a hydrogen zeolite softening system including chemical reactions.
8. Describe the design, components, and operation of a dealkalization system including chemical reactions.
9. Describe the design, components, and operation of a demineralizer system, including mixed bed and degasification.
10. Explain the principle and operation of a reverse osmosis system.
11. Describe the design, principle, and operation controls of a typical deaerator.

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Topic 12 Pump Designs and Operation

Learning Outcome

Describe the designs, principles, components and operating procedures for common industrial pumps.

Learning Objectives

1. Explain the principle of operation and describe the components of typical plunger, piston and diaphragm reciprocating pumps.
2. Explain the designs and operating principles of the external gear, internal gear, sliding vane, lobe, and screw type rotary pumps.
3. Explain the designs and operating principles of volute and diffuser centrifugal pumps, including impeller designs.
4. Describe centrifugal pump arrangements, including vertical, horizontal, single and double suction, opposed impellers, multi-staging, split and barrel casings.
5. Describe the design and applications of axial and mixed flow pumps.
6. Describe the design and components of a multistage centrifugal pump, clearly stating the purpose and general design of: wear rings, shaft sleeves, seals, bearings and lubrication components, vents and drains.
7. Explain design features that eliminate thrust in large centrifugal pumps.
8. Describe systems used to maintain minimum flow through a centrifugal pump.
9. Explain priming, start-up, capacity control and operating cautions for centrifugal pumps.

Topic 13 Pump Head Calculations

Learning Outcome

Define terms associated with pumping and perform pump head calculations.

Learning Objectives

1. Explain the relationship between the height of a liquid, the density of the liquid and the pressure exerted at the bottom of the liquid. Perform simple calculations involving this relationship.
2. Define equivalent head and calculate equivalent heads for water and other liquids.
3. Define static suction head, static suction lift, static discharge head, total static head, pressure head, and calculate each of these for a given pump arrangement.
4. Define and calculate friction head and velocity head.
5. Define dynamic suction head, dynamic suction lift, dynamic discharge head, total dynamic head, and calculate each of these for a given pump arrangement.
6. Explain vapor pressure, cavitation, and net positive suction head. Calculate the required suction pressure for a water pump, given the manufacturers required NPSH.

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Topic 14 Welding Procedures and Inspection

Learning Outcome

Explain the processes and applications of different welding techniques and describe the testing of welds and procedures.

Learning Objectives

1. Describe the equipment, procedure and applications of shielded metal arc welding (SMAW). Explain the classification of arc welding electrodes.
2. Describe the equipment, procedure and applications of submerged arc welding (SAW).
3. Describe the equipment, procedure and applications of gas tungsten arc welding (GTAW).
4. Describe the equipment, procedure and applications of gas metal arc welding (GMAW).
5. Explain weld preparation and terminology of a butt weld; explain preheating and post-weld heat treatment.
6. Describe common defects in welds, including undercut, lack of penetration, porosity, slag inclusion, and cracking; explain how each occurs and its effect on the integrity of the weld.
7. Explain the equipment and procedures for dye penetrant, magnetic particle, radiographic, and ultrasonic inspection of a weld; explain the potential weld defects revealed by each test.
8. Explain the requirements and process for Weld Procedure and Welder Performance qualification, per the ASME Code, Section IX.

Topic 15 Pressure Vessels

Learning Outcome

Explain pressure vessel design, stresses, and operating considerations.

Learning Objectives

1. Define “pressure vessel” and explain, in general terms, how pressure vessels are regulated in design, construction and repair (including purpose of Section VIII, ASME).
2. Explain the stamping/nameplate requirements for pressure vessels and identify terms and specifications on a typical nameplate.
3. Describe the weld locations on a typical pressure vessel and identify head designs, including ellipsoidal, torispherical, hemispherical, conical, and toriconical.
4. Describe acceptable nozzle attachment methods, including reinforcements; describe inspection openings.
5. Explain the loads that contribute to stresses in pressure vessels, including pressure, thermal, attachments, static, wind, seismic, and cyclic loads.
6. Explain the components and fittings of a typical pressure vessel.
7. Explain operating and maintenance considerations for the safe operation of pressure vessels, including the appropriate use of hydrostatic and pneumatic testing.

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Major Topic: Prime Movers and Refrigeration Topic 1

Steam Turbine Principles and Design Learning Outcome

Describe designs, operating principles, and major components of steam turbines.

Learning Objectives

1. Explain impulse turbine operating principles. Describe convergent and divergent nozzles, and the pressure-velocity profiles through an impulse section.
2. Explain reaction turbine operating principles and describe the pressure-velocity profiles through reaction blading.
3. Explain pressure, velocity, and pressure-velocity compounding of impulse turbines. Describe the pressure-velocity profiles and the purpose and applications of each.
4. Explain the purpose, general operating principles and arrangement for each of the following turbine types: condensing, condensing-bleeder, backpressure, extraction, topping, mixed-pressure, cross-compounded, tandem compounded, double flow and reheat.
5. Describe the designs of typical turbine casings and state the purpose and location of casing fittings, including drains and sentinel valves. Describe the designs and principles of casing/shaft seals.
6. Describe the designs and applications of disc and drum rotors. Describe methods of rotor and casing blade attachment and explain blade-sealing arrangements.
7. Explain thrust in a large turbine and describe methods to offset thrust, including thrust bearings, dummy piston, and thrust-adjusting gear.
8. Identify typical designs and components for small and large industrial turbines. Explain typical size/ capacity rating specifications and explain typical applications.
9. Explain the use and design of reducing gears attached to steam turbines.

Topic 2 Steam Turbine Auxiliaries and Operation

Learning Outcome

Describe auxiliary support and control systems for steam turbines and explain start-up and shutdown procedures.

Learning Objectives

1. Describe typical lube oil systems for small and large steam turbines.
2. Explain the purpose and describe the design and operation of barring gear and jacking oil systems on a large turbine.
3. Describe a condensing turbine circuit and explain typical operating parameters.
4. Explain and state the applications, where applicable, of the following governor types: speed-sensitive, pressure-sensitive, nozzle, throttle, and bypass. Explain governor droop and isochronous control.
5. Explain the operation and the major components of the three main speed-sensitive governor systems: mechanical, mechanical-hydraulic, and electronic-hydraulic.
6. Explain the operation and describe the components of typical mechanical and electronic overspeed trip systems.
7. Explain the sequence followed for the cold start-up and the shutdown of a non-condensing steam turbine.
8. Explain the sequence followed for the cold start-up and the shutdown of a condensing and extracting steam turbine.

Topic 3 Turbine Condenser Systems

Learning Outcome

Explain typical designs, components and operating principles of steam turbine condensers.

Learning Objectives

1. Explain the purposes of a turbine condenser in a steam plant cycle and describe a typical condensing circuit, with operating temperatures and pressures.
2. Explain the design, operation and applications of the jet condenser, including the ejector type.
3. Explain the design, operation and applications of the surface condenser, including air cooled and water-cooled, down flow and central flow.
4. Describe construction details for surface condensers, including shells, tube attachment, supports, and allowances for expansion.
5. Explain the effects of air in a condenser and describe the design and operation of single and two-stage air ejectors. Explain the detection of condenser air leaks. Explain vacuum pumps.
6. Explain the devices and operating considerations used to protect a condenser against high backpressure, high condensate level, and cooling water contamination. Describe a cooling water leak test.
7. Describe the operating conditions and corresponding design considerations for condensate extraction pumps and cooling water pumps.
8. Describe a feed water heater system in conjunction with a steam condenser and explain the designs of low-pressure and high-pressure feed water heaters.

Topic 4 Gas Turbine Principles and Designs

Learning Outcome

Explain common designs, major components, operating principles, and arrangements for industrial gas turbines.

Learning Objectives

1. Explain gas turbine advantages and disadvantages, background and industrial applications. Identify the types of gas turbines, their major components and describe the operating principles of a simple gas turbine.
2. Explain single and dual shaft arrangements for gas turbines. Describe open cycle and closed cycle operation.
3. Describe a typical open cycle gas turbine installation, including buildings or enclosures, intake and exhaust systems, auxiliary systems, and reducing gear.
4. Explain the efficiency and rating of gas turbines and describe the purpose and applications of gas turbine cycle improvements, including intercooling, regenerating, reheating and combined cycle.
5. Describe various aspects of compressor design and centrifugal and axial types of compressors.
6. Describe the types, operation, components and arrangements of combustors.
7. Describe turbine section design and operation especially with respect to blading and materials.
8. Explain the types and functions of the control systems and instrumentation needed for gas turbine operation.
9. Explain the typical operating parameters of a gas turbine; describe the effects of compressor inlet temperature, compressor discharge pressure, and turbine inlet temperature on gas turbine performance.

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Topic 5 Gas Turbine Auxiliaries and Operation

Learning Outcome

Describe the support auxiliaries for a gas turbine and explain common operational, control and maintenance procedures.

Learning Objectives

1. Describe the types of bearings used in a gas turbine and explain the components, operation, protective devices and routine maintenance of a typical lube oil system.
2. Describe and explain the operation and routine maintenance of a typical fuel gas supply system for a gas turbine.
3. Describe and explain the operation and routine maintenance of a typical fuel oil supply system for a gas turbine.
4. Explain the control of NO_X from a gas turbine and describe the purpose and operation of water/steam injection and dry low NO_X systems.
5. Explain the purpose, location and operation of the gas turbine starting motor and turning gear.
6. Describe the compressor intake and the turbine exhaust components.
7. Describe the preparation and complete start-up sequence for a gas turbine.
8. Describe the shutdown sequence and procedure for a gas turbine.
9. Explain the purpose and describe typical on-line and off-line waterwash procedures for gas turbine blades.

Topic 6 Internal Combustion Engines

Learning Outcome

Explain the operating principles, designs, support systems, and operation of industrial internal combustion engines (ICE).

Learning Objectives

1. Explain the principles of spark ignition and compression ignition; describe the operating cycles for two-stroke and four-stroke designs.
2. Identify and state the purpose of the major mechanical components of an internal combustion engine.
3. Describe carburetor, fuel injection, battery ignition, and magneto ignition systems for a spark ignition engine.
4. Describe individual pump, distributor, and common rail fuel injection systems for a diesel engine.
5. Explain the purpose and describe the operation of superchargers and turbochargers.
6. Describe and explain the operation of a typical cooling system for an industrial ICE.
7. Describe and explain the operation of a typical lubrication system for an industrial ICE.
8. Describe engine-starting devices/systems for diesel and gas engines.
9. Explain the monitoring, protection and control devices on a large industrial diesel or gas engine, including shutdowns and governing.
10. Explain a typical start-up procedure for a large industrial diesel engine, plus the routine monitoring requirements of a running engine.

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Topic 7 Cogeneration Systems and Operation

Learning Outcome

Explain cogeneration and describe common configurations, components and applications.

Learning Objectives

1. Define cogeneration and explain its purpose, advantages, and applications.
2. Explain the components and operation of simple-cycle cogeneration systems.
3. Explain the components and operation of combined-cycle, gas/steam turbine cogeneration systems.
4. Explain the components and operation of a fully fired, combined-cycle cogeneration system.
5. Explain single-shaft and dual-shaft combined-cycle power plants.
6. Explain the general control strategies and components, for both power and steam production, including diverter and duct burner operation.
7. Describe the various designs of heat recovery steam generators (HRSGs) and explain their industrial applications.
8. Explain the environmental considerations and techniques in the operation of a cogeneration system.
9. Describe typical cogeneration systems that use internal combustion engines (gas or diesel) and heat recovery water heaters (HRWHs).
10. Explain a typical start-up procedure for a combined cycle cogeneration system.

Topic 8 Compressor Theory and Designs

Learning Outcome

Explain the classification, designs, and operating principles of industrial air and gas compressors.

Learning Objectives

1. Explain compressor terminologies, including compression ratio, capacity, staging, intercooling and aftercooling. Explain the effects of moisture in compressed gases. Explain the effects of altitude on the compression process.
2. Describe the operation and common arrangements of reciprocating compressors, including single-acting, double-acting, and tandem arrangements.
3. Identify the components of a reciprocating compressor and describe the operation of plate and channel valves.
4. Describe internal and external lubrication systems for reciprocating compressors.
5. Describe the design and explain the operating principles of rotary compressors, including sliding vane, rotary lobe, and rotary screw.
6. Identify the components and controls for a packaged industrial screw compressor.
7. Describe designs and principles of centrifugal compressors/blowers, including single and multi-stage designs.
8. Describe designs and principles of axial compressors/blowers.

Topic 9 Compressor Auxiliaries and Operation

Learning Outcome

Explain the controls and system auxiliaries for a typical instrument air system and explain startup procedures for air compressors.

Learning Objectives

1. Describe the control devices and strategies for air compressors, including start-and-stop, variable speed, constant speed; describe pilot and unloader devices.
2. Explain the design and operation of an anti-surge system for a dynamic compressor.
3. Describe the designs of water and air-cooled aftercoolers and intercoolers, with separators.
4. Describe the components, arrangement, and parameters of a typical, complete instrument air system, including wet and dry receivers, dryers.
5. Describe the components and operating principles and sequences of instrument air dryers. Explain dewpoint monitoring of air systems.
6. Describe the design, fittings, and operating consideration for air receivers.
7. Explain the start-up procedure for a positive displacement compressor.
8. Explain the start-up procedure for a dynamic compressor/blower.

Topic 10 Refrigeration Principles and Systems

Learning Outcome

Explain the classification and properties of refrigerants and describe the operating principles and components of compression and absorption systems.

Learning Objectives

1. Explain the required properties of a refrigerant and describe the six group classifications for refrigerants. Identify the properties of common refrigerants.
2. Explain the ammonia compression refrigeration cycle, explaining the purpose of each major component and stating typical pressures and temperatures in the system.
3. Explain direct and indirect refrigeration. Describe a centrifugal compression system, using chilled water.
4. Describe and explain the operation of a two-stage, duplex compressor system with a brine cooler.
5. Describe and explain the operation of a two-stage refrigeration system with a rotary booster compressor.
6. Describe and explain the operation of a low-temperature multi-stage refrigeration system.
7. Explain the components and operating principle of an ammonia absorption system.

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Topic 11 Refrigeration Auxiliaries and Operation

Learning Outcome

Explain control and safety devices on a compression refrigeration system and explain procedures and equipment to control oil, non-condensables, moisture, refrigerant, and brine.

Learning Objectives

1. Explain the purpose, design and operation of the following controls on a compression refrigeration system: expansion valve, low-side float, high-side float, compressor controls (temperature and pressure-actuated), and condenser cooling water control.
2. Explain the purpose of the following refrigeration system safety devices: high-pressure cutout, oil pressure cutout and pressure relief devices.
3. Explain the effects of oil in ammonia and Freon systems and describe the location and operation of an oil separator and oil still. Explain how oil is manually drained from these systems.
4. Explain the effects and location of non-condensable gases. Describe the operation of manual and automatic purge devices.
5. Explain the effects of moisture in a refrigeration system and describe its removal.
6. Explain leak testing of a system and describe the procedure for adding refrigerant.
7. Explain the principles of brine control in an indirect system and explain the procedures for charging and controlling brine strength.
8. Explain refrigeration safety and environmental issues.

Topic 12 Heat Exchangers and Cooling Towers

Learning Outcome

Describe the design, operation, and applications of various types of industrial heat exchangers.

Learning Objectives

1. Describe double pipe heat exchangers, including jacketed pipe, U-tube, and concentric pipe designs.
2. Describe shell-and-tube heat exchangers including fixed straight tube and U-tube designs. Describe common front and rear head designs, shell flow configurations, and explain the purpose of baffles.
3. Explain the operation and the typical fittings/equipment on the steam/condensate side of a reboiler and a feed water heater.
4. Describe the design and operation of a plate-and-frame exchanger.
5. Describe the design and components of overhead, aerial coolers, including fan and cooler arrangements. Explain cooler control
6. Describe the design and components, including controls, of an overhead, aerial condenser. Explain condenser operation, control and precautions when used to condense excess steam.
7. Describe the design and explain the operation of natural draft cooling towers, including atmospheric and hyperbolic styles

8 Describe the design and operation of mechanical draft cooling towers, including forced draft, induced draft counterflow, and induced draft crossflow.

Topic 13 Fired Heaters

Learning Outcome

Describe the design, components, operation, and applications of direct-fired and indirect-fired natural draft process heaters.

Learning Objectives

1. Describe the common process applications for direct-fired heaters. Explain direct-fired heater designs and classifications.
2. Describe the design, identify the tube banks and explain the fluid and combustion gas flows through a multi-burner, vertical fired heater.
3. Describe typical burner designs and configurations, identifying burner components, including air registers, pilots, and flame scanners. Describe burner operation.
4. Describe the fuel gas supply system to the burners and explain the purpose of the major fittings.
5. Describe the monitoring, control, and shutdown devices on a typical heater.
6. Explain heater start-up procedure, including the lighting of additional burners once flame is established. Explain heater shutdown procedure.
7. Describe the design, components and operation of a typical horizontal, indirect-fired heater such as a salt bath heater.
8. Explain start-up and shutdown procedures for an indirect-fired heater.

Topic 14 Wastewater Treatment

Learning Outcome

Explain the purpose, designs, processes and control of industrial wastewater treatment.

Learning Objectives

1. State the purpose of wastewater treatment, list typical waste liquids, and explain the legislation and permitting, including parameters, for the disposal of wastewater.
2. Sketch an industrial wastewater treatment system and describe the processes that occur at each stage of treatment.
3. Describe the equipment and process involved in the removal of suspended solids from wastewater, including screening, flotation, and sedimentation.
4. Describe the equipment and process involved in the removal of colloidal solids from wastewater, including chemical coagulation, flocculation, and clarification.
5. Describe the equipment and process involved in the biological removal of solids from wastewater, including activated sludge, rotating biological contactors, and trickling filters.
6. Describe the control strategy for a wastewater treatment system. Define and explain the control of and sampling points for the main control parameters, including nutrients, BOD, COD, pH, and settle ability.

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Topic 15 Plant Maintenance and Administration

Learning Outcome

Explain typical components of maintenance and administration programs for utilities and process facilities.

Learning Objectives

1. Explain typical communication and accountability structures within a large facility, including the responsibilities for external communication.
2. Describe the typical components and responsibilities of scheduled and preventive maintenance management programs.
3. Explain the importance and extent of record keeping and describe the quality and content requirements for operating logbooks and records.
4. Using a complete boiler turnaround and inspection as an example, describe project management using two methods, Gantt Chart and critical path.
5. Explain the importance of procedures in the operation of a facility and describe the application of well-written procedures to personnel training and daily operation.
6. Explain typical environmental monitoring and management programs for operating facilities.

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REFERENCE CURRICULUM

For

International Power Engineer (4th Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
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Introduction

This Curriculum is intended to assist candidates studying for the International Power Engineer (4th Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for International Power Engineer (4th Class) Examination Candidates

Major Topic: Preparatory Math Topics for Power Engineering

Topic 1 Numerical Unit Systems

Learning Outcome

Perform simple calculations involving SI units.

Learning Objectives

1. Describe basic SI and USCS units, matching associated symbols for unit prefixes.
2. Perform conversions both within and between SI and USCS units.

Topic 2 Basic Arithmetic Operations

Learning Outcome

Perform basic arithmetic operations without the use of a calculator.

Learning Objectives

1. Add and subtract integers.
2. Multiply and divide whole and decimal numbers.
3. Perform arithmetic operations involving combinations of addition, subtraction, multiplication, division, and powers in the proper order of operation.

Topic 3 Fractions, Decimals, and Percentages

Learning Outcome

Perform basic arithmetic operations involving fractions, decimals, and percentages.

Learning Objectives

1. Identify proper and improper fractions and mixed numbers.
2. Add, subtract, and multiply fractions, and reduce them to lowest terms.
3. Convert fractions to decimal numbers and decimal numbers to fractions.
4. Analyze percentage problems.

Topic 4 Ratio and Proportion

Learning Outcome

Describe the concepts of ratio and proportion.

Learning Objectives

1. Convert ratios of one quantity to another quantity.
2. Solve word problems involving ratios and proportions.

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Topic 5 Equations and Transposition

Learning Outcome

Transpose equations in order to find values for different variables in a formula.

Learning Objectives

1. Solve equations and word problems.

Topic 6 Length, Lines, and Simple Plane Figures

Learning Outcome

Describe measurement of length, types of lines and angles, and calculate perimeters and areas of simple plane figures.

Learning Objectives

1. Describe linear measurement systems and convert measurement units from one system to another.
2. Define parallel and perpendicular lines and types of angles.
3. Describe types of simple plane figures, including triangles and quadrilaterals.
4. Describe the components of a circle, circumference, area, and diameter.

Topic 7 Length, Lines, and Simple Plane Figures

Learning Outcome

Calculate the volumes of rectangular objects, cylinders, and spheres and the surface areas of cylinders and spheres.

Learning Objectives

1. Convert between commonly used volume units.
2. Calculate the volume of a rectangular prism.
3. Calculate the surface area and volume of a cylinder.
4. Calculate the surface area and volume of a sphere.

Major Topic: Elementary Physical, Chemical, and Thermodynamic Principles

Topic 1 Introduction to Matter and Chemistry

Learning Outcome

Identify basic types of matter, their properties, and the associated chemical principles.

Learning Objectives

1. Differentiate among the physical states of matter.
2. Differentiate between chemical and physical changes in matter.
3. Classify matter as either a type of mixture or a pure substance.
4. Describe the purpose and uses of the periodic table using the parts of an atom.
5. Describe the three main ways atoms bond together: covalent, ionic, and metallic bonding.
6. Discuss chemical equations and their purpose.
7. Perform simple stoichiometric calculations.
8. Demonstrate how unstable compounds are combined to make stable compounds.

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Topic 2 Introduction to Thermodynamics

Learning Outcome

Explain the principles and laws of thermodynamics.

Learning Objectives

1. Define the first two laws of thermodynamics.
2. Define heat and specific heat, and perform sensible heat calculations.
3. Describe the expansion of solids and liquids.

Topic 3 Introduction to Heat Transfer and Heat Exchangers

Learning Outcome

Explain the modes of heat transfer and the theory of heat exchanger operation.

Learning Objectives

1. Describe the three modes of heat transfer with reference to heat exchangers.
2. Discuss the general design and construction of typical heat exchangers.
3. Describe heat transfer fluids and how they affect the operation of a heat exchanger, including fouling, leakage, and vapor locking.
4. Describe heat exchanger inspection, maintenance, and operation, including placing them in service and removing them from service.

Topic 4 Thermodynamics of Steam

Learning Outcome

Apply the thermodynamics principles through practical applications using the steam tables and the temperature-enthalpy chart.

Learning Objectives

1. Describe heat as it relates to steam, water, and ice.
2. Explain the various columns of the steam tables.
3. Explain the thermodynamic principles of steam, using the steam tables.

Major Topic: Introduction to Power Engineering and its Governance

Topic 1 Introduction to Power Engineering

Learning Outcome

Describe the Power Engineer profession.

Learning Objectives

1. Describe steam, its uses and the basic steam cycle.
2. Describe the role and duties of a Power Engineer.
3. Describe how shift work affects sleep patterns, diet, and overall health.

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Topic 2 Jurisdictional Legislation for Power Engineers

Learning Outcome

Describe the application of Jurisdictional Acts and Regulations with respect to boilers and pressure vessels.

Learning Objectives

1. Describe how the Power Engineering profession is regulated in Canada.
2. Explain the purpose and scope of your Jurisdictional Act and Regulations pertaining to Power Engineering and Pressure Equipment.
3. Explain the purpose and intent of the Regulations governing Power Engineers and Pressure Welders.

Topic 3 Codes and Standards for Power Engineers and Pressure Vessels

Learning Outcome

Describe the purpose of boiler and pressure vessel Codes and Standards.

Learning Objectives

1. Discuss the history of how codes and standards became necessary in the pressure equipment field.
2. Explain the content and use of the CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code.
3. Explain the content and use of the CSA B52 Mechanical Refrigeration Code.
4. Explain the content and use of ASME Boiler and Pressure Vessel Code (ASME BPVC) Section I Power Boilers.
5. Explain the content and use of ASME BPVC Section VII - Recommended Guidelines for the Care of Power Boilers.
6. Explain the content and use of ASME BPVC Section IV - Rules for Construction of Heating Boilers.
7. Explain the content and use of ASME BPVC Section VI - Recommended Rules for Care and Operation of Heating Boilers.
8. Explain the purpose, intent, and limitation of ASME CSD-1 (Controls and Safety Devices) Standard.

Major Topic: Introduction to Plant and Fire Safety

Topic 1 Introduction to Plant Safety

Learning Outcome

Describe general plant safety as it related to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may be in an energy plant, and the basic Personal Protective Equipment that may be required.
3. Define, give examples of, and describe common power house hazards.
4. Describe Industrial health and safety management system.
5. Describe Hazard Assessment and Control programs.

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Topic 2 Plant Safety Programs

Learning Outcome

Describe common safety programs generally applied in plants.

Learning Objectives

1. Describe common occupational health and safety (OH&S) programs found in most plants.
2. Describe industrial safety programs in which Power Engineers may require additional training.
3. Discuss safe work permits.
4. Describe methods of equipment isolation and lock out.

Topic 3 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous materials.

Learning Objectives

1. Discuss the WHMIS system.
2. Discuss the essential components required in the WHMIS systems.
3. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
4. Discuss the safe handling of Hydrocarbons.

Topic 4 Plant Fire Safety

Learning Outcome

Explain fire safety in an industrial plant.

Learning Objectives

1. Discuss the theory, terminology, and the life safety issues associated with fires.
2. Explain the five classes of fires, and describe the types of fire extinguishing media and how they act on these fires.
3. Explain fire prevention.
4. Discuss fire prevention methods for the five types of fires.

Topic 5 Fire Extinguishing Methods and Equipment

Learning Outcome

Describe typical fire extinguishing equipment and its operation in plant environments.

Learning Objectives

1. Describe the construction and operation of various types of portable fire extinguishers.
2. Discuss the inspection and maintenance requirements of portable fire extinguishers.
3. Describe the types, layout, and operation of standpipe and sprinkler systems.
4. Discuss the maintenance requirements of standpipe and sprinkler system components.
5. Describe the purpose, operation, and maintenance of fire pumps.

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Major Topic: Introduction to Plant Operations and the Environment

Topic 1 Introduction to the Environment

Learning Outcome

Identify environmental considerations and how they relate to an operating plant.

Learning Objectives

1. Describe four important Biogeochemical Cycles that operate within the environment.
2. Describe typical interdependencies seen among elements within an "ecosystem."
3. List the types of impacts that operating facilities can have on the environment.
4. Describe the alert processes related to environmental problems of plants.
5. Explain the importance of "attitude" in limiting environmental impacts of plants.
6. Describe the long-term environmental impacts after the decommissioning and abandonment of plants.

Topic 2 Gas and Noise Emissions

Learning Outcome

Explain how gas and noise emissions affect plant operations.

Learning Objectives

1. Identify the sources and effects of common gases and vapours that have an adverse environmental impact.
2. Identify the common greenhouse and acid rain causing gases and describe their effects.
3. Describe the common methods for monitoring and reducing gaseous pollutants.
4. Describe the effects of noise pollution and methods of identifying, measuring, and controlling it.

Topic 3 Liquid and Solid Emissions

Learning Outcome

Explain how liquid and solid emissions affect plant operation.

Learning Objectives

1. Describe the sources and effects of solid pollutants from energy plants.
2. Describe the theory of operation of separators/collectors and monitoring of flue gas particulates.
3. Describe the disposal methods of solid waste from energy plants.
4. List sources and effects of liquid and thermal pollution.
5. Describe the preventive measures that can be taken to prevent liquid and thermal pollution.
6. Describe methods of liquid waste disposal.

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Major Topic: Elements of Material Science and Welding Technology

Topic 1 Energy Plant Construction and Operation Materials

Learning Outcome

Describe the mechanical properties of engineering materials used in engineering.

Learning Objectives

1. Describe the mechanical properties of materials.
2. Describe the various types of ferrous materials.
3. Describe the various types of non-ferrous materials.

Topic 2 Introduction to Welding

Learning Outcome

Describe welding processes relevant to the plant and Power Engineering.

Learning Objectives

1. Describe non-fusion welding process, equipment used, and methods.
2. Describe forge and oxy-fuel fusion welding processes and cutting processes.
3. Describe metal arc welding processes.
4. Describe heat treatment of welds.
5. Describe the types of weld joints used in pressure vessel construction.
6. Describe the additional construction components required for pressure vessels to ensure structural integrity and "access".

Topic 3 Boiler and Pressure Vessel Inspection

Learning Outcome

Describe inspection processes and testing methods for welds and materials.

Learning Objectives

1. Describe common weld defects.
2. Describe the process of Visual Testing of welds.
3. Describe the process of Penetrant Testing for detecting weld or material defects.
4. Describe the process of radiographic weld testing.
5. Describe the process of ultrasonic weld testing.

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Major Topic: Introductory Fluid Handling Technology <u>Topic 1</u>

<u>Introduction to Energy Plant Piping Systems</u> Learning Outcome

Discuss the basic types of piping, piping connections, supports, and drainage devices used in industry.

Learning Objectives

1. State the applications for the most common materials and identify the sizes of commercial pipe.
2. Describe methods of connection for screwed, flanged, and welded pipe; identify fittings and their markings.
3. Describe methods and devices used to allow for pipe expansion and support.
4. Explain the methods used to promote good drainage of steam pipes, including the installation and maintenance of steam traps, to reduce the effects of water hammer.
5. Explain the requirements, materials, and methods for insulating pipe.

<u>Topic 2 Introduction to Energy Plant Valves</u>

Learning Outcome

Discuss the design and uses of the valve designs most commonly used in industry and on boilers.

Learning Objectives

1. Describe standard valve designs.
2. Describe design and operation of specialized boiler valves.
3. Describe a typical steam pressure reducing station, and the design and operation of steam system pressure-reducing valves.
4. Discuss valve details, including materials of construction and identification markings.
5. Describe typical valve maintenance requirements.

Major Topic: Basic Concepts in Electrotechnology

<u>Topic 1 Basic Electricity</u>

Learning Outcome

Apply the concepts of basic electricity while performing simple calculations using voltage, current, resistance, and power.

Learning Objectives

1. Describe the atomic structure of matter and its relationship to electricity.
2. Describe basic electrical circuits.
3. State Ohm's Law and apply it to single-resistor circuits.
4. Apply Ohm's Law to series resistance circuits.
5. Apply Ohm's Law to parallel resistance circuits.
6. Explain electrical conductors and insulators using examples.
7. Explain the factors that affect resistance mathematically.
8. Calculate the power developed in an electrical circuit.

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Topic 2 Magnetism and Electromagnetism

Learning Outcome

Describe the basic principles of magnetism.

Learning Objectives

1. Describe magnetism and the relationship between magnetism and electricity.
2. Describe the relationship between electricity and magnetism in an electrical generator.
3. Describe the relationship between electricity and magnetism in an electric motor.

Topic 3 Electrical Metering Devices

Learning Outcome

Describe the design and application of electrical metering devices.

Learning Objectives

1. Describe electrical meters and their uses.
2. Describe how voltage, current, and resistance are measured in an electric circuit.
3. Describe the construction and operation of a kilowatt hour meter.

Topic 4 Motors and Generators

Learning Outcome

Describe the operating principles of the various types of AC and DC motors and generators.

Learning Objectives

1. Describe the construction and operation of DC generators and motors.
2. Describe the construction and operation of AC generators (alternators) and motors.
3. Interpret the information on a motor nameplate.
4. Perform basic calculations relating to power factor and power factor correction.

Topic 5 Transformers

Learning Outcome

Describe the operating principles of electrical transformers.

Learning Objectives

1. Describe the principle of operation of transformers.
2. Perform basic transformer calculations as they relate to the construction and operation of single-phase transformers.
3. Describe the construction and operation of three-phase transformers.
4. Discuss special transformer types and their applications.
5. Discuss transformer cooling, safety, and maintenance.

Topic 6 Electrical Distribution Circuits

Learning Outcome

Describe an electrical distribution system.

Learning Objectives

1. List and describe the standard types of electrical voltage systems.
2. Interpret electrical single-line diagrams and circuit symbols.
3. Describe the major components of an electrical distribution system.
4. Describe the function and operation of fuses and circuit breakers.
5. Describe the function and operation of alternate power supply system equipment.

Major Topic: Energy Plant Instrumentation and Controls Topic 1

Introduction to Energy Plant Controls and Instrumentation Learning Outcome

Describe the overall purpose and function of plant instrumentation systems.

Learning Objectives

1. Describe the concept and basic components of a control loop.
2. Describe the various means by which control signals are transmitted, and the function of transducers.
3. List and describe the types of instruments that are not control loop components.

Topic 2 Introduction to Process Measurement

Learning Outcome

Describe the construction and operation of common devices used to measure pressure, level, flow, temperature, humidity, and composition.

Learning Objectives

1. Describe the types of pressure sensing and measuring devices.
2. Describe the types of level sensing and measuring devices.
3. Describe the types of flow sensing and measuring devices.
4. Describe the types of temperature sensing and measuring devices.
5. Describe the types of humidity sensing and measuring devices.
6. Describe the types of gas sensing and measuring devices.

Topic 3 Basic Control and Instrumentation Components

Learning Outcome

Describe the basic types and functions of transmitters, recorders, controllers, and control actuators.

Learning Objectives

1. Describe the construction and operational principles of instrumentation transmitters.
2. Describe the construction and operational principles of instrumentation indicators and recorders.
3. Describe the construction and operational principles of instrumentation controllers.
4. Describe the construction and operational principles of final control elements.

Topic 4 Introduction to Programmable Controllers

Learning Outcome

Describe the operation of programming controls for boilers, including applicable testing and maintenance procedures.

Learning Objectives

1. Discuss how programmable controllers work and how they act as sequencers for equipment.
2. Describe applications of programmable controllers.
3. Explain the HMI (human machine interface) and purpose of touchscreen displays, functions, and alarm handling.

Topic 5 Electronic Control Systems and Computer Applications

Learning Outcome

Describe the design and operation of electronic control systems.

Learning Objectives

1. Discuss electronic process control systems.
2. Describe computers and how they operate within control systems.
3. Describe the applications of computerized control systems and plant computers.

Topic 6 Electrical Control Systems

Learning Outcome

Describe the design and operation of electrical control systems.

Learning Objectives

1. Describe the basic construction and operation of various electric control system components.
2. Describe the function of control devices in electric control systems.
3. Explain the operating sequence of basic electric control circuits.

Major Topic: Fundamental Industrial Communication Skills

Topic 1 Energy Plant Sketching

Learning Outcome

Create engineering equipment sketches.

Learning Objectives

1. Create sketches using center lines and dimensioning.
2. Recognize standard views of an object.
3. Recognize cross-hatching methods in sectional drawings.
4. Identify common symbols and lines used in plant system trace drawings.
5. Complete a plant line tracing.

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Topic 2 Plant Diagrams and Drawings

Learning Outcome

Identify common types of diagrams used in plants.

Learning Objectives

1. Explain the layout of plant diagrams.
2. Explain the use of process flow diagrams (PFDs).
3. Explain the use of piping and instrumentation diagrams (P&IDs).
4. Explain the use of general arrangement, block plans and equipment diagrams.

Topic 3 Plant Communications

Learning Outcome

Describe the types and proper usage of plant communication systems.

Learning Objectives

1. Discuss effective written and verbal communication skills, including the use of two-way radios.
2. Describe the legal documentation requirements for Power Engineers, including log books and log sheets.
3. Discuss the elements of Maintenance Management Systems, including work requests, and work orders.
4. Discuss the purpose, revision, and control of Standard Operating Procedures.
5. Discuss updating procedures for piping and instrumentation diagrams.

Major Topic: Introduction to Boiler Designs

Topic 1 Introduction to Boilers

Learning Outcome

Describe the historical development of boilers, boiler design, components, and configuration.

Learning Objectives

1. Describe the history of boiler applications, boiler design, and modern boiler improvements.
2. Describe packaged boilers.
3. Describe the construction of shop-assembled and field-erected boilers.
4. Describe components and design aspects common to all boiler vessels.

Topic 2 Firetube Boilers

Learning Outcome

Describe the design, components, and characteristics of firetube boilers.

Learning Objectives

1. Differentiate the Scotch Boiler from the other firetube boilers, and describe its development history.
2. Describe circulation patterns in firetube boilers.
3. Discuss construction details of firetube boilers.

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Topic 3 Watertube Boilers

Learning Outcome

Describe the design, components, and characteristics of watertube boilers.

Learning Objectives

1. Describe the design and operating principles of watertube boilers.
2. Describe watertube boiler components.
3. Explain the design and application of packaged watertube boilers.
4. Describe the design, construction, and components of large-scale steam generating units.

Topic 4 Electric Boilers

Learning Outcome

Explain the general design and application of electric boilers.

Learning Objectives

1. Discuss the advantages and disadvantages of electric boilers.
2. Describe the construction and operating principle of electric boilers.

Topic 5 Special Boiler Designs for Heating Plants

Learning Outcome

Describe the special design considerations of boilers used in heating plants.

Learning Objectives

1. Describe the design of watertube and coil tube heating boilers.
2. Describe cast iron boilers and vertical firetube boilers.
3. Describe the construction and application of firetube heating boiler designs.

Topic 6 Differences between Power and Heating Boilers

Learning Outcome

Differentiate between ASME Section I and ASME Section IV boilers.

Learning Objectives

1. Discuss the differences between power boiler and heating boiler design and installation.
2. Discuss the differences between power boiler and heating boiler operation.

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Major Topic: Elements of Boiler Systems

Topic 1 Combustion

Learning Outcome

Discuss the basic theory of combustion, and the equipment used to provide proper combustion conditions within a boiler.

Learning Objectives

1. Discuss combustion, combustion equations, and the relationship between theoretical and excess air.
2. Discuss the characteristics of solid, liquid, and gaseous fuels.
3. Explain the effects of fuels and combustion on refractory materials.

Topic 2 Fuel Delivery and Firing Systems

Learning Outcome

Describe common fuel systems found in boiler systems.

Learning Objectives

1. Describe solid fuel delivery systems.
2. Describe the main types of solid fuel firing systems.
3. Describe gaseous fuel delivery systems.
4. Describe the main types of gaseous fuel firing systems.
5. Describe liquid fuel delivery systems.
6. Describe the main types liquid fuel firing systems.
7. Describe flue gas analysis and how it relates to boiler efficiency.

Topic 3 Draft

Learning Outcome

Describe basic concepts and equipment used to supply combustion air to boiler furnaces.

Learning Objectives

1. Describe the various air streams that deliver combustion air to a furnace.
2. Relate differential pressure to the creation of draft.
3. Describe forced, induced, and balanced mechanical draft.
4. Discuss common methods of controlling combustion airflow.
5. Discuss common methods of measuring furnace pressures.

Topic 4 Feedwater Systems

Learning Outcome

Describe feedwater systems used with boilers.

Learning Objectives

1. Describe the overall layout of feedwater, condensate, and make-up water systems.
2. Describe the valves used in feedwater systems.
3. Describe the control strategies for single-element, two-element, and three-element boiler feedwater systems.
4. Describe methods of supplying feedwater to steam heating boilers.
5. Explain the operation of condensate receiver make-up water controls.
6. Describe the return of condensate, and the supply of feedwater to high-pressure boilers.

Topic 5 Blowof f and Blowdown Systems

Learning Outcome

Describe the equipment, operation, and purpose of boiler blowoff and blowdown systems.

Learning Objectives

1. Describe blowoff, blowoff equipment and blowoff procedures.
2. Describe continuous blowdown, blowdown equipment, and blowdown procedures.
3. Describe the maintenance and repair of blowoff systems.

Topic 6 Boiler Fireside Cleaning Systems

Learning Outcome

Describe types of boiler fireside cleaning equipment, their purpose, and their operation.

Learning Objectives

1. Describe common options for in-service fireside cleaning.
2. Describe the construction and operation of retractable soot blowers.
3. Describe the construction and operation of stationary soot blowers.
4. Describe falling shot cleaning methods.

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Major Topic: Lubrication and Bearings

Topic 1 Lubrication Principles

Learning Outcome

Describe the importance of lubrication and the principles concerned with lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and application.
3. List the properties of lubricating oils, the additives used, and their selection criteria.

Topic 2 Types of Bearings and Lubrication

Learning Outcome

Describe bearing types, methods for care and maintenance of bearings, and bearing lubrication systems.

Learning Objectives

1. Define boundary and full fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of antifriction and thrust bearings.
4. Describe how to clean and replace roller and ball type bearings.
5. Explain the causes of bearing failure.

Major Topic: Pumps and Compressors

Topic 1 Types of Pumps

Learning Outcome

Describe the construction and operating principles of various types of pumps used in plants.

Learning Objectives

1. List common pump applications.
2. Define the terms associated with pump performance.
3. Describe the common pumps found in plants.

Topic 2 Pump Operation and Maintenance

Learning Outcome

Describe the major considerations and procedures for pump operation and maintenance.

Learning Objectives

1. Discuss the components of a driver and pump assembly.
2. Discuss pump shaft sealing, compression packing, and the replacement of compression packing.
3. Describe the standard types of mechanical seals.
4. Describe pump bearings, shaft alignment procedures, and the equipment used to align shafts.
5. Describe centrifugal pump startup and priming procedures.
6. Describe positive displacement pump operating characteristics, priming, startup, and routine checks.

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Topic 3 Introduction to Compressors

Learning Outcome

Describe the operating principles of the different types of compressors.

Learning Objectives

1. Describe the main classifications and types of compressors.
2. Describe gaseous compression systems.

Topic 4 Compressor Operation and Maintenance

Learning Outcome

Describe the major considerations and general procedures for compressor operation and maintenance.

Learning Objectives

1. Describe compressor parts and auxiliary equipment.
2. Describe the construction and operation of seals for compressors.
3. Describe the capacity control of compressors.
4. Describe preventative maintenance and routine procedures for compressors.

Major Topic: Boiler Safety Devices Topic 1

Pressure Relief Valves Learning Outcome

Explain the code requirements, design, and operation of pressure relief valves for power boilers, heating boilers, and pressure vessels.

Learning Objectives

1. Discuss the code requirements, construction, and operation of ASME Section I Pressure Relief Valves and Devices.
2. Discuss the code requirements, construction, and operation of ASME Section IV Pressure Relief Valves and Devices.
3. Describe the testing and repair of pressure relief valves.
4. Describe the construction and operation of temperature and pressure relief valves.

Topic 2 Combustion Safety

Learning Outcome

Explain the design and operation of combustion safety controls on burners and boilers.

Learning Objectives

1. Describe the operation of control and safety devices found on boiler fuel supplies.
2. Describe the construction and operation of flame detectors.
3. Describe the combustion safety controls for boilers and burner systems.
4. Describe burner management systems.
5. Interpret burner operating sequence charts, and provide a typical sequence of startup and shutdown events.

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Topic 3 Water Level Safety Controls

Learning Outcome

Describe feedwater devices, and control methods used on boilers.

Learning Objectives

1. Describe the construction and operation of boiler low water level fuel cut-off equipment.
2. List the CSA and ASME code requirements regarding low water fuel cut-off devices.
3. Describe direct and indirect type boiler water level indicators.

Topic 4 Boiler Fittings

Learning Outcome

Relate the code, operation, and required fittings to the operating principles of fittings found on boilers.

Learning Objectives

1. Explain the code references for boiler fittings.
2. Describe the code requirements for pressure gauges on steam boilers.
3. Describe the code requirements for the boiler connections and valves on steam boilers.
4. Describe the code requirements for fittings on hot water heating boilers.
5. Describe the non-code fittings used on boilers.

Topic 5 Firing Rate Controls

Learning Outcome

Describe the operating and safety controls found on boilers.

Learning Objectives

1. Describe basic boiler firing rate controls.
2. Discuss various operating controls for steam and hot water boilers.

Major Topic: Boiler Plant Operation and Management

Topic 1 Boiler Plant Startup

Learning Outcome

Describe the operational procedures related to starting up auxiliary equipment in a boiler plant.

Learning Objectives

1. Describe the basic auxiliaries that need to be checked, prepared, or placed in service before starting a boiler plant.
2. Describe the general procedures for starting a plant for the first time, or restarting after an outage or turnaround.
3. Discuss basic operating practices for starting pumps and fans.
4. Describe the general preparation for a hot water boiler startup.
5. Describe the general preparation for a steam boiler startup.
6. Describe the safety and housekeeping preparation requirements for boiler plant startup.

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Topic 2 Boiler Startup

Learning Outcome

Describe procedures for safely starting boiler systems.

Learning Objectives

1. Describe operating considerations when warming a cold boiler.
2. Describe how to start and cut-in a hot water boiler.
3. Describe how to start a single boiler steam plant.
4. Describe how to cut-in a steam boiler in a multiple boiler plant.
5. Describe semi-automatic burner ignition systems.
6. Discuss the post startup inspection for boilers returning to service after a major outage.

Topic 3 Boiler Operation

Learning Outcome

Describe operational procedures related to operating boilers.

Learning Objectives

1. Describe the operation of a hot water heating boiler under routine conditions.
2. Describe routine steam boiler operating duties.
3. Describe emergency conditions in boiler plants and the required responses.
4. Describe basic boiler troubleshooting activities.

Topic 4 Operational Checks

Learning Outcome

Describe operational checks for operating boiler plants.

Learning Objectives

1. Describe the shift based operator responsibilities for boiler plants.
2. Describe the safety device operational checks carried out on boilers.
3. Describe routine maintenance activities for boiler plant operation.
4. Describe the use of Standard Operating Procedures (SOPs).
5. Describe the need for boiler operating and maintenance logs, and the type of information that should be recorded.

Topic 5 Shutdown Procedures

Learning Outcome

Describe generic shutdown and layup procedures for different boiler types.

Learning Objectives

1. Describe hot water boiler shutdown procedures.
2. Describe steam boiler shutdown and lockout procedures.
3. Describe extended period layup requirements for steam boilers.

Topic 6 Boiler Plant Monitoring and Reporting

Learning Outcome

Describe the points and readings that need to be monitored and recorded in a plant.

Learning Objectives

1. Discuss recording requirements for operating and performance conditions.
2. Discuss the various systems required to conduct equipment repairs, and to manage the related maintenance records.
3. Describe the operational causes, consequences, and prevention of water hammer.
4. Describe the consequences and actions required for various equipment failures.
5. Describe the consequences, and actions required, in the event of boiler accidents.

Major Topic: Energy Plant Maintenance

Topic 1 Energy Plant Maintenance I

Learning Outcome

Describe the safe use of common hand tools in the powerhouse.

Learning Objectives

1. Describe the types and proper use of hacksaws, files, chisels, hammers, screwdrivers, and wrenches.
2. Describe the types and proper use of hand threading tools.
3. Describe the types and proper use of measuring tools.
4. Describe the proper layout of work and the use of layout tools.
5. Describe the types and proper use of portable and fixed grinders, hand drills, drill presses, and the care of drill bits.

Topic 2 Energy Plant Maintenance II

Learning Outcome

Discuss and describe the safe and proper setup of equipment for hoisting and working above ground.

Learning Objectives

1. Describe the requirements for setting up work platforms in general and ladders and scaffolding in particular.
2. Describe the general safety precautions and calculations used when rigging equipment.
3. Describe the general safety precautions used when hoisting equipment.
4. Discuss the correct use and limitations of wire cable and rope, including cable attachments and rope knots.
5. List and describe common types of metal fasteners, such as screws, bolts, studs, nuts, and washers.

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Topic 3 Boiler Maintenance

Learning Outcome

Describe the service and maintenance required for boilers.

Learning Objectives

1. Describe the general maintenance and service of packaged firetube and cast iron sectional boilers.
2. Identify the operational procedures for wet and dry boiler layups.
3. Describe ways of detecting firetube and tubesheet leaks.
4. Describe the general procedure for the removal and replacement of defective firetubes.

Topic 4 Boiler Cleaning

Learning Outcome

Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical and chemical boiler cleaning methods.

Learning Objectives

1. List the steps and precautions to prepare a boiler for inspection.
2. Describe the internal inspection of a boiler.
3. Describe the methods and tools used to mechanically clean boilers.
4. Describe two methods used to chemically clean boilers.

Major Topic: Water Treatment

Topic 1 External Boiler Water Treatment

Learning Outcome

Describe the general principle, methods, and equipment used in preparing raw feedwater for steam production.

Learning Objectives

1. Describe typical impurities and their effects on plant and boiler water pre-treatment systems, and their treatment process.
2. Describe the equipment requirements for pre-treatment of plant water systems.
3. Describe water filtration and the removal of suspended solids.
4. Describe the purpose, processes, and equipment used in water softening.
5. Describe the theory, process, and equipment used in deaeration.

Topic 2 Internal Boiler Water Treatment

Learning Outcome

Describe the general principles, methods, and equipment used for internal boiler water treatment.

Learning Objectives

1. Describe the types of problems, and associated treatments, related to internal boiler water contamination.
2. Describe internal boiler feedwater chemical feed systems.
3. Describe standard boiler water testing.

Topic 3 Condensate Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condensate.

Learning Objectives

1. Describe condensate treatment and the effects of non-treatment.
2. Describe the tests conducted on condensate.

Topic 4 Cooling Tower and Condenser Water Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condenser water, and their effects on the cooling tower.

Learning Objectives

1. Describe the effects of water on condensers and cooling tower materials.
2. Describe condenser and cooling tower water treatment.
3. Describe cooling tower and condenser water tests for common treatment methods.

Topic 5 Recirculating System Water Treatment

Learning Outcome

Describe recirculating water systems, their effects, treatment, and tests.

Learning Objectives

1. Describe recirculating water system corrosion and deposition.
2. Describe the use of sacrificial anodes, and measurement techniques to determine corrosion.
3. Describe glycol system testing requirements.
4. Discuss the monitoring tools, procedures, and tests used in recirculating water systems.

Major Topic: Types of Prime Movers and Heat Engines

Topic 1 Heat Engines and Prime Movers

Learning Outcome

Discuss the historical conversion of heat energy into mechanical energy.

Learning Objectives

1. Differentiate between the terms “heat engine” and “prime mover.”
2. Discuss the history of the steam engine and the expansive power of steam.

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Topic 2 Steam Turbines

Learning Outcome

Describe the construction and operation of steam turbines.

Learning Objectives

1. Describe the principle of operation and major components of a steam turbine.
2. Describe the lubrication and sealing of steam turbine shafts.
3. Describe how the rotational speed of a steam turbine is governed and controlled.
4. List the steps to follow in a typical steam turbine start-up and shut-down.

Topic 3 Condensers and Cooling Towers

Learning Outcome

Describe the operation and maintenance of condensers and cooling towers.

Learning Objectives

1. Explain the construction and operation of condensers, and how they relate to the operation of cooling towers.
2. Explain the principle of operation, the purpose, and the major components of cooling towers.
3. Describe the construction and operation of natural draft cooling towers.
4. Describe the construction and operation of mechanical draft cooling towers.
5. Discuss cold climate operation for cooling towers.
6. Explain typical problems and resolutions required within the operation of cooling towers.

Topic 4 Gas Turbines

Learning Outcome

Describe the application, startup, operation, and maintenance required for gas turbines.

Learning Objectives

1. Describe the principle of construction and operation of gas turbines.
2. Identify the operational characteristics of gas turbines.
3. Describe regeneration and combined steam-gas turbine operating cycles.
4. Describe the key elements of gas turbine startup, operation, and auxiliaries.

Topic 5 Internal Combustion Engines

Learning Outcome

Describe the application, construction, and operation of internal combustion engines.

Learning Objectives

1. Discuss the fuels used in internal combustion engines.
2. Describe the working cycles of the 4-stroke and 2-stroke spark ignition engines.
3. Describe the working cycle of the 4-stroke compression ignition (diesel) cycle.
4. Describe the construction of basic spark and compression engines.
5. Explain the basic operating considerations for diesel engines.

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Major Topic: Plant Auxiliary Systems

Topic 1 Lighting Systems

Learning Outcome

Explain the various lighting systems and some of the basic design considerations for lighting a space.

Learning Objectives

1. Describe the common types of lighting equipment and systems.
2. Discuss the different types of artificial light sources.
3. Explain the various methods of lighting control.
4. Describe the general requirements and criteria for emergency lighting in buildings.
5. Discuss the interrelationship between lighting, air conditioning, and energy conservation in buildings.

Topic 2 Building Water Systems

Learning Outcome

Explain the various water supply systems used in buildings.

Learning Objectives

1. Describe the cold water distribution system in a building.
2. Describe the hot water distribution system in a building.
3. Describe the construction and operation of building system hot water heaters, including temperature regulation.
4. List and describe the construction and operation of water system protective devices in buildings.
5. Explain what is meant by "backflow prevention" and describe the common methods used.
6. Describe the maintenance requirements for the components in a building water distribution system.

Topic 3 Drainage Systems

Learning Outcome

Describe the design and components of various drainage systems used in facilities.

Learning Objectives

1. Describe the overall layout of building drainage systems.
2. Describe storm water drainage systems for buildings.
3. Describe how surface runoff is managed in order to minimize environmental impact.

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Major Topic: Basic Concepts of Compression and Absorption Refrigeration

Topic 1 Refrigeration Basics

Learning Outcome

Explain the basic concept of refrigeration and refrigerants.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the cycle of operations in a vapor compression refrigeration system.
3. Explain how the operating temperatures and pressures are selected and related for a vapor compression refrigeration system.
4. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.
5. Describe how refrigerants are classified.
6. Describe the thermodynamic properties of refrigerants.
7. Describe the properties of refrigerants relating to miscibility, leakage tendency, odor, moisture reaction, toxicity, and flammability.

Topic 2 Compression Refrigeration Systems

Learning Outcome

Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Distinguish between direct and indirect refrigeration systems.
3. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizer.
4. Describe the special types of refrigeration compressors, and how they are similar to and different from air compressors.
5. Describe the special designs of refrigeration system evaporators and condensers.

Topic 3 Refrigeration System Control and Operation

Learning Outcome

Describe the purposes and operating principles of refrigeration system operational and safety controls.

Learning Objectives

1. Describe refrigeration system controls.
2. List the safety shutdown devices specific to centrifugal compressor water chillers.
3. Describe typical refrigeration system safety shutdown devices.
4. Describe the construction and operation of refrigerant metering devices.
5. Describe the different methods used to control evaporator capacity.
6. Describe the different methods used to control the capacity of refrigeration compressors.

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Topic 4 Refrigeration System Operation and Maintenance

Learning Outcome

Describe the operating principles and maintenance of refrigeration systems.

Learning Objectives

1. Discuss refrigeration auxiliaries.
2. Describe refrigeration system leak test procedures.
3. Describe how a refrigeration system is dried and charged prior to start-up.
4. List the steps for adding oil to an in-service refrigeration compressor.
5. Describe the start-up and shut-down procedure for a compression refrigeration system.
6. Describe operational log sheets and preventative maintenance procedures for refrigeration systems.
7. Describe how a refrigeration system is purged of noncondensable gases.
8. Discuss refrigeration condenser operation and maintenance requirements.
9. Explain typical problems and resolutions related to refrigeration systems.

Topic 5 Absorption Refrigeration Systems

Learning Outcome

Describe the operating principle, maintenance, and operation of absorption refrigeration systems.

Learning Objectives

1. Describe the basic absorption system, comparing the differences to the compression system.
2. Describe the theory and operation of an ammonia absorption refrigeration system.
3. Describe the theory and operation of a lithium bromide absorption refrigeration system.
4. Explain the operation of absorption refrigeration systems with respect to crystallization and dilution.
5. Describe the major parts and systems of an absorption system, including: heat exchanger bypass system, pump motor lubrication and cooling system, and purging system.
6. Describe the startup and shutdown procedures for an absorption refrigeration system.
7. Describe the preventive maintenance that should be performed on an absorption refrigeration system.
8. Explain typical problems and resolutions related to an absorption refrigeration system.

Topic 6 Refrigeration Plant Safety

Learning Outcome

Outline the potential hazards inherent to refrigeration plants, the CSA requirements intended to mitigate hazards, and typical responses taken in the case of a significant leak.

Learning Objectives

1. Identify and provide a basic explanation of the CSA B52 Code requirements for refrigeration plant machinery rooms.
2. Identify safe practices for refrigeration plant operation and maintenance.
3. Describe the appropriate emergency response to a significant refrigerant leak.
4. Describe the Canadian Environmental Emergency Regulations and how they relate to refrigeration plants.

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Major Topic: HVAC Fundamentals for Facility Operators

Topic 1 Conditioning the Air

Learning Outcome

Explain the methods and techniques for conditioning air in plants and buildings.

Learning Objectives

1. Discuss the process to condition air for human comfort and health.
2. List the categories and functions of HVAC systems.
3. Describe the operation of air-handling units.
4. Define the terms humidity, relative humidity, and dewpoint.
5. Define the terms dry-bulb temperature, wet-bulb temperature, wet-bulb depression, and how they relate to relative humidity.

Topic 2 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and warm air types of humidifiers.
3. Describe industrial and commercial types of humidifiers.

Topic 3 Fans for Air Distribution Systems

Learning Outcome

Describe the airflow behavior and movement of air through distribution systems.

Learning Objectives

1. Discuss the theory of airflow and pressure conversions.
2. Describe the major types of air handling fans, their construction, and operation.
3. Interpret fan performance curves.
4. Describe fan motors, drives, and belt guards.
5. Describe fan volume controls.

Topic 4 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems, including various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the various contaminants found in air.
3. Describe the types of air cleaning devices used in industrial/commercial buildings.

Topic 5 HVAC Duct Systems

Learning Outcome

Describe the designs and components of duct systems used in HVAC applications.

Learning Objectives

1. Explain how air duct systems are classified.
2. Describe air duct materials, system layout, fabrication, and installation.
3. Describe air duct leakage.
4. List and describe the types of liners, dampers, and louvres used in air duct systems.
5. Discuss terminal air distribution devices, and the principles of diffusion, induction, entrainment, and aspiration.

Topic 6 Types of Coils and Operation

Learning Outcome

Describe the various types and operation of coils used in HVAC systems.

Learning Objectives

1. Explain how steam, hot water, and glycol coils are sized, configured, and operated to reduce the chance of freezing.
2. Describe the installation recommendations for coils, piping, steam traps, control valves, air vents, and vacuum relief devices.

Major Topic: Building Environmental Systems and Control

Topic 1 Steam Heating

Learning Outcome

Describe the components, operating principles, and maintenance procedures of steam heating systems.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. Describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.
3. Describe standard types of piping and equipment layout for steam heating systems.
4. Describe the general operation and maintenance of steam heating systems.
5. Apply a steam heating system troubleshooting guide.

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Topic 2 Hot Water Heating

Learning Outcome

Describe the various designs, equipment, and operation of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe various types of special hot water heating systems.
4. Describe the purpose and function of standard hot water heating system accessories.
5. Explain how the location of the hot water circulating pump and the expansion tank are determined.
6. Describe the routine operation of hot water heating systems, including cleaning, filling, starting, and use of glycol/antifreeze.
7. Apply a hot water heating troubleshooting guide.

Topic 3 Other Heating Systems

Learning Outcome

Describe common heating systems encountered by Power Engineers.

Learning Objectives

1. Describe natural gas fueled warm air heating systems.
2. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
3. Discuss the concept and application of infrared heating.
4. Describe the different methods of electric heating, and their advantages and disadvantages as compared to other types of systems.

Topic 4 Cooling Systems and Combination Systems

Learning Outcome

Describe central, unitary and combined HVAC systems.

Learning Objectives

1. Describe the general layout and operation of unitary air conditioning systems.
2. Describe the general layout and operation of central air conditioning systems.
3. Describe the general layout and operation of combined air conditioning systems.
4. Discuss how HVAC systems should be operated under different situations.

Topic 5 Heat Gains and Losses, and Heat Recovery Methods

Learning Outcome

Describe heat gains and losses, and common methods for energy recovery.

Learning Objectives

1. Define heat transmission terminology.
2. Describe heat gain and heat loss analysis in a building or plant.
3. Describe the general principles of HVAC heat recovery.

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Topic 6 HVAC Control Strategy

Learning Outcome

Describe the control systems strategies used in HVAC systems.

Learning Objectives

1. Describe a basic ventilation control strategy for HVAC systems.
2. Describe heating control strategies for HVAC systems.
3. Describe humidification, dehumidification, and cooling control strategies for HVAC systems.
4. Describe volume control with static pressure regulation for HVAC systems.

Major Topic: Typical Industrial Plant Configurations

Topic 1 Common Plant Configurations in Hydrocarbon Centric Industries

Learning Outcome

Identify steam-related processes employed in common types of plants.

Learning Objectives

1. Identify standard thermal system pathways and segments commonly used in plants.
2. Identify equipment and processes in heat transfer fluid (HTF) heating systems.
3. Identify the main thermal processes used in oil refining industries.
4. Describe the main processes used in steam assisted gravity drainage (SAGD) and cyclic steam stimulation (CSS).
5. Identify thermal processes used in gas separation and compression plants.

Topic 2 Common Plant Configurations in Energy Intensive Industries

Learning Outcome

Identify steam related processes employed in common types of plants.

Learning Objectives

1. Identify the main steam/boiler processes used in wood and biomass processing plants.
2. Identify the important thermal processes used in food production and preservation.
3. Identify the common processes and equipment used in metallurgical processing plants.

Major Topic: Elementary Mechanics and Dynamics

Topic 1 Introduction to Basic Mechanics

Learning Outcome

Apply basic terms and calculations used in the study of mechanics.

Learning Objectives

1. Define mass, force, acceleration, velocity, and weight.
2. Perform simple calculations involving force, pressure, work, power, and energy.

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Topic 2 Forces and Moments

Learning Outcome

Perform calculations involving forces and moments, and determine when a system of forces is in equilibrium.

Learning Objectives

1. Define the moment of a force and its units.
2. Determine the direction and calculate the magnitude of the moment of a force.

Topic 3 Simple Machines

Learning Outcome

Perform calculations relating to mechanical advantage, velocity ratio and efficiency.

Learning Objectives

1. Define the term simple machine and apply to calculations of mechanical advantage, velocity ratio and efficiency of simple machines.

Topic 4 Scalars and Vectors

Learning Outcome

Define and identify scalar and vector quantities and solve simple vector problems graphically.

Learning Objectives

1. Define scalar and vector quantities as they apply to drawing vector diagrams.

Topic 5 Linear Velocity and Acceleration

Learning Outcome

Solve simple problems involving linear velocity, time, and distance.

Learning Objectives

1. Solve distance, displacement, speed, and velocity problems.
2. Draw graphs of velocity as a function of time.
3. Define acceleration, state its units, and solve simple acceleration problems.
4. Apply mathematical formulae relating acceleration, velocity, distance and time to solve problems.

Topic 6 Force, Work, Pressure, Power, and Energy

Learning Outcome

Perform calculations involving force, work, pressure, power, and energy.

Learning Objectives

1. Perform calculations involving force and work.
2. Perform calculations involving gauge, atmospheric, and absolute pressure.
3. Perform calculations involving power and different forms of mechanical energy.

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Topic 7 Friction

Learning Outcome

Solve problems involving friction.

Learning Objectives

1. Apply the laws governing the types of friction.
2. Apply the coefficient of friction to problems involving forces on a horizontal plane.

Topic 8 Stress and Strain

Learning Outcome

Explain physical properties of materials and how their behavior is affected when external forces are applied.

Learning Objectives

1. Describe the mechanical properties of materials, including elasticity, stiffness, plasticity, ductility, toughness, brittleness, and hardness.
2. Calculate stress including tensile, compressive, and shear stresses within rigid bodies due to external loads.
3. Calculate the strain of members under load.

Topic 9 Power Transmission

Learning Outcome

Perform calculations pertaining to common power transmission systems.

Learning Objectives

1. Calculate pulley speeds, transmitted power, and efficiency of belt drive systems.
2. Calculate gear speeds for gear and chain drive systems.

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REFERENCE CURRICULUM

For

International Power Engineer (5th Class)

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Introduction

This Curriculum is intended to assist candidates studying for the International Power Engineer (5th Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for International Power Engineer (5th Class) Examination Candidates

Major Topic: Low Pressure Boiler Components and Operation Unit 1:

Boiler Details

Topic 1 Watertube Boilers (Heating, Power, and Tubular)

Learning Outcome

Describe the various types of watertube boilers used in small industrial and heating systems.

Learning Objectives

1. Describe the construction of watertube and copper-tubular boilers.
2. Describe the water circulation in a longitudinal drum straight tube boiler.
3. Describe two-drum bent tube boilers, and the advantages of a bent tube boiler compared to a straight tube boiler.
4. Describe the construction of the “A” type, “D” type, and “O” type and the advantages of packaged watertube boilers.

Topic 2 Cast-Iron Sectional and Modular Boilers

Learning Outcome

Describe and explain the uses of cast-iron boilers.

Learning Objectives

1. Describe the general construction of cast-iron sectional boilers.
2. List the advantages of cast-iron sectional boilers over watertube and firetube boilers.
3. Describe the arrangement of equipment in a multiple cast-iron sectional boiler heating plant.
4. Describe the construction and operation of cast-iron modular boilers.

Topic 3 Firetube Boilers (Heating and Power)

Learning Outcome

Describe the various types of firetube boilers used in power and heating systems.

Learning Objectives

1. Explain the difference between power and heating boilers.
2. Describe the historical significance, the construction, and application of the early types of firetube boilers: the HRT, or horizontal return tubular, locomotive, and firebox boilers.
3. Describe the construction and application of wetback and dryback Scotch boilers.
4. Describe the construction and application of vertical firetube boilers and tubeless boilers used in heating plant service.
5. Describe the construction of packaged firetube boilers.

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Topic 4 Electric Boilers

Learning Outcome

Describe electric boilers with regard to their use and general design.

Learning Objectives

1. Compare electric boilers to fuel-fired boilers.
2. Describe the construction and operating principle of electrode-type electric boilers.
3. Describe the construction and operating principle of immersion-type electric boilers.

Unit 2: Boiler Fittings and Controls

Topic 5 Basic Fittings for Steam Boilers

Learning Outcome

Name, identify, and explain the operating principles and the differences, if any, between the following low and high pressure boiler fittings: pressure gauges, gauge siphons, safety valves, gauge glasses and water columns, safety shutoff valves, quick opening valves, stop valves, check valves, and vent valves.

Learning Objectives

1. Describe the construction, purpose, and operation of pressure gauges and gauge siphons (pigtails).
2. Describe the testing of pressure gauges.
3. Describe the construction, operation, installation, and testing of low-pressure (safety relief) and high-pressure (safety or pop) valves.
4. Describe the purpose, function, and testing of gauge glasses and water columns.
5. Explain how to change a gauge glass.
6. Describe the construction, operation, and purpose of the following valves: gauge glass safety shutoff valves, gauge glass quick closing valves, stop valves, check valves, blowoff (blowdown) valves, and vent valves.

Topic 6 Basic Fittings for Hot Water Boilers

Learning Outcome

Name, identify and explain the operating principles of the following hot water boiler fittings and equipment: pressure, altitude or combination gauges, thermometers, safety relief valves, temperature relief devices, stop valves or drain valves, backflow preventers, and expansion tanks.

Learning Objectives

1. Identify the required instruments, fittings, and controls on a hot water boiler system.
2. Explain how to change a gauge glass on an expansion tank.
3. Describe the construction and operation of the “auto fill valve.”
4. List the usual devices and fittings that are used in hot water heating boiler systems.

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Topic 7 Low Water Fuel Cut-Offs and Feedwater Controls

Learning Outcome

Discuss the design, operation and testing of low-water fuel cutoffs and describe feedwater control methods and devices used on low-pressure boilers.

Learning Objectives

1. Describe the construction and operation of float and electrode low water level fuel cut-off equipment.
2. Describe the testing and maintenance of float and electrode low water level fuel cut-offs.
3. Describe the operation of a feedwater float switch operating a valve and a float switch operating a pump.
4. Explain the purpose and function of heating boiler feedwater and condensate piping connections.

Topic 8 Heating Boiler Operating Controls

Learning Outcome

Name and describe the various operating controls found on low-pressure boilers.

Learning Objectives

1. Describe the operation of the on-off control, the high-low fire control, the modulating control, and the high limit control found on low-pressure steam boilers and hot water heating boilers.
2. Explain the operation of the common control switches found on a low-pressure heating boiler.
3. Describe the operation of the safety switches or interlocks found on the fuel supplies of low-pressure heating boilers.
4. Explain the required testing and maintenance of heating boiler controls.

Topic 9 Boiler Combustion Controls

Learning Outcome

Explain the design and operation of various combustion controls on heating boilers.

Learning Objectives

1. List and discuss the various types of boiler flame failure detectors.
2. Describe the testing of boiler flame failure safety devices.

Topic 10 Boiler Programming Controls

Learning Outcome

Describe the basic operation of boiler programming controls.

Learning Objectives

1. Describe the operation of equipment that is used to automatically start up and shut down boilers.
2. List a typical sequence of startup and shutdown events.
3. Describe common 5th Class Power Engineer responses to a boiler programmer startup or shutdown.

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Unit 3: Boiler Operation and Maintenance

Topic 11 Basic Boiler Operation

Learning Outcome

Describe the preparation, start-up and shutdown, abnormal conditions, and routine operational checks in the operation of steam and hot water boilers.

Learning Objectives

1. Explain the preparation required before starting a steam or hot water boiler.
2. Explain the startup steps once the boiler has been prepared.
3. State possible abnormal conditions during startup and the cautions required to avoid uneven expansion and thermal shock.
4. Describe the procedure required when “cutting in” an additional boiler.
5. Describe the operating conditions for hot water and steam boilers that must be checked daily, and state the required monthly checks.
6. Explain the procedure for removing a hot water boiler from service.
7. Describe the procedure for removing a steam boiler from service.
8. Explain the emergency conditions that can occur during the operation of a steam boiler. Explain the causes and prevention of furnace and pressure explosions.
9. Explain the reasons for boiler accidents, and describe the role and design of operating logs in the safe operation of a boiler.
10. Operator traits, good operating practice, curiosity, using your senses, (sense-interpret-analyze-perform = SIAP), trusting your instincts, experience and due diligence.

Topic 12 Routine Boiler Maintenance and Inspection

Learning Outcome

Describe the service and maintenance required for boilers. Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical boiler cleaning methods.

Learning Objectives

1. Describe the general servicing and routine maintenance of packaged firetube and cast-iron sectional boilers.
2. Explain the importance of layups and state the procedures to be followed for wet and dry boiler layups.
3. Describe the symptoms of a leaking firetube.
4. List the steps and precautions to be taken to prepare a boiler for inspection.
5. Describe the inspection of a boiler.
6. Describe the methods and tools used for mechanical and chemical cleaning of a boiler.
7. Discuss the standard procedure for a hydrostatic test and the reason for doing the test.

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Unit 4: Fuels and Combustion

Topic 13 Combustion and Draft

Learning Outcome

Discuss the characteristics of common fuels used in heating boilers, conditions for complete and incomplete combustion, draft methods, and the application of flue gas analysis.

Learning Objectives

1. Explain natural and mechanical draft arrangements.
2. Describe draft measurement using U-tube and inclined draft gauges.
3. Describe the use, advantages, and characteristics of common boiler fuels.
4. State the requirements and reactions for complete and incomplete combustion.
5. Explain the difference between a pressure explosion and a furnace explosion.

Topic 14 Burners for Boilers

Learning Outcome

Describe the operation of the various types of gas and oil burners used on boilers.

Learning Objectives

1. Describe the operation of atmospheric and ring gas burners.
2. Describe the construction and operation of automatic valves.
3. Describe the principle of oil atomizing burners for boilers.
4. List and describe the auxiliary equipment needed for an oil combustion system.
5. Describe the overall components and operation of fuel oil systems.

Unit 5: Piping and Valves

Topic 15 Piping Materials and Connections

Learning Outcome

Discuss the various construction materials, size classification, and connection methods for the piping in a plant.

Learning Objectives

1. Explain the characteristics and applications of the various materials used to manufacture piping and fittings.
2. Explain pipe size, schedules, and classifications.
3. Identify screwed, flanged, and welded pipe connections.

Topic 16 Piping Expansion, Support, and Insulation

Learning Outcome

Discuss piping expansion, support, and insulation.

Learning Objectives

1. Explain pipe expansion and the principle of expansion bends and joints.
2. Explain the purpose of pipe supports and describe various pipe support designs.
3. Explain the purposes for pipe insulation and describe the use of the common insulation materials.

Topic 17 Steam Traps

Learning Outcome

Explain the purpose of steam traps and describe the installation and operating principles of the various steam traps found on piping systems.

Learning Objectives

1. Describe the designs and operating principles of mechanical traps.
2. Describe the designs and operating principles of thermostatic steam traps.
3. Describe the correct piping arrangement and procedures for a steam trap.
4. Explain the purpose and design of a strainer.
5. Explain the causes, effects, and prevention of water hammer.

Topic 18 Introduction to Valves

Learning Outcome

Discuss the design, application, and maintenance of common types of valves used in piping systems.

Learning Objectives

1. Describe five standard valve designs: gate, globe, butterfly, ball, and plug.
2. Describe the design and operation of check and non-return valves.
3. Describe the function of a pressure-reducing valve.
4. Describe valve identification markings.
5. Describe typical valve maintenance requirements.

Unit 6: Thermoil Systems

Topic 19 Introduction to Thermoil Heaters and Systems

Learning Outcome

Discuss the design and application of basic thermoil systems.

Learning Objectives

1. Describe the principle of thermoil heating.
2. Describe a direct heating thermoil system.
3. Describe the design and operation of unfired steam generating systems.

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Major Topic: Elements of Human Comfort in Facility Operation Unit 1:

Heating Systems and Human Comfort

Topic 1 Heat Gains and Losses

Learning Outcome

Describe the various ways a building gains and loses heat.

Learning Objectives

1. Define heat transmission terminology and identify conversions or related units.
2. Describe the heat gains that occur in a building due to conduction, infiltration, ventilation, and radiation.
3. Describe the heat gains that occur in a building due to people, lighting, electric motors, appliances, and cooking.
4. Describe the heat losses that occur in a building due to conduction, convection, radiation, infiltration, and ventilation.

Topic 2 Steam Heating Equipment

Learning Outcome

Describe the operating principles of steam heating equipment and components.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. List and describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.

Topic 3 Steam Heating Systems

Learning Outcome

Describe the operating principles and maintenance procedures of steam heating systems and the components of these systems.

Learning Objectives

1. Describe standard types of piping and equipment layout for steam heating systems.
2. Describe the general operation and maintenance of steam heating systems.
3. Apply a steam heating system troubleshooting guide.

Topic 4 Hot Water Heating Systems

Learning Outcome

Describe the various designs of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe radiant panel and snow melting hot water systems.

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Topic 5 Hot Water Heating System Equipment and Operation

Learning Outcome

Describe accessories, operation and troubleshooting of a hot water heating system.

Learning Objectives

1. Describe the purpose and function of standard hot water heating system components such as diverter fittings, air vents, air separators, flow control valves, balancing valves and fittings, riser stop valves, pressure reducing valves, circulating pumps, expansion tanks, and steam to hot water converters.
2. Explain how the location of the hot water circulating pump and the expansion tank are determined.
3. Describe the cleaning, filling, starting, routine operation, and troubleshooting of hot water heating systems.
4. Apply a hot water heating system troubleshooting guide.

Topic 6 Warm Air Heating System Equipment

Learning Outcome

Describe the operating principles of warm air heating sources.

Learning Objectives

1. Compare the advantages and disadvantages of forced air and gravity warm air systems.
2. List and describe the common sources of warm air heat.
3. List and describe the operational characteristics of directly fired space heaters.

Topic 7 Warm Air Furnace Components and Maintenance

Learning Outcome

Describe the components and maintenance requirements of typical warm air heating and ventilating systems.

Learning Objectives

1. Describe the operation of furnace components.
2. Describe and discuss the relative merits of three types of air distribution and duct systems.
3. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
4. Apply a troubleshooting guide for forced warm air systems and components.

Topic 8 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems found in buildings, as well as describe the various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the types of contaminants found in air.
3. Describe the types of air cleaning devices used in buildings.

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Topic 9 Infrared and Electric Heating

Learning Outcome

Describe infrared and electric heating systems.

Learning Objectives

1. Discuss the concept and application of infrared heating.
2. Describe the construction and operation of gas-fired and electric infrared heaters.
3. List the advantages of electric heating systems compared to other types of heating systems.
4. Describe the different methods of electric heating.

Topic 10 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and commercial types of humidifiers.
3. Describe industrial types of humidifiers.

Topic 11 Electric Controls for Heating Systems

Learning Outcome

Describe and explain the function of the various components of an electric control circuit.

Learning Objectives

1. Discuss the various terms associated with electric control systems.
2. Describe the basic construction and operation of electric thermostats, humidity controllers, and pressure controllers.
3. Describe the function and operation of the controlled devices in electric control systems.
4. Explain the operating sequence of a basic electric control circuit.

Unit 2: Plumbing and Auxiliaries

Topic 12 Building Water Supply Systems

Learning Outcome

Explain the various water supply systems in a building.

Learning Objectives

1. Describe the cold water distribution system in a building.
2. Describe the hot water distribution system in a building.
3. Describe the construction and operation of building system hot water heaters.
4. Explain what is meant by “backflow prevention” and describe the common methods used.
5. List and describe the construction and operation of water system protective devices in buildings.

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Topic 13 Sanitary Drainage Systems

Learning Outcome

Describe various sanitary drainage systems employed in buildings.

Learning Objectives

1. Describe the overall layout of building drainage systems.
2. Describe storm water drainage systems for buildings.
3. List the steps to take in the routine maintenance of building sanitary drainage system devices.
4. Apply a troubleshooting guide for sanitary drainage systems.

Unit 3: Lighting

Topic 14 Lighting Systems

Learning Outcome

Explain the various lighting systems and some of the basic design considerations for lighting a space.

Learning Objectives

1. Describe the common types of lighting equipment and systems.
2. Explain the various methods of lighting control.
3. Describe the general requirements and criteria for emergency lighting in buildings.
4. Discuss the interrelationship between lighting, air conditioning, and energy conservation in buildings.

Unit 4: Refrigeration

Topic 15 Refrigeration Theory

Learning Outcome

Explain the theory and terms associated with refrigeration.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the practical cycle of operations in a vapour compression refrigeration system.
3. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.

Topic 16 Refrigerants

Learning Outcome

Describe the different refrigerants used and explain the various properties of these refrigerants.

Learning Objectives

1. Describe the identification and classification of refrigerants.
2. Describe the characteristics and thermodynamic properties of refrigerants.
3. Describe the physical properties of refrigerants.

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Topic 17 Compression Refrigeration Systems

Learning Outcome

Describe the operating principle of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Distinguish between direct and indirect refrigeration systems.
3. Explain how compression refrigeration system temperatures and pressures are related.
4. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizer.

Topic 18 Refrigeration Compressors

Learning Outcome

Describe the operating principles and the components of refrigeration compressors and perform simple compressor calculations.

Learning Objectives

1. Describe the construction and operation of a reciprocating refrigeration compressor.
2. Describe the construction and operation of a rotary refrigeration compressor.
3. Describe the construction and operation of a centrifugal refrigeration compressor.
4. Describe the construction and operation of seals for refrigeration compressors.
5. Calculate the capacity, efficiency, and ratio of a refrigeration compressor.

Topic 19 Heat Exchangers for Refrigeration Systems

Learning Outcome

Describe the different types of heat exchangers used in refrigeration systems.

Learning Objectives

1. Describe the designs and construction of refrigeration system evaporators.
2. Describe the designs and construction of refrigeration system condensers.
3. Discuss refrigeration condenser operation and maintenance.

Topic 20 Refrigeration Accessories

Learning Outcome

Describe the various accessories used in refrigeration systems.

Learning Objectives

1. List and describe the operation of the gauges, separators, strainers, and indicators that are used as accessories in refrigeration systems.

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Topic 21 Cooling Towers

Learning Outcome

Describe the operation and maintenance of cooling towers.

Learning Objectives

1. List the factors that determine rate of cooling in a cooling tower and the basic components of a cooling tower.
2. Describe the construction and operation of a natural draft cooling tower.
3. Describe the construction and operation of a mechanical draft cooling tower.
4. Discuss cold climate operation for cooling towers.
5. Apply a cooling tower troubleshooting guide.

Topic 22 Air Conditioning Systems

Learning Outcome

Describe the operation of various air conditioning systems.

Learning Objectives

1. List the functional components and categories of air conditioning systems.
2. Describe the operation of air handling units.
3. Describe the general layout and operation of unitary air conditioning systems.
4. Describe the general layout and operation of central air conditioning systems.

Unit 5: Refrigeration and AC System Controls

Topic 23 Refrigeration Metering Devices and Capacity Controls

Learning Outcome

Describe the operating principles of refrigeration metering devices and capacity controls.

Learning Objectives

1. Describe the construction and operation of compression refrigeration cycle expansion valves.
2. Describe the types of evaporator and compressor capacity controls.

Topic 24 Refrigeration Cycle Controls

Learning Outcome

Describe the purposes and operating principles of the operational and safety controls on a refrigeration system.

Learning Objectives

1. Describe the operation of the various operating controls for refrigeration systems.
2. Describe the actuators used in refrigeration control systems.
3. Describe the typical refrigeration system safety shutdown devices.

Topic 25 Compression Refrigeration System Pre-Startup Procedures

Learning Outcome

Describe the various pre-startup procedures used on compression refrigeration systems.

Learning Objectives

1. Describe how to perform refrigeration system leak tests.
2. Describe how a refrigeration system is dried and charged prior to startup.
3. Describe how a refrigeration system is purged of noncondensable gases prior to startup.
4. List the steps for adding oil to a refrigeration compressor when it is in service.

Topic 26 Compression Refrigeration System Operations

Learning Outcome

Describe the various operation and maintenance procedures used on compression refrigeration systems.

Learning Objectives

1. Describe the steps in the startup and shutdown of a compression refrigeration system.
2. List the safety shutdown devices that are specific to centrifugal compressors.
3. Describe the routine operation and associated log sheets for compression refrigeration systems.
4. List and describe the standard preventive maintenance procedures for compression refrigeration systems.
5. Apply a compression refrigeration system troubleshooting guide.

Unit 6: Pumps and Air Compressors

Topic 27 Air Compression

Learning Outcome

Describe the operating principles of the different types of air compressors.

Learning Objectives

1. Describe the main classifications and types of air compressors.
2. Describe air compressor auxiliary equipment, including capacity control systems.
3. Discuss preventive maintenance for reciprocating air compressors.

Topic 28 Types of Pumps

Learning Outcome

Describe the various types of pumps found in buildings and industrial plants.

Learning Objectives

1. List the common applications of pumps in the power industry.
2. Define the terms associated with pump performance.
3. Describe the common types of pumps used in the power industry.

Topic 29 Pump Operation and Maintenance

Learning Outcome

Describe all details pertaining to pump operation and various maintenance procedures performed on pumps.

Learning Objectives

1. Describe the construction and function of pump wear rings.
2. Discuss pump shaft sealing and describe the process that is followed when replacing compression type packing.
3. Sketch and describe the standard types of mechanical seals.
4. Describe pump bearing and shaft alignment equipment and procedures.
5. Describe pump startup and priming procedures.
6. Identify pump troubles and their possible causes.

Topic 30 Lubrication

Learning Outcome

Describe the importance and the principles of lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and applications.
3. List the properties of lubricating oils and the additives used.

Topic 31 Types of Bearing Lubrication

Learning Outcome

Describe the methods for simple care and maintenance of bearings and their related lubrication systems.

Learning Objectives

1. Define boundary and fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of thrust bearings.
4. Describe how to clean and replace roller and ball bearings.
5. List the causes of bearing failure.

Unit 7: Distributed Generation

Topic 32 Microturbines

Learning Outcome

Describe the application and operation of microturbines.

Learning Objectives

1. Explain the application of microturbines in the generation of electricity and heat.

Topic 33 Internal Combustion (IC) Engine Gen-Sets

Learning Outcome

Describe the application and operation of IC gen-sets.

Learning Objectives

1. Explain startup and shutdown procedures.
2. Explain the proper routine pre-start and operational checks.
3. Identify the three main methods of starting gen-sets.

Major Topic: Basic Physical Science, Safety, and Regulation for Facility Operations

Unit 1: Acts, Regulations, and Adopted Codes

Topic 1 Boiler and Pressure Vessels Act

Learning Outcome

Discuss the purpose of the jurisdictional acts/regulations pertaining to the operation of boilers and pressure equipment.

Learning Objectives

1. Explain the purpose and scope of your jurisdictional act and regulations.
2. Explain the purpose and intent of the regulations governing the operation of boilers and pressure equipment.
3. Discuss the regulations relating to Power Engineering qualifications.

Topic 2 Introduction to CSA and ASME Codes for Boilers

Learning Outcome

Demonstrate a working knowledge of the CSA codes, and the ASME codes of concern to the 5th Class Power Engineer.

Learning Objectives

1. Explain the content and use of the CSA-B51: Boiler, Pressure Vessel, and Pressure Piping Code.
2. Explain the content and use of the CSA-B52: Mechanical Refrigeration Code.
3. Explain the purpose of ASME Boiler and Pressure Vessel Code, Section I - Rules for Construction of Power Boilers.
4. Explain the purpose of ASME Boiler and Pressure Vessel Code, Section VII - Recommended Guidelines for the Care of Power Boilers.
5. Explain the purpose of ASME Boiler and Pressure Vessel Code, Section IV - Rules for Construction of Heating Boilers.
6. Explain the purpose of ASME Boiler and Pressure Vessel Code, Section VI - Recommended Rules for the Care and Operation of Heating Boilers.

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Unit 2: Basic Math

Topic 3 SI Units

Learning Outcome

Perform simple calculations involving SI units.

Learning Objectives

1. List SI units for length, mass, temperature, speed, and their symbols.
2. Identify and list symbols for unit prefixes.
3. Perform conversions between basic SI, imperial, and U.S. customary system (USCS) units.

Topic 4 Basic Arithmetic Operations

Learning Outcome

Perform basic arithmetic operations.

Learning Objectives

1. Perform basic arithmetic operations (addition, subtraction, multiplication, and division) on whole numbers without the use of a calculator.
2. Perform basic arithmetic operations on decimal numbers.
3. Perform basic arithmetic operations on fractions.
4. Reduce fractions to lowest terms.
5. Convert fractions to decimals and decimals to fractions.
6. Solve percentage problems.
7. Given a ratio, determine the correct quantity of a substance.

Topic 5 Transposition

Learning Outcome

Transpose equations in order to find values for different variables in a formula.

Learning Objectives

1. Transpose commonly used equations involving up to two variables and all basic mathematical operations.
2. Insert values into common equations and solve them.

Topic 6 Areas and Volumes of Solids

Learning Outcome

Calculate the volumes of rectangular objects, cylinders, and spheres and the surface areas of cylinders and spheres.

Learning Objectives

1. State the SI units for area and volume.
2. Calculate the surface area and volume of a rectangular tank.
3. Calculate the surface area and volume of a cylinder.

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Unit 3: Applied Science

Topic 7 Application of Basic Mechanics

Learning Outcome

Define basic terms used in the study of mechanics.

Learning Objectives

1. Define the terms force, velocity, mass, pressure, energy, work and power.
2. Explain the application of levers, pulleys, and inclined planes.
3. Identify where simple machines are used in the plant.
4. Define mechanical advantage.

Topic 8 Introduction to Thermodynamics

Learning Outcome

Explain the principles of thermodynamics and the modes of heat transfer.

Learning Objectives

1. Describe the three states of matter.
2. Describe the expansion of solids and liquids.
3. Explain the different temperature scales used in thermodynamics (Celsius and Fahrenheit).
4. Explain sensible and latent heat, and the thermodynamic transformation of ice to steam.
5. Describe the three modes of heat transfer.
6. Explain the energy in the expansion of water to steam.

Unit 4: Safety

Topic 9 Fire Safety and Site Hazards

Learning Outcome

Discuss acceptable methods of extinguishing various classifications of fire. Briefly describe site hazards awareness.

Learning Objectives

1. Explain the overall need for and the intent of fire protection standards, laws, and regulations.
2. Explain the different fire classifications and describe the extinguishing methods for each.
3. Explain the application and operation of standpipes, hoses, and sprinklers in buildings.
4. Explain the various types of fire and smoke detectors.
5. Describe the operation, placement, and maintenance of the common types of portable extinguishers.
6. Discuss the need for and use of a fire pump.
7. Briefly describe safety aspects of common site hazards.
8. Explain how to perform a pre-job hazard assessment.

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Topic 10 Building Safety

Learning Outcome

Describe how the building operator can prevent accidental situations to protect the occupants of their facility.

Learning Objectives

1. Explain the personal safety responsibilities and precautions that must be applied by the building operator.
2. Describe the general safety precautions required in the maintenance and operation of buildings.
3. Identify common scenarios where the building operator can prevent accidents, and explain the importance of first aid and CPR training.

Topic 11 Confined Space Entry

Learning Outcome

Describe procedures needed to enter into, or work safely in confined spaces.

Learning Objectives

1. Define confined space, list some confined spaces, and describe the hazards of being in a confined space.
2. Refer to local jurisdictional regulations and describe procedures to be followed when performing a confined space entry, including completion of an entry checklist.

Topic 12 Introduction to Occupational Health and Safety Legislation

Learning Outcome

Discuss the provincial legislation addressing occupational health and safety.

Learning Objectives

1. Explain the general intent of occupational health and safety standards.
2. Discuss some of the responsibilities, according to the Act, of workers, employers, and others in relation to health and safety.
3. Describe the conditions that must exist before a worker can refuse to work.
4. Identify jurisdictional regulations related to health and safety.
5. List the two different types of logs kept in boiler plants and the importance of each.

Topic 13 Introduction to Heating Plant Safety

Learning Outcome

Describe general plant safety as it relates to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may exist in an energy plant, and the basic personal protective equipment that may be required.
3. Define, give examples of, and describe common workplace hazards. (Note that additional training will be required beyond this course material.)
4. Describe equipment isolation and lockout procedures.

Topic 14 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous goods and materials.

Learning Objectives

1. Discuss the WHMIS.
2. Describe the Safety Data Sheets (SDS) and Material Safety Data Sheets (MSDS) required in the WHMIS.
3. Identify the labels required in the WHMIS.
4. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
5. Discuss the safe handling of hydrocarbons.

Unit 5: Electricity

Topic 15 Introduction to Electricity

Learning Outcome

Discuss the design and accessories of an electrical circuit; describe the design and troubleshooting of lighting systems and electric motors.

Learning Objectives

1. Explain electricity, electric circuits, and voltage drop.
2. Calculate current and power in an electric circuit, estimate the cost of electrical power for a facility, and describe how to read a power meter.
3. Describe circuit accessories, including switches, fuses, breakers, and receptacles. Explain the danger of electric shock.
4. Explain what constitutes a good lighting system. Explain maintenance of a lighting system and troubleshooting of incandescent and fluorescent systems.
5. Describe simple electrical system problems, including short circuits, grounds, and bad connections. Describe static electricity.
6. Describe transformers and electric motors. Explain motor types, bearing care, and troubleshooting of motors.
7. Explain the CSA approval and markings for electrical appliances.

Unit 6: Welding

Topic 16 Welding Terms and Inspection

Learning Outcome

Define welding terms and describe methods of weld inspection.

Learning Objectives

1. Define the common terms used in welding.
2. Describe the jurisdictional requirements for a weld repair.
3. Explain the role of the 5th Class Power Engineer in preparing for a welder.
4. Discuss the commonly used methods of weld inspection and testing.

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Unit 7: Water Treatment

Topic 17 Water Treatment

Learning Outcome

Explain the purpose of the common external and internal water treatment methods.

Learning Objectives

1. Explain the four general sources of impurities and the three general treatment methods.
2. Explain the purpose of external filtration and describe the design of pressure, filter-aid, and cartridge filters.
3. Explain boiler blowoff/blowdown.
4. Describe the operating principles of a sodium zeolite water softener.
5. Explain troubleshooting and common operating problems associated with water softeners.
6. Describe methods of feeding treatment chemicals into a boiler.
7. Define potable water and explain the importance of backflow prevention.
8. Describe the testing of potable water.

Topic 18 Monitoring and Testing

Learning Outcome

Explain general sampling and testing procedures and equipment, and describe specific testing procedures, plus interpret test results for a boiler water treatment monitoring and testing program.

Learning Objectives

1. List the four classes of impurities and three general treatment methods.
2. Explain how to obtain a representative water sample.
3. Discuss testing methods.
4. Describe the principles and procedures for testing for hardness, dissolved solids, phosphate, molybdate, pH, sodium sulfite, and alkalinity.

Unit 8: Communications

Topic 19 Technical Communications

Learning Outcome

Utilize some of the best practices on various types of communication techniques. Identify the key elements of an SOP with document control and update methods. Identify the key components of a Maintenance Management System.

Learning Objectives

1. Discuss effective communication in written, verbal, and radio techniques.
2. Discuss the importance of standard operating procedures (SOPs), how they are written, and how to have them updated.
3. Explain a maintenance management system and the essential information and requirements in this system.

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Topic 20 Plant Diagrams

Learning Outcome

Use basic engineering diagrams to learn the processes within the specific workplace.

Learning Objectives

1. Discuss the different types of plant (or building) diagrams (drawings) that the Power Engineer may encounter, including the basic symbols and lines used.
2. Explain how to trace out lines in a plant and make a sketch using basic drawing symbols of multiple systems.

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REFERENCE CURRICULUM

For

Green Facility Manager

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the NIULPE Green Facility Manager Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Green Facility Manager Examination Candidates

Topic 1 Hot Water and Steam Heating Boiler Operation

Learning Outcome

Describe the specific safe and efficient operational procedures that relate to automatically-fired, low-pressure hot water and steam heating boilers.

Learning Objectives

1. Describe the general preparation and start-up of a hot water heating boiler.
2. Describe the operation of a hot water heating boiler under routine conditions, including removal from service.
3. Describe the preparation, start-up, routine operation and removal from service of a steam heating boiler.

Topic 2 Heating Boiler Feedwater Controls

Learning Outcome

Describe the various feedwater control methods and devices used on low-pressure steam boilers.

Learning Objectives

1. Describe the operation of a feedwater float switch operating a valve and a pump.
2. Describe how condensate is collected and returned to the boiler.
3. Explain the purpose and function of heating boiler feedwater and condensate piping connections.

Topic 3 Heating Boiler Combustion Controls

Learning Outcome

Explain the design and operation of various combustion controls on heating boilers.

Learning Objectives

1. Describe the construction and operation of heating boiler flame failure detectors.
2. Describe the testing of hot water heating boiler flame failure safety devices.

Topic 4 Steam Heating Equipment

Learning Outcome

Describe the components and operating principles of steam heating equipment.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. Describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.

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Topic 5 Steam Heating Systems

Learning Outcome

Describe the operating principles and maintenance procedures of steam heating systems and the components of these systems.

Learning Objectives

1. Describe standard types of piping and equipment layout for steam heating systems.
2. Describe the general operation and maintenance of steam heating systems.
3. Apply a steam heating system troubleshooting guide.

Topic 6 Hot Water Heating System Equipment and Operation

Learning Outcome

Describe accessories, operation and troubleshooting of a hot water heating system.

Learning Objectives

1. Describe the purpose and function of standard hot water heating system accessories.
2. Explain how the location of the hot water circulating pump and the expansion tank are determined.
3. Describe the cleaning, filling, starting, use of antifreeze in, and routine operation of hot water heating systems.
4. Apply a hot water heating system troubleshooting guide.

Topic 7 Hot Water Heating Systems

Learning Outcome

Describe the various designs of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe various types of special hot water heating systems.

Topic 8 Pneumatic Controls for Heating Systems

Learning Outcome

Explain the purpose of the various components found in a pneumatic control system.

Learning Objectives

1. Describe the layout of a pneumatic control system and the construction and operation of pneumatic controllers.
2. Describe the construction and operation of final control elements.
3. Explain the function of the various auxiliary devices associated with pneumatic control systems.
4. Describe a typical self-contained pneumatic control system.

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Topic 9 Electric Controls for Heating Systems

Learning Outcome

Describe and explain the various components of an electric control circuit.

Learning Objectives

1. Discuss the various terms associated with electric control systems.
2. Describe the basic construction and operation of various electric control system components for heating systems.
3. Describe the function and operation of the controlled devices in electric control systems.
4. Explain the operating sequence of a basic electric control circuit.

Topic 10 Electronic Controls for Heating Systems

Learning Outcome

Describe and explain the function of the various components of an electronic control circuit.

Learning Objectives

1. Define the various terms associated with electronic control systems.
2. Describe a simple electronic control system.
3. Describe the common types of sensors used in HVAC electronic control systems.
4. Describe the types and functions of controllers used in HVAC electronic control systems.
5. Describe the output and indicating devices in an HVAC electronic control system, including interfacing with other systems.

Topic 11 Building Water Supply Systems

Learning Outcome

Explain the various water supply systems used in buildings.

Learning Objectives

1. Describe the cold water distribution system in a building.
2. Describe the hot water distribution system in a building.
3. Describe the construction and operation of building system hot water heaters, including temperature regulation.
4. Explain what is meant by “backflow prevention” and describe the common methods used.
5. List and describe the construction and operation of water system protective devices in buildings.

Topic 12 Types of Pumps

Learning Outcome

Describe the design and operating principles of various types of pumps used in buildings and industrial plants.

Learning Objectives

1. List the common applications of pumps in the power industry.
2. Define the terms associated with pump performance.
3. Describe the common types of pumps used in industry.

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Topic 13 Pump Operation and Maintenance

Learning Outcome

Describe the major considerations and procedures for pump operation and maintenance.

Learning Objectives

1. Describe the construction and function of pump wearing rings.
2. Discuss pump shaft sealing and describe the process that is followed when replacing compression type packing.
3. Describe the standard types of mechanical seals.
4. Describe pump bearing and shaft alignment equipment and procedures.
5. Describe pump start-up and priming procedures.
6. Apply pump troubleshooting steps.

Topic 14 Powerhouse Plant Maintenance I

Learning Outcome

Describe the safe use of common hand tools in the powerhouse.

Learning Objectives

1. List the general safe working practices identified by the Workers' Compensation Board.
2. Describe the types and proper use of hacksaws, files, chisels, hammers, screwdrivers and wrenches.
3. Describe the types and proper use of hand threading tools.
4. Describe the types and proper use of measuring tools.
5. Describe the proper layout of work and the use of layout tools.
6. Describe the types and proper use of portable and fixed grinders, hand drills, drill presses and the care of drill bits.

Topic 15 Powerhouse Plant Maintenance II

Learning Outcome

Discuss and describe the safe and proper setup of equipment for hoisting and working above ground.

Learning Objectives

1. Describe the requirements for setting up work platforms in general and ladders and scaffolding in particular.
2. Describe the general safety precautions and calculations used when rigging equipment.
3. Describe the general safety precautions used when hoisting equipment.

Topic 16 Powerhouse Plant Maintenance III

Learning Outcome

Discuss the designs and safe applications and attachment of lifting cables and ropes, and the designs and uses of metal fasteners.

Learning Objectives

1. Discuss the correct use and limitations of wire cable and rope, including cable attachments and rope knots.
2. List and describe common types of metal fasteners, such as screws, bolts, studs, nuts and washers.

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Topic 17 Boiler Cleaning

Learning Outcome

Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical and chemical boiler cleaning methods.

Learning Objectives

1. List the steps and precautions to be taken to prepare a boiler for inspection.
2. Describe the internal inspection of a boiler.
3. Describe the methods and tools used for mechanical cleaning of a boiler.
4. Describe two methods used for the chemical cleaning of a boiler.

Topic 18 Boiler Maintenance

Learning Outcome

Describe the service and maintenance required for boilers.

Learning Objectives

1. Describe the general maintenance and servicing of packaged firetube and cast-iron sectional boilers.
2. State the procedures to be followed for wet and dry boiler lay-ups.
3. Describe the causes and symptoms of a leaking firetube and the procedure for removing a firetube from service.
4. Describe two methods of detecting cracks in firetube ends and tube sheets.
5. Describe the general procedure for the removal and replacement of a defective firetube.

Topic 19 Safety Management Systems

Learning Outcome

Discuss typical legislation and programs that manage safety in the industrial workplace.

Learning Objectives

1. Explain the general intent, power and scope of Occupational and Safety Health Act (OSHA) legislation.
2. Explain the intent and scope of a workplace OSHA program and state the responsibilities of company, employees, and the OH&S Committee within the program.
3. Define and give examples of typical workplace hazards and describe a system of hazard identification and control.
4. Explain the purpose of work permits and describe typical hot and cold work permit systems.
5. Explain the purpose of equipment lockout, describe lockout devices, and describe a typical equipment lockout procedure.
6. Define and identify a confined space and a permit-required confined space, describe a typical confined space permit and entry procedure.
7. Explain the hazards of excavation and describe typical excavation procedures and permits.
8. Explain the purpose and describe the typical components of an emergency response plan.
9. State the purpose of OSHA Hazard Communication Standard, explain the use of labels and material safety data sheets, and explain the responsibilities of employer and employee.
10. Explain the purpose, requirements, and procedures for incident and accident investigation and reporting.

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Topic 20 Fire Protection Systems

Learning Outcome

Discuss the classes and extinguishing media of fires, and explain systems that are used to detect and extinguish industrial fires.

Learning Objectives

1. Explain the classifications of fires and describe the extinguishing media that are appropriate for each classification.
2. Describe the components and operation of a typical fire detection and alarm system in an industrial setting.
3. Describe the design and operation of a typical standpipe system.
4. Describe the wet pipe, dry pipe, preaction and deluge designs for sprinkler systems.
5. Describe the layout, components and operation of a typical firewater system with fire pump and hydrants. Explain seasonal considerations for a firewater system.
6. Describe the construction and operation of a typical fire hydrant.
7. Explain the purpose and describe a typical deluge water system for hydrocarbon storage vessels.
8. Explain the purpose and describe a typical foam system for process buildings and tanks.
9. Describe a typical fire response procedure for an industrial setting.

Topic 21 Wastewater Treatment

Learning Outcome

Explain the purpose, designs, processes and control of industrial wastewater treatment.

Learning Objectives

1. State the purpose of wastewater treatment, list typical waste liquids, and explain the legislation and permitting, including parameters, for the disposal of wastewater.
2. Sketch an industrial wastewater treatment system and describe the processes that occur at each stage of treatment.
3. Describe the equipment and process involved in the removal of suspended solids from wastewater, including screening, flotation, and sedimentation.
4. Describe the equipment and process involved in the removal of colloidal solids from wastewater, including chemical coagulation, flocculation, and clarification.
5. Describe the equipment and process involved in the biological removal of solids from wastewater, including activated sludge, rotating biological contactors, and trickling filters.
6. Describe the control strategy for a wastewater treatment system. Define and explain the control of and sampling points for the main control parameters, including nutrients, BOD, COD, pH, and settle ability.

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Topic 22 Plant Maintenance and Administration

Learning Outcome

Explain typical components of maintenance and administration programs for utilities and process facilities.

Learning Objectives

1. Explain typical communication and accountability structures within a large facility, including the responsibilities for external communication.
2. Describe the typical components and responsibilities of scheduled and preventive maintenance management programs.
3. Explain the importance and extent of record keeping and describe the quality and content requirements for operating logbooks and records.
4. Using a complete boiler turnaround and inspection as an example, describe project management using two methods, Gantt Chart and critical path.
5. Explain the importance of procedures in the operation of a facility and describe the application of well-written procedures to personnel training and daily operation.
6. Explain typical environmental monitoring and management programs for operating facilities.

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REFERENCE CURRICULUM

For

Green Facility Operator

National Institute for the Uniform Licensing of Power Engineers, Inc.
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Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the NIULPE Green Facility Operator Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Green Facility Operator Examination Candidates

Topic 1 Basic Concepts about Matter

Learning Outcome

Discuss the basic types of matter and their properties.

Learning Objectives

1. Describe the physical states of matter.
2. Define the properties of and distinguish between chemical and physical changes in matter.
3. Classify matter as a type of mixture or a pure substance.
4. Describe the purpose of the periodic table.

Topic 2 Introduction to Thermodynamics

Learning Outcome

Explain the principles of thermodynamics, including the laws of thermodynamics and the modes of heat transfer.

Learning Objectives

1. Define various terms associated with the study of thermodynamics.
2. Describe the laws and the different temperature scales used in thermodynamics.
3. Define heat and specific heat and perform sensible heat calculations.
4. Describe the expansion of solids and liquids.
5. Describe the three modes of heat transfer.

Topic 3 Thermodynamics of Steam

Learning Outcome

Describe the principles of the thermodynamics of steam and the associated terms.

Learning Objectives

1. Define the various terms related to steam.
2. Explain the various columns of the steam tables.
3. Explain the principles of the thermodynamics of steam using the steam tables.

Topic 4 Introduction to Boilers

Learning Outcome

By using common terms relating to boilers discuss the historical developments of, and the general requirements for proper boiler design.

Learning Objectives

1. Apply common terminology used in the description of boilers and registered plants in Ontario.
2. Describe early boiler designs and explain developments that improved boiler operation.
3. List the general requirements for proper boiler design.

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Topic 5 Firetube Boilers

Learning Outcome

Discuss the design, components and characteristics of HRT, locomotive, firebox, Scotch and packaged firetube boilers.

Learning Objectives

1. Describe horizontal return tubular and locomotive type boilers.
2. Describe firebox, scotch and heating boilers.
3. Describe vertical and packaged firetube boilers.

Topic 6 Watertube Boilers

Learning Outcome

Describe various watertube boiler designs, including large generating units.

Learning Objectives

1. Describe the operating principle and design of watertube boilers.
2. Explain the design and application of packaged watertube boilers.
3. Describe the design, construction and components of large scale steam generating units.
4. Describe the design of watertube and copper-tubular heating boilers.

Topic 7 Cast-Iron Sectional and Modular Boilers

Learning Outcome

Describe cast iron boilers and explain their uses.

Learning Objectives

1. Describe the general construction and the advantages of cast-iron sectional heating boilers over watertube and firetube boilers.
2. Describe the arrangement of equipment in a multiple, cast-iron sectional boiler heating plant.
3. Describe the construction and operation of cast-iron modular heating boilers.

Topic 8 Electric Boilers

Learning Outcome

Describe electric boilers in regard to their use and general design.

Learning Objectives

1. Describe the construction and operating principle of electric boilers.

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Topic 9 Basic Boiler Construction

Learning Outcome

Describe fabrication and general construction features of watertube and firetube boilers.

Learning Objectives

1. Describe the design and manufacturing of boiler shells and drums.
2. Describe the standard types of welded joints, heat treatments and welding inspection used in the construction of pressure vessels.
3. Describe the general design of riveted joints.
4. Describe the tools and standard methods used to attach boiler tubes to tubesheets, headers and drums.
5. Describe the need for, and application of, boiler stays.
6. Describe boiler access and inspection openings and drum connections.
7. Identify the different types of internal firetube furnace designs.
8. Describe boiler foundations and supports.
9. Describe the design and construction of water-cooled furnace walls in watertube boilers.

Topic 10 Basic Fittings for Low Pressure Steam Boilers

Learning Outcome

Describe, and explain the operating principles of pressure gauges and safety valves found on low-pressure steam boilers.

Learning Objectives

1. Describe the code requirements for pressure gauges on low-pressure steam boilers.
2. Describe the code requirements for the boiler connections and valves on low-pressure steam boilers.

Topic 11 Basic Fittings for Hot Water Boilers

Learning Outcome

Describe the purpose and operating principles of basic boiler fittings on hot water boilers.

Learning Objectives

1. Describe the code requirements for the required fittings on hot water heating boilers.
2. Discuss the types of non-required fittings that are used on hot water heating boilers.

Topic 12 Water Columns and Gauge Glasses

Learning Outcome

Describe different types of direct and inferential level gauges or indicators.

Learning Objectives

1. Describe direct type water level indicators.
2. Describe indirect type water level indicators.

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Topic 13 Safety and Pressure Relief Valves

Learning Outcome

Discuss the design and operation of safety valves for power and heating boilers.

Learning Objectives

1. Describe the ASME code requirements and the construction and operation of high pressure relief valves.
2. Describe the ASME code requirements and the construction and operation of low pressure heating boiler safety and pressure relief valves.
3. Describe the testing and repair of safety valves.
4. Describe the construction and operation of a temperature relief device.

Topic 14 Boiler Draf t Equipment

Learning Outcome

Discuss draft and describe the basic equipment used to supply combustion air to a boiler furnace.

Learning Objectives

1. Describe the forced, induced and balanced methods of mechanical draft.
2. Discuss the common methods of controlling combustion air flow.
3. Discuss the common methods of measuring furnace pressures.

Topic 15 Introduction to Boiler Combustion

Learning Outcome

Discuss the basic theory of combustion in a boiler, and the equipment used to provide proper combustion conditions.

Learning Objectives

1. Describe the principles of combustion, combustion equations and the relationships between theoretical and excess air.
2. Describe the three general classes of boiler fuels.
3. Describe the firing methods used in the combustion of various fuels, the effects of combustion on refractory and how the flow of fuel is controlled.
4. Describe flue gas analysis and its relationship to boiler efficiency.

Topic 16 Oil Burners for Heating Boilers

Learning Outcome

Describe the various oil burners used on heating boilers.

Learning Objectives

1. Describe air, steam and mechanical oil atomizing burners for boilers.
2. Describe the auxiliary equipment needed for an oil combustion system.
3. Describe the design and operation of fuel oil systems, including storage.

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Topic 17 Gas Burners for Heating Boilers

Learning Outcome

Describe the operation of the various types of gas burners used on heating boilers.

Learning Objectives

1. Describe the operation of various types of gas burners.
2. Describe the construction and operation of automatic gas valves.

Topic 18 Introduction to Piping and Pipe Fittings

Learning Outcome

Discuss the basic types of piping, piping connections, supports and drainage devices used in industry.

Learning Objectives

1. State the applications for the most common materials and identify the sizes of commercial pipe.
2. Describe methods of connection for screwed, flanged and welded pipe and identify fittings and their markings.
3. Describe methods and devices used to allow for pipe expansion and support.
4. Explain the methods used to promote good drainage of steam piping, including the installation and maintenance of steam traps. Explain water hammer.
5. Explain the need for piping insulation and describe materials and methods of insulation.

Topic 19 Introduction to Valves

Learning Outcome

Discuss the design and uses of the valve designs most commonly used in industry and on boilers.

Learning Objectives

1. Describe standard valve designs.
2. Describe design and operation of specialized boiler valves.
3. Describe piping arrangements and the design and operation of steam system pressure-reducing valves.
4. Discuss valve details, including materials of construction and identification markings.
5. Describe typical valve maintenance requirements.

Topic 20 External Feedwater Treatment

Learning Outcome

Discuss the general principles, methods and equipment used in preparing raw feedwater for steam production in a boiler.

Learning Objectives

1. Discuss the common impurities in raw water and their potential effects on a boiler.
2. Describe the various ways in which water is filtered to remove suspended solids.
3. Describe the purpose, processes and equipment used in boiler water softening.
4. Describe the theory, process and equipment used in deaeration.

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Topic 21 Internal Feedwater Treatment and Testing Methods

Learning Outcome

Discuss the general principles, methods and equipment used for the internal treatment of boiler water.

Learning Objectives

1. Describe the types of problems associated with internal boiler water contamination and their treatment.
2. Describe internal boiler feedwater chemical feed systems.
3. List and describe the standard boiler water tests and what they measure.

Topic 22 Continuous and Intermittent Blowdown

Learning Outcome

Describe the purposes, equipment and operation of continuous and intermittent blowdown.

Learning Objectives

1. Describe the equipment and processes involved in continuous and intermittent blowdown systems.

Topic 23 Boiler Preparation,Start-Up and Shutdown

Learning Outcome

Describe the basic preparation of a boiler for start-up and shutdown procedures.

Learning Objectives

1. Describe the steps that must be taken to prepare a boiler for start-up.
2. Describe a typical boiler start-up procedure.
3. Describe the boiler and steam header warm-up procedures.
4. Describe the procedure for shutting down a boiler.

Topic 24 Routine and Emergency Boiler Operation

Learning Outcome

Discuss routine and emergency practices for operation of a packaged boiler.

Learning Objectives

1. Describe the proper routine care and operation of a boiler.
2. Describe emergency conditions in boilers and the required responses.
3. List types and causes of boiler accidents and explosions.
4. Discuss the need for boiler operating and maintenance logs and the type of information that should be recorded.

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Topic 25 Introduction to Instrumentation

Learning Outcome

Describe the overall purpose and function of plant instrumentation systems.

Learning Objectives

1. Describe the concept and basic components of a control loop.
2. Describe the various means by which control signals are transmitted.
3. Describe the function of transducers.
4. List and describe the types of instrumentation which are not necessarily part of a control loop.

Topic 26 Boiler Water Level and Combustion Controls

Learning Outcome

Describe specific types of instrumentation and controls used on boilers.

Learning Objectives

1. Describe the construction and operation of boiler low water level fuel cutoff equipment.
2. List the ASME and CSA code regulations regarding low water fuel cutoffs.
3. Describe the testing and maintenance of boiler low water level fuel cutoffs.
4. Describe the components and component functions of boiler water level control systems.
5. Describe basic boiler combustion control systems.

Topic 27 Drum Internals

Learning Outcome

Describe the operating principles of compression refrigeration systems. Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the purposes of and the general principles and equipment used to separate steam and water in a steam drum.
2. Describe steam drum internal feedwater, continuous blowdown and chemical feed pipes.

Topic 28 Introduction to Process Measurement

Learning Outcome

Describe the construction and operation of common devices used to measure pressure, level, temperature, flow, and composition.

Learning Objectives

1. Describe the standard types of pressure measuring devices.
2. Describe the standard types of level sensing and measuring devices.
3. Describe the standard types of flow sensing and measuring devices.
4. Describe the standard types of temperature sensing and measuring devices.
5. Describe the principle and basic operation of a chromatograph.

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Topic 29 Basic Control Loop Components

Learning Outcome

Describe the basic types and functions of transmitters, recorders, controllers and control valves.

Learning Objectives

1. Describe the principle, construction and operation of instrumentation transmitters.
2. Describe the principle, construction and operation of instrumentation indicators and recorders.
3. Describe the principle, construction and operation of instrumentation controllers and control valves.

Topic 30 Boiler Programming Controls

Learning Outcome

Describe the operation of programming controls for boilers and discuss testing and maintenance procedures for these controls.

Learning Objectives

1. Describe the operation of equipment that is used to automatically start up and shut down boilers.
2. Interpret operating sequence bar graphs and provide a typical sequence of start-up and shutdown events.
3. Apply a boiler start-up and shutdown programmer troubleshooting guide.

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REFERENCE CURRICULUM

For

Facility Engineer (1st Class)

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Introduction

This Curriculum is intended to assist candidates studying for the NIULPE Facility Engineer (1st Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Facility Engineer (1st Class) Examination Candidates

Major Topic: Boiler Codes, Electrical and Instrumentation Theory

Topic 1 Legislation and Codes for Power Engineers

Learning Outcome

Explain the purpose of, general content of, and interaction with the legislation and codes that pertain to the design and operation of boilers and related equipment.

Learning Objectives

1. Explain Codes and Standards.
2. Explain the purpose and scope of the National Board of Boiler Inspectors (NBBI).
3. Explain the scope of the ASME and state the purpose and general content of the following sections of the ASME Codes: Section I, II, IV, V, VI, VII, VIII, IX.

Topic 2 Fuels, Combustion, and Flue Gas Analysis

Learning Outcome

Explain the properties and combustion of common fuels and the analysis of combustion flue gas.

Learning Objectives

1. Explain/define complete combustion, incomplete combustion, combustion products, and write balanced combustion equations.
2. Explain the purpose and benefits of excess air and calculate the theoretical and excess air required for the complete combustion of a given fuel.
3. Explain proximate analysis, ultimate analysis, and heating value of a fuel and describe the use of calorimetry to determine heating value. Explain higher and lower heating values.
4. Given the ultimate analysis of a fuel, use Dulong’s Formula to calculate the heating value of the fuel.
5. Describe the properties, classifications and combustion characteristics of coal.
6. Describe the properties, classifications and combustion characteristics of fuel oil.
7. Describe the properties and combustion characteristics of natural gas.
8. Explain the use and combustion characteristics of alternatives to traditional fossil fuels, including biomass, coke and oil emulsions.
9. Explain the analysis of flue gas for the measurement of O_2, CO, and CO_2 in relation to combustion efficiency. Describe typical, automatic flue gas analyzers.
10. Explain the formation, monitoring and control of nitrogen oxides (NO_X), sulfur dioxide, and particulates.

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Topic 3 Piping Design, Connections, Support

Learning Outcome

Discuss the codes, designs, specifications, and connections for ferrous, non-ferrous and non-metallic piping and explain expansion and support devices common to piping systems.

Learning Objectives

1. Identify and explain the general scope of the ASME, ANSI, ASTM codes and standards with respect to piping and pipe fittings. Differentiate between power piping (Code B31.1) and pressure piping (Code B31.3).
2. Explain methods of pipe manufacture; size specifications and service ratings, and the material specifications and applications for ferrous pipe.
3. Using pipe specifications and the ASME code Sections I and II you will be able to identify the size of pipe required for a particular installation, process or operating condition.
4. Explain the materials, code specifications and applications of common, non-ferrous metal piping and cast iron.
5. Describe screwed, welded, and flanged methods of pipe connection and identify the fittings used for each method.
6. Describe the construction, designs, and materials of flange gaskets and explain the confined, semi-confined, and unconfined flange styles.
7. Explain the materials, construction and approved applications of common, non-metallic pipe.
8. Explain the effects of temperature on piping; explain the mechanisms and the dangers of expansion in piping systems, including attached equipment.
9. State the purpose and explain the designs, locations and applications of simple and offset U-bend expansion bends.
10. Describe designs, locations, care and maintenance of slip, corrugated, bellows, hinged, universal, pressure-balanced, and externally pressurized expansion joints.
11. Describe design, location, operation of pipe support components, including hangers, roller stands, variable spring hangers, constant load hangers, anchors, and guides.

Topic 4 Steam Traps, Water Hammer, Insulation

Learning Outcome

Explain the designs and operation of steam trap systems, the causes and prevention of water hammer, and the designs and applications of pipe insulation.

Learning Objectives

1. Explain the dynamics, design, and components of steam/condensate return systems for steam lines and condensing vessels. Explain roles and locations of separators and traps.
2. Describe the design, operation and application of ball float, inverted bucket, thermostatic, bi-metallic, impulse, controlled disc, and liquid expansion steam traps.
3. Explain the selection, sizing and capacity of steam traps and explain the factors that determine efficient trap operation.
4. Explain the procedures for commissioning, testing, and maintenance of steam traps.
5. Explain and compare condensate-induced and flow-induced water hammer in steam and condensate lines. Explain the typical velocities, pressures and damage that can be created in steam/condensate lines due to water hammer.
6. Describe specific trap and condensate return arrangements that are designed to prevent water hammer in steam and condensate lines.
7. State precautions that must be observed to prevent water hammer and describe a typical steam system start-up procedure that will prevent water hammer.
8. State the purposes of insulation and explain the properties required for a good insulating material. Explain thermal conductivity, K-Factor and R-Value.
9. Identify the most common industrial insulating materials, describe the composition and characteristics of each, and explain in what service each would be used.
10. Describe common methods for applying insulation to piping and equipment, including wrap and clad, blanket, insulated covers and boxes. Explain the care of insulation and cladding and the importance of maintaining good condition.

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Topic 5 Valves and Actuators

Learning Outcome

Describe the designs, configurations and operation of the common valve designs that are used in power and process piping.

Learning Objectives

1. Explain the factors that determine the suitability and applications of the major valve styles; gate, globe, ball, plug, butterfly and needle.
2. Explain the factors that determine the selection of valve materials, and describe examples of typical valve body and trim materials. How are common control valves identified?
3. Describe the configurations and applications for gate valves, including gate designs (solid, split, flexible, sliding), stem configurations (rising, non-rising, outside screw-and-yoke, inside screw), and bonnet designs (flanged, screwed, welded).
4. Describe the designs and applications of globe valves, including conventional disc, composition disc, plug-type disc, and angle valves. Describe high-pressure plug-type control valves.
5. Describe the designs, application and operation of single-seated and double-seated balance valves. Explain caged trim for balanced control valves.
6. Describe the designs and applications of typical plug valves, including tapered and cylindrical plug, four-way, eccentric, and jacketed.
7. Describe the designs and configurations for mixing and diverter valves.
8. Describe the designs and operation of diaphragm valves.
9. Describe designs and operation of butterfly valves, including vertical, horizontal, swing-through, lined, and high-performance.
10. Describe the design, application, and operation of gear, motor, air-diaphragm, and air-piston actuators for valves.

Topic 6 Safety Management Systems

Learning Outcome

Discuss typical legislation and programs that manage safety in the industrial workplace.

Learning Objectives

1. Explain the general intent, power and scope of Occupational and Safety Health Act (OSHA) legislation.
2. Explain the intent and scope of a workplace OSHA program and state the responsibilities of company, employees, and the OH&S Committee within the program.
3. Define and give examples of typical workplace hazards and describe a system of hazard identification and control.
4. Explain the purpose of work permits and describe typical hot and cold work permit systems.
5. Explain the purpose of equipment lockout, describe lockout devices, and describe a typical equipment lockout procedure.
6. Define and identify a confined space and a permit-required confined space, describe a typical confined space permit and entry procedure.
7. Explain the hazards of excavation and describe typical excavation procedures and permits.
8. Explain the purpose and describe the typical components of an emergency response plan.
9. State the purpose of OSHA Hazard Communication Standard, explain the use of labels and material safety data sheets, and explain the responsibilities of employer and employee.
10. Explain the purpose, requirements, and procedures for incident and accident investigation and reporting.

Topic 6 Fire Protection Systems

Learning Outcome

Discuss the classes and extinguishing media of fires, and explain systems that are used to detect and extinguish industrial fires.

Learning Objectives

1. Explain the classifications of fires and describe the extinguishing media that are appropriate for each classification.
2. Describe the components and operation of a typical fire detection and alarm system in an industrial setting.
3. Describe the design and operation of a typical standpipe system.
4. Describe the wet pipe, dry pipe, preaction and deluge designs for sprinkler systems.
5. Describe the layout, components and operation of a typical firewater system with fire pump and hydrants. Explain seasonal considerations for a firewater system.
6. Describe the construction and operation of a typical fire hydrant.
7. Explain the purpose and describe a typical deluge water system for hydrocarbon storage vessels.
8. Explain the purpose and describe a typical foam system for process buildings and tanks.
9. Describe a typical fire response procedure for an industrial setting.

Major Topic: Pumps and Boilers

Topic 1 Boiler Construction

Learning Outcome

Explain Code requirements, in general terms, and describe construction and assembly methods for the major components of a large boiler.

Learning Objectives

1. Explain top and bottom support and describe the support techniques for various components of a large boiler, including lateral supports for furnace walls. Explain allowances for expansion.
2. Explain the purpose, design, locations and installation methods for boiler casing insulation, refractory, and cladding.
3. Describe the methods used to fabricate boiler tubes.
4. Describe the preparation, fabrication, and testing of boiler drums.
5. Describe methods of attaching tubes to drums and headers, including expanding and welding, and explain where each method would be used.
6. Explain code requirements/sizes for, and describe the designs and installation of, manholes and handholes, including welded handholes. Explain procedures for removing and installing covers.
7. Describe the field assembly of a large boiler or steam generating unit.

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Topic 2 Boiler Heat Transfer Components

Learning Outcome

Explain the purpose, location, design and operating conditions for the major heat transfer components of a large watertube boiler or steam generator.

Learning Objectives

1. Describe baffle designs and locations and explain their significance to boiler heat transfer.
2. Describe the designs of integral furnace sidewall and header arrangements, including tube-and-tile, tangent tube, and membrane.
3. Define primary, secondary, convection, radiation, platen, and pendant as they apply to superheaters. Describe the locations of superheaters within a steam generator and state the operating characteristics of convection and radiant superheaters.
4. Explain the purpose and design of a separately-fired superheater.
5. Explain the purpose and describe the locations of reheaters. Explain the position of and flow through the reheater in relation to the superheaters.
6. Describe designs and locations for integral and separate economizers.
7. Describe the designs, operation, and location of plate, tubular, and rotary regenerative air heaters.
8. Explain operating care and considerations that must be given to the various heat transfer sections of the boiler.
9. Explain a typical water and gas temperature profile through a large steam generating unit.

Topic 3 High Pressure Boiler Fittings

Learning Outcome

Describe the design and operation of common external and internal fittings attached to the pressure side of a high-pressure boiler.

Learning Objectives

1. Describe the design, installation, operation, and setting of a high-pressure pressure relief valve. Explain the Code requirements for size, capacity and locations of the pressure relief valves on a boiler.
2. Describe the code requirements for boiler pressure gages, including attachment and locations.
3. Describe common designs, connections and components of high-pressure water columns and flat gage glasses, including illumination and quick shut-off devices and bulls-eye glasses. Explain testing and maintenance of a high-pressure gage glass.
4. Describe the float and probe designs for low-water fuel cutoffs and explain how these are tested.
5. Describe boiler steam outlet arrangements and fittings including gate, angle, and globe stop valves and globe, Y, angle, and spring-cushioned non-return valves.
6. Describe manual blowoff piping arrangements. Describe the design and operation of sliding disc, seatless sliding plunger, seat and disc, and combination valves. Explain manual blowoff procedures. Describe the requirements for a blowoff tank.
7. Explain the components of the steam drum internals of a watertube boiler. Describe the design and operation of various steam separation devices, including baffles, primary and secondary separators, and scrubbers.

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Topic 4 Burner Designs and Supply Systems

Learning Outcome

Describe the typical components of fuel supply systems and describe common burner/furnace designs for gas, oil, and coal-fired boilers.

Learning Objectives

1. Describe a complete fuel gas supply system from fuel gas header to burner and explain the function of each component, including control and shut-off valves, auto-vents, and instruments. State the typical operating pressures.
2. Describe the design and operation of spud and ring burners, and explain high-efficiency, low NO_X designs.
3. Describe a complete fuel oil supply system from storage tanks to burners and explain the function of each system component.
4. Describe the design and operation of air, steam, and mechanical atomizing burners.
5. Describe a coal supply system from stockpiles to burners for a typical pulverized coal furnace.
6. Describe the design and operation of a pulverized coal burner and explain turbulent vertical, tangential, and cyclone furnaces.
7. Describe the design and operation of ball, impact, ball-race, and bowl mill pulverizers.
8. Describe the designs and operation of underfeed, overfeed, and crossfeed stokers for furnaces burning solid fuels.

Topic 5 Boiler Draf t and Flue Gas Equipment

Learning Outcome

Explain boiler draft systems and fans and describe the equipment used to remove ash from flue gas.

Learning Objectives

1. Define and explain the applications and designs of natural, forced, induced and balanced draft.
2. Explain how draft is measured, monitored, and controlled in a large, balanced draft boiler. Explain the position of control dampers.
3. Describe typical draft fan designs, single and double inlet arrangements, and explain methods used to control fan output.
4. Explain the start-up and running checks that must be made on draft fans.
5. Describe typical windbox and air louver arrangements and distinguish between primary and secondary air.
6. Describe the design and operation of flue gas particulate clean-up equipment, including mechanical and electrostatic precipitators and baghouse filters.
7. Describe the design and operation of ash handling systems, including hydro and air systems, bottom ash systems, and scraper conveyor systems.
8. Describe the designs and operation of SO_2 recovery systems, including lime and wet gas scrubbing.

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Topic 6 Boiler Control Systems

Learning Outcome

Explain the components and operation of automatic control systems for boiler water level, combustion, steam temperature, and start-up.

Learning Objectives

1. Describe on-off and single element control of boiler feedwater.
2. Explain swell and shrinkage in a boiler. Describe the components and operation of a two-element feedwater control system, explaining the interaction of the controllers.
3. Describe the components and operation of a three-element feedwater control system.
4. Describe the components and operation of a direct combustion control system.
5. Describe the components and operation of a ‘steam flow – airflow’ combustion control system.
6. Describe the components and operation of a ‘fuel flow – airflow’ combustion control system.
7. Describe the components and operation of an ‘airflow – fuel flow’ combustion control system.
8. Describe the components and operation of a multi-element combustion control system.
9. Describe steam temperature control methods and equipment, including attemperation (desuperheating), gas recirculation, gas bypass, and tilting burners.
10. Describe the automatic, programmed start-up sequence for a gas-fired boiler.

Topic 7 Boiler Procedures

Learning Outcome

Describe common procedures in the operation and maintenance of high pressure boilers.

Learning Objectives

1. Explain the steps involved in the commissioning of a new boiler or before starting a boiler after major repairs, including:
   a) hydrostatic test
   b) external and internal inspections
   c) drying out refractory
   d) boiling out
   e) testing shutdowns and safety devices
2. Describe the wet and dry methods when laying up a boiler for an extended time, including nitrogen blanketing.
3. Describe the proper shut down and preparation of a boiler for internal inspection.
4. Describe a thorough inspection of the water and furnace sides of a boiler.
5. Describe typical equipment and procedures for cleaning the water side of a boiler:
   a) mechanically
   b) chemically
6. Explain routine tasks and visual monitoring that the operator must perform on a large operating boiler.
7. Explain the procedures and precautions that an operator must exercise to avoid furnace and pressure-side explosions.
8. Describe sootblowing systems and describe the procedures for operating sootblowers.

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Topic 8 Internal Water Treatment for Boilers

Learning Outcome

Discuss internal water treatment methods and systems for the control of scale, corrosion, and carryover and explain testing and monitoring strategies.

Learning Objectives

1. Explain the causes and effects of boiler scale; explain the most common internal methods of scale control, including phosphate treatment, chelate treatment, sludge conditioning and dispersion.
2. Explain the causes and effects of boiler and condensate return line corrosion; explain treatment methods for acidic, caustic, oxygen, and carbon dioxide corrosion, including sulphite, hydrazine, and amine treatment.
3. Explain the mechanical and chemical causes, effects and types of carryover; explain methods of carryover control, including the use of antifoam and blowdown.
4. Describe the design and explain the operation of simple blowdown, heat recovery, and automatic blowdown systems.
5. Explain, in general terms, the sampling and testing strategies for boiler internal conditions; describe typical sampling and automatic monitoring equipment.
6. Describe typical chemical feed systems, including pot feeders, continuous feed with day tanks, and continuous feed with pump tanks.

Topic 9 Boiler Water Pretreatment

Learning Outcome

Explain the purpose, principles, equipment, and monitoring of boiler water pretreatment processes.

Learning Objectives

1. Describe the design and explain the terms, purpose and operation of a clarifier, using coagulation, flocculation, and subsidence.
2. Describe the design and explain the terms, purpose and operation of gravity and pressure filters.
3. Describe the design and explain the terms, purpose and operation, including chemical reactions for a cold lime softener.
4. Describe the design and explain the terms, purpose and operation of a hot lime softener.
5. Explain the principles of ion exchange softening in general, identifying the common anions and cations in untreated water.
6. Describe the design, components, and operation of a sodium zeolite softening system including chemical reactions.
7. Describe the design, components, and operation of a hydrogen zeolite softening system including chemical reactions.
8. Describe the design, components, and operation of a dealkalization system including chemical reactions.
9. Describe the design, components, and operation of a demineralizer system, including mixed bed and degasification.
10. Explain the principle and operation of a reverse osmosis system.
11. Describe the design, principle, and operation controls of a typical deaerator.

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Topic 10 Pump Designs and Operation

Learning Outcome

Describe the designs, principles, components and operating procedures for common industrial pumps.

Learning Objectives

1. Explain the principle of operation and describe the components of typical plunger, piston and diaphragm reciprocating pumps.
2. Explain the designs and operating principles of the external gear, internal gear, sliding vane, lobe, and screw type rotary pumps.
3. Explain the designs and operating principles of volute and diffuser centrifugal pumps, including impeller designs.
4. Describe centrifugal pump arrangements, including vertical, horizontal, single and double suction, opposed impellers, multi-staging, split and barrel casings.
5. Describe the design and applications of axial and mixed flow pumps.
6. Describe the design and components of a multistage centrifugal pump, clearly stating the purpose and general design of: wear rings, shaft sleeves, seals, bearings and lubrication components, vents and drains.
7. Explain design features that eliminate thrust in large centrifugal pumps.
8. Describe systems used to maintain minimum flow through a centrifugal pump.
9. Explain priming, start-up, capacity control and operating cautions for centrifugal pumps.

Topic 11 Welding Procedures and Inspection

Learning Outcome

Explain the processes and applications of different welding techniques and describe the testing of welds and procedures.

Learning Objectives

1. Describe the equipment, procedure and applications of shielded metal arc welding (SMAW). Explain the classification of arc welding electrodes.
2. Describe the equipment, procedure and applications of submerged arc welding (SAW).
3. Describe the equipment, procedure and applications of gas tungsten arc welding (GTAW).
4. Describe the equipment, procedure and applications of gas metal arc welding (GMAW).
5. Explain weld preparation and terminology of a butt weld; explain preheating and post-weld heat treatment.
6. Describe common defects in welds, including undercut, lack of penetration, porosity, slag inclusion, and cracking; explain how each occurs and its effect on the integrity of the weld.
7. Explain the equipment and procedures for dye penetrant, magnetic particle, radiographic, and ultrasonic inspection of a weld; explain the potential weld defects revealed by each test.
8. Explain the requirements and process for Weld Procedure and Welder Performance qualification, per the ASME Code, Section IX.

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Major Topic: Prime Movers and Refrigeration

Topic 1 Internal Combustion Engines

Learning Outcome

Explain the operating principles, designs, support systems, and operation of industrial internal combustion engines (ICE).

Learning Objectives

1. Explain the principles of spark ignition and compression ignition; describe the operating cycles for two-stroke and four-stroke designs.
2. Identify and state the purpose of the major mechanical components of an internal combustion engine.
3. Describe carburetor, fuel injection, battery ignition, and magneto ignition systems for a spark ignition engine.
4. Describe individual pump, distributor, and common rail fuel injection systems for a diesel engine.
5. Explain the purpose and describe the operation of superchargers and turbochargers.
6. Describe and explain the operation of a typical cooling system for an industrial ICE.
7. Describe and explain the operation of a typical lubrication system for an industrial ICE.
8. Describe engine-starting devices/systems for diesel and gas engines.
9. Explain the monitoring, protection and control devices on a large industrial diesel or gas engine, including shutdowns and governing.
10. Explain a typical start-up procedure for a large industrial diesel engine, plus the routine monitoring requirements of a running engine.

Topic 2 Cogeneration Systems and Operation

Learning Outcome

Explain cogeneration and describe common configurations, components and applications.

Learning Objectives

1. Define cogeneration and explain its purpose, advantages, and applications.
2. Explain the components and operation of simple-cycle cogeneration systems.
3. Explain the components and operation of combined-cycle, gas/steam turbine cogeneration systems.
4. Explain the components and operation of a fully fired, combined-cycle cogeneration system.
5. Explain single-shaft and dual-shaft combined-cycle power plants.
6. Explain the general control strategies and components, for both power and steam production, including diverter and duct burner operation.
7. Describe the various designs of heat recovery steam generators (HRSGs) and explain their industrial applications.
8. Explain the environmental considerations and techniques in the operation of a cogeneration system.
9. Describe typical cogeneration systems that use internal combustion engines (gas or diesel) and heat recovery water heaters (HRWHs).
10. Explain a typical start-up procedure for a combined cycle cogeneration system.

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Topic 3 Compressor Theory and Designs

Learning Outcome

Explain the classification, designs, and operating principles of industrial air and gas compressors.

Learning Objectives

1. Explain compressor terminologies, including compression ratio, capacity, staging, intercooling and aftercooling. Explain the effects of moisture in compressed gases. Explain the effects of altitude on the compression process.
2. Describe the operation and common arrangements of reciprocating compressors, including single-acting, double-acting, and tandem arrangements.
3. Identify the components of a reciprocating compressor and describe the operation of plate and channel valves.
4. Describe internal and external lubrication systems for reciprocating compressors.
5. Describe the design and explain the operating principles of rotary compressors, including sliding vane, rotary lobe, and rotary screw.
6. Identify the components and controls for a packaged industrial screw compressor.
7. Describe designs and principles of centrifugal compressors/blowers, including single and multi-stage designs.
8. Describe designs and principles of axial compressors/blowers.

Topic 4 Compressor Auxiliaries and Operation

Learning Outcome

Explain the controls and system auxiliaries for a typical instrument air system and explain startup procedures for air compressors.

Learning Objectives

1. Describe the control devices and strategies for air compressors, including start-and-stop, variable speed, constant speed; describe pilot and unloader devices.
2. Explain the design and operation of an anti-surge system for a dynamic compressor.
3. Describe the designs of water and air-cooled aftercoolers and intercoolers, with separators.
4. Describe the components, arrangement, and parameters of a typical, complete instrument air system, including wet and dry receivers, dryers.
5. Describe the components and operating principles and sequences of instrument air dryers. Explain dewpoint monitoring of air systems.
6. Describe the design, fittings, and operating consideration for air receivers.
7. Explain the start-up procedure for a positive displacement compressor.
8. Explain the start-up procedure for a dynamic compressor/blower.

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Topic 5 Refrigeration Principles and Systems

Learning Outcome

Explain the classification and properties of refrigerants and describe the operating principles and components of compression and absorption systems.

Learning Objectives

1. Explain the required properties of a refrigerant and describe the six group classifications for refrigerants. Identify the properties of common refrigerants.
2. Explain the ammonia compression refrigeration cycle, explaining the purpose of each major component and stating typical pressures and temperatures in the system.
3. Explain direct and indirect refrigeration. Describe a centrifugal compression system, using chilled water.
4. Describe and explain the operation of a two-stage, duplex compressor system with a brine cooler.
5. Describe and explain the operation of a two-stage refrigeration system with a rotary booster compressor.
6. Describe and explain the operation of a low-temperature multi-stage refrigeration system.
7. Explain the components and operating principle of an ammonia absorption system.

Topic 6 Heat Exchangers and Cooling Towers

Learning Outcome

Describe the design, operation, and applications of various types of industrial heat exchangers.

Learning Objectives

1. Describe double pipe heat exchangers, including jacketed pipe, U-tube, and concentric pipe designs.
2. Describe shell-and-tube heat exchangers including fixed straight tube and U-tube designs. Describe common front and rear head designs, shell flow configurations, and explain the purpose of baffles.
3. Explain the operation and the typical fittings/equipment on the steam/condensate side of a reboiler and a feed water heater.
4. Describe the design and operation of a plate-and-frame exchanger.
5. Describe the design and components of overhead, aerial coolers, including fan and cooler arrangements. Explain cooler control
6. Describe the design and components, including controls, of an overhead, aerial condenser. Explain condenser operation, control and precautions when used to condense excess steam.
7. Describe the design and explain the operation of natural draft cooling towers, including atmospheric and hyperbolic styles
8. Describe the design and operation of mechanical draft cooling towers, including forced draft, induced draft counterflow, and induced draft crossflow.

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Topic 7 Wastewater Treatment

Learning Outcome

Explain the purpose, designs, processes and control of industrial wastewater treatment.

Learning Objectives

1. State the purpose of wastewater treatment, list typical waste liquids, and explain the legislation and permitting, including parameters, for the disposal of wastewater.
2. Sketch an industrial wastewater treatment system and describe the processes that occur at each stage of treatment.
3. Describe the equipment and process involved in the removal of suspended solids from wastewater, including screening, flotation, and sedimentation.
4. Describe the equipment and process involved in the removal of colloidal solids from wastewater, including chemical coagulation, flocculation, and clarification.
5. Describe the equipment and process involved in the biological removal of solids from wastewater, including activated sludge, rotating biological contactors, and trickling filters.
6. Describe the control strategy for a wastewater treatment system. Define and explain the control of and sampling points for the main control parameters, including nutrients, BOD, COD, pH, and settle ability.

Topic 8 Plant Maintenance and Administration

Learning Outcome

Explain typical components of maintenance and administration programs for utilities and process facilities.

Learning Objectives

1. Explain typical communication and accountability structures within a large facility, including the responsibilities for external communication.
2. Describe the typical components and responsibilities of scheduled and preventive maintenance management programs.
3. Explain the importance and extent of record keeping and describe the quality and content requirements for operating logbooks and records.
4. Using a complete boiler turnaround and inspection as an example, describe project management using two methods, Gantt Chart and critical path.
5. Explain the importance of procedures in the operation of a facility and describe the application of well-written procedures to personnel training and daily operation.
6. Explain typical environmental monitoring and management programs for operating facilities.

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REFERENCE CURRICULUM

For

Facility Engineer (2nd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
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Introduction

This Curriculum is intended to assist candidates studying for the Facility Engineer (2nd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Facility Engineer (2nd Class) Examination Candidates

Major Topic: Elementary Physical, Chemical, and Thermodynamic Principles

Topic 1 Introduction to Matter and Chemistry

Learning Outcome

Identify basic types of matter, their properties, and the associated chemical principles.

Learning Objectives

1. Differentiate among the physical states of matter.
2. Differentiate between chemical and physical changes in matter.
3. Classify matter as either a type of mixture or a pure substance.
4. Describe the purpose and uses of the periodic table using the parts of an atom.
5. Describe the three main ways atoms bond together: covalent, ionic, and metallic bonding.
6. Discuss chemical equations and their purpose.
7. Perform simple stoichiometric calculations.
8. Demonstrate how unstable compounds are combined to make stable compounds.

Topic 2 Introduction to Thermodynamics

Learning Outcome

Explain the principles and laws of thermodynamics.

Learning Objectives

1. Define the first two laws of thermodynamics.
2. Define heat and specific heat, and perform sensible heat calculations.
3. Describe the expansion of solids and liquids.

Topic 3 Introduction to Heat Transfer and Heat Exchangers

Learning Outcome

Explain the modes of heat transfer and the theory of heat exchanger operation.

Learning Objectives

1. Describe the three modes of heat transfer with reference to heat exchangers.
2. Discuss the general design and construction of typical heat exchangers.
3. Describe heat transfer fluids and how they affect the operation of a heat exchanger, including fouling, leakage, and vapour locking.
4. Describe heat exchanger inspection, maintenance, and operation, including placing them in service and removing them from service.

Topic 4 Thermodynamics of Steam

Learning Outcome

Apply the thermodynamics principles through practical applications using the steam tables and the temperature-enthalpy chart.

Learning Objectives

1. Describe heat as it relates to steam, water, and ice.
2. Explain the various columns of the steam tables.
3. Explain the thermodynamic principles of steam, using the steam tables.

Major Topic: Introduction to Plant and Fire Safety

Topic 1 Introduction to Plant Safety

Learning Outcome

Describe general plant safety as it related to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may be in an energy plant, and the basic Personal Protective Equipment that may be required.
3. Define, give examples of, and describe common power house hazards.
4. Describe Industrial health and safety management system.
5. Describe Hazard Assessment and Control programs.

Topic 2 Plant Safety Programs

Learning Outcome

Describe common safety programs generally applied in plants.

Learning Objectives

1. Describe common occupational health and safety (OH&S) programs found in most plants.
2. Describe industrial safety programs in which Power Engineers may require additional training.
3. Discuss safe work permits.
4. Describe methods of equipment isolation and lock out.

Topic 3 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous materials.

Learning Objectives

1. Discuss the WHMIS system.
2. Discuss the essential components required in the WHMIS systems.
3. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
4. Discuss the safe handling of Hydrocarbons.

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Topic 4 Plant Fire Safety

Learning Outcome

Explain fire safety in an industrial plant.

Learning Objectives

1. Discuss the theory, terminology, and the life safety issues associated with fires.
2. Explain the five classes of fires, and describe the types of fire extinguishing media and how they act on these fires.
3. Explain fire prevention.
4. Discuss fire prevention methods for the five types of fires.

Topic 5 Fire Extinguishing Methods and Equipment

Learning Outcome

Describe typical fire extinguishing equipment and its operation in plant environments.

Learning Objectives

1. Describe the construction and operation of various types of portable fire extinguishers.
2. Discuss the inspection and maintenance requirements of portable fire extinguishers.
3. Describe the types, layout, and operation of standpipe and sprinkler systems.
4. Discuss the maintenance requirements of standpipe and sprinkler system components.
5. Describe the purpose, operation, and maintenance of fire pumps.

Major Topic: Introduction to Plant Operations and the Environment

Topic 1 Introduction to the Environment

Learning Outcome

Identify environmental considerations and how they relate to an operating plant.

Learning Objectives

1. Describe four important Biogeochemical Cycles that operate within the environment.
2. Describe typical interdependencies seen among elements within an “ecosystem.”
3. List the types of impacts that operating facilities can have on the environment.
4. Describe the alert processes related to environmental problems of plants.
5. Explain the importance of “attitude” in limiting environmental impacts of plants.
6. Describe the long-term environmental impacts after the decommissioning and abandonment of plants.

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Topic 2 Gas and Noise Emissions

Learning Outcome

Explain how gas and noise emissions affect plant operations.

Learning Objectives

1. Identify the sources and effects of common gases and vapours that have an adverse environmental impact.
2. Identify the common greenhouse and acid rain causing gases and describe their effects.
3. Describe the common methods for monitoring and reducing gaseous pollutants.
4. Describe the effects of noise pollution and methods of identifying, measuring, and controlling it.

Topic 3 Liquid and Solid Emissions

Learning Outcome

Explain how liquid and solid emissions affect plant operation.

Learning Objectives

1. Describe the sources and effects of solid pollutants from energy plants.
2. Describe the theory of operation of separators/collectors and monitoring of flue gas particulates.
3. Describe the disposal methods of solid waste from energy plants.
4. List sources and effects of liquid and thermal pollution.
5. Describe the preventive measures that can be taken to prevent liquid and thermal pollution.
6. Describe methods of liquid waste disposal.

Major Topic: Introductory Fluid Handling Technology Topic 1

Introduction to Energy Plant Piping Systems Learning Outcome

Discuss the basic types of piping, piping connections, supports, and drainage devices used in industry.

Learning Objectives

1. State the applications for the most common materials and identify the sizes of commercial pipe.
2. Describe methods of connection for screwed, flanged, and welded pipe; identify fittings and their markings.
3. Describe methods and devices used to allow for pipe expansion and support.
4. Explain the methods used to promote good drainage of steam pipes, including the installation and maintenance of steam traps, to reduce the effects of water hammer.
5. Explain the requirements, materials, and methods for insulating pipe.

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Topic 2 Introduction to Energy Plant Valves

Learning Outcome

Discuss the design and uses of the valve designs most commonly used in industry and on boilers.

Learning Objectives

1. Describe standard valve designs.
2. Describe design and operation of specialized boiler valves.
3. Describe a typical steam pressure reducing station, and the design and operation of steam system pressure-reducing valves.
4. Discuss valve details, including materials of construction and identification markings.
5. Describe typical valve maintenance requirements.

Major Topic: Basic Concepts in Electrotechnology

Topic 1 Basic Electricity

Learning Outcome

Apply the concepts of basic electricity while performing simple calculations using voltage, current, resistance, and power.

Learning Objectives

1. Describe the atomic structure of matter and its relationship to electricity.
2. Describe basic electrical circuits.
3. State Ohm's Law and apply it to single-resistor circuits.
4. Apply Ohm's Law to series resistance circuits.
5. Apply Ohm's Law to parallel resistance circuits.
6. Explain electrical conductors and insulators using examples.
7. Explain the factors that affect resistance mathematically.
8. Calculate the power developed in an electrical circuit.

Major Topic: Fundamental Industrial Communication Skills

Topic 1 Plant Communications

Learning Outcome

Describe the types and proper usage of plant communication systems.

Learning Objectives

1. Discuss effective written and verbal communication skills, including the use of two-way radios.
2. Describe the legal documentation requirements for Power Engineers, including log books and log sheets.
3. Discuss the elements of Maintenance Management Systems, including work requests, and work orders.
4. Discuss the purpose, revision, and control of Standard Operating Procedures.
5. Discuss updating procedures for piping and instrumentation diagrams.

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Major Topic: Introduction to Boiler Designs

Topic 1 Introduction to Boilers

Learning Outcome

Describe the historical development of boilers, boiler design, components, and configuration.

Learning Objectives

1. Describe the history of boiler applications, boiler design, and modern boiler improvements.
2. Describe packaged boilers.
3. Describe the construction of shop-assembled and field-erected boilers.
4. Describe components and design aspects common to all boiler vessels.

Topic 2 Firetube Boilers

Learning Outcome

Describe the design, components, and characteristics of firetube boilers.

Learning Objectives

1. Differentiate the Scotch Boiler from the other firetube boilers, and describe its development history.
2. Describe circulation patterns in firetube boilers.
3. Discuss construction details of firetube boilers.

Topic 3 Watertube Boilers

Learning Outcome

Describe the design, components, and characteristics of watertube boilers.

Learning Objectives

1. Describe the design and operating principles of watertube boilers.
2. Describe watertube boiler components.
3. Explain the design and application of packaged watertube boilers.
4. Describe the design, construction, and components of large-scale steam generating units.

Topic 4 Electric Boilers

Learning Outcome

Explain the general design and application of electric boilers.

Learning Objectives

1. Discuss the advantages and disadvantages of electric boilers.
2. Describe the construction and operating principle of electric boilers.

Topic 5 Special Boiler Designs for Heating Plants

Learning Outcome

Describe the special design considerations of boilers used in heating plants.

Learning Objectives

1. Describe the design of watertube and coil tube heating boilers.
2. Describe cast iron boilers and vertical firetube boilers.
3. Describe the construction and application of firetube heating boiler designs.

Major Topic: Elements of Boiler Systems

Topic 1 Combustion

Learning Outcome

Discuss the basic theory of combustion, and the equipment used to provide proper combustion conditions within a boiler.

Learning Objectives

1. Discuss combustion, combustion equations, and the relationship between theoretical and excess air.
2. Discuss the characteristics of solid, liquid, and gaseous fuels.
3. Explain the effects of fuels and combustion on refractory materials.

Topic 2 Fuel Delivery and Firing Systems

Learning Outcome

Describe common fuel systems found in boiler systems.

Learning Objectives

1. Describe solid fuel delivery systems.
2. Describe the main types of solid fuel firing systems.
3. Describe gaseous fuel delivery systems.
4. Describe the main types of gaseous fuel firing systems.
5. Describe liquid fuel delivery systems.
6. Describe the main types liquid fuel firing systems.
7. Describe flue gas analysis and how it relates to boiler efficiency.

Topic 3 Draft

Learning Outcome

Describe basic concepts and equipment used to supply combustion air to boiler furnaces.

Learning Objectives

1. Describe the various air streams that deliver combustion air to a furnace.
2. Relate differential pressure to the creation of draft.
3. Describe forced, induced, and balanced mechanical draft.
4. Discuss common methods of controlling combustion airflow.
5. Discuss common methods of measuring furnace pressures.

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Topic 4 Feedwater Systems

Learning Outcome

Describe feedwater systems used with boilers.

Learning Objectives

1. Describe the overall layout of feedwater, condensate, and make-up water systems.
2. Describe the valves used in feedwater systems.
3. Describe the control strategies for single-element, two-element, and three-element boiler feedwater systems.
4. Describe methods of supplying feedwater to steam heating boilers.
5. Explain the operation of condensate receiver make-up water controls.
6. Describe the return of condensate, and the supply of feedwater to high-pressure boilers.

Topic 5 Blowof f and Blowdown Systems

Learning Outcome

Describe the equipment, operation, and purpose of boiler blowoff and blowdown systems.

Learning Objectives

1. Describe blowoff, blowoff equipment and blowoff procedures.
2. Describe continuous blowdown, blowdown equipment, and blowdown procedures.
3. Describe the maintenance and repair of blowoff systems.

Topic 6 Boiler Fireside Cleaning Systems

Learning Outcome

Describe types of boiler fireside cleaning equipment, their purpose, and their operation.

Learning Objectives

1. Describe common options for in-service fireside cleaning.
2. Describe the construction and operation of retractable soot blowers.
3. Describe the construction and operation of stationary soot blowers.
4. Describe falling shot cleaning methods.

Major Topic: Lubrication and Bearings

Topic 1 Lubrication Principles

Learning Outcome

Describe the importance of lubrication and the principles concerned with lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and application.
3. List the properties of lubricating oils, the additives used, and their selection criteria.

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Topic 2 Types of Bearings and Lubrication

Learning Outcome

Describe bearing types, methods for care and maintenance of bearings, and bearing lubrication systems.

Learning Objectives

1. Define boundary and full fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of antifriction and thrust bearings.
4. Describe how to clean and replace roller and ball type bearings.
5. Explain the causes of bearing failure.

Major Topic: Pumps and Compressors

Topic 1 Types of Pumps

Learning Outcome

Describe the construction and operating principles of various types of pumps used in plants.

Learning Objectives

1. List common pump applications.
2. Define the terms associated with pump performance.
3. Describe the common pumps found in plants.

Topic 2 Pump Operation and Maintenance

Learning Outcome

Describe the major considerations and procedures for pump operation and maintenance.

Learning Objectives

1. Discuss the components of a driver and pump assembly.
2. Discuss pump shaft sealing, compression packing, and the replacement of compression packing.
3. Describe the standard types of mechanical seals.
4. Describe pump bearings, shaft alignment procedures, and the equipment used to align shafts.
5. Describe centrifugal pump startup and priming procedures.
6. Describe positive displacement pump operating characteristics, priming, startup, and routine checks.

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Topic 3 Introduction to Compressors

Learning Outcome

Describe the operating principles of the different types of compressors.

Learning Objectives

1. Describe the main classifications and types of compressors.
2. Describe gaseous compression systems.

Topic 4 Compressor Operation and Maintenance

Learning Outcome

Describe the major considerations and general procedures for compressor operation and maintenance.

Learning Objectives

1. Describe compressor parts and auxiliary equipment.
2. Describe the construction and operation of seals for compressors.
3. Describe the capacity control of compressors.
4. Describe preventative maintenance and routine procedures for compressors.

Major Topic: Boiler Safety Devices Topic 1

Pressure Relief Valves Learning Outcome

Explain the code requirements, design, and operation of pressure relief valves for power boilers, heating boilers, and pressure vessels.

Learning Objectives

1. Discuss the code requirements, construction, and operation of ASME Section I Pressure Relief Valves and Devices.
2. Discuss the code requirements, construction, and operation of ASME Section IV Pressure Relief Valves and Devices.
3. Describe the testing and repair of pressure relief valves.
4. Describe the construction and operation of temperature and pressure relief valves.

Topic 2 Combustion Safety

Learning Outcome

Explain the design and operation of combustion safety controls on burners and boilers.

Learning Objectives

1. Describe the operation of control and safety devices found on boiler fuel supplies.
2. Describe the construction and operation of flame detectors.
3. Describe the combustion safety controls for boilers and burner systems.
4. Describe burner management systems.
5. Interpret burner operating sequence charts, and provide a typical sequence of startup and shutdown events.

Topic 3 Water Level Safety Controls

Learning Outcome

Describe feedwater devices, and control methods used on boilers.

Learning Objectives

1. Describe the construction and operation of boiler low water level fuel cut-off equipment.
2. List the CSA and ASME code requirements regarding low water fuel cut-off devices.
3. Describe direct and indirect type boiler water level indicators.

Topic 4 Boiler Fittings

Learning Outcome

Relate the code, operation, and required fittings to the operating principles of fittings found on boilers.

Learning Objectives

1. Explain the code references for boiler fittings.
2. Describe the code requirements for pressure gauges on steam boilers.
3. Describe the code requirements for the boiler connections and valves on steam boilers.
4. Describe the code requirements for fittings on hot water heating boilers.
5. Describe the non-code fittings used on boilers.

Topic 5 Firing Rate Controls

Learning Outcome

Describe the operating and safety controls found on boilers.

Learning Objectives

1. Describe basic boiler firing rate controls.
2. Discuss various operating controls for steam and hot water boilers.

Major Topic: Boiler Plant Operation and Management

Topic 1 Boiler Plant Startup

Learning Outcome

Describe the operational procedures related to starting up auxiliary equipment in a boiler plant.

Learning Objectives

1. Describe the basic auxiliaries that need to be checked, prepared, or placed in service before starting a boiler plant.
2. Describe the general procedures for starting a plant for the first time, or restarting after an outage or turnaround.
3. Discuss basic operating practices for starting pumps and fans.
4. Describe the general preparation for a hot water boiler startup.
5. Describe the general preparation for a steam boiler startup.
6. Describe the safety and housekeeping preparation requirements for boiler plant startup.

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Topic 2 Boiler Startup

Learning Outcome

Describe procedures for safely starting boiler systems.

Learning Objectives

1. Describe operating considerations when warming a cold boiler.
2. Describe how to start and cut-in a hot water boiler.
3. Describe how to start a single boiler steam plant.
4. Describe how to cut-in a steam boiler in a multiple boiler plant.
5. Describe semi-automatic burner ignition systems.
6. Discuss the post startup inspection for boilers returning to service after a major outage.

Topic 3 Boiler Operation

Learning Outcome

Describe operational procedures related to operating boilers.

Learning Objectives

1. Describe the operation of a hot water heating boiler under routine conditions.
2. Describe routine steam boiler operating duties.
3. Describe emergency conditions in boiler plants and the required responses.
4. Describe basic boiler troubleshooting activities.

Topic 4 Operational Checks

Learning Outcome

Describe operational checks for operating boiler plants.

Learning Objectives

1. Describe the shift based operator responsibilities for boiler plants.
2. Describe the safety device operational checks carried out on boilers.
3. Describe routine maintenance activities for boiler plant operation.
4. Describe the use of Standard Operating Procedures (SOPs).
5. Describe the need for boiler operating and maintenance logs, and the type of information that should be recorded.

Topic 5 Shutdown Procedures

Learning Outcome

Describe generic shutdown and layup procedures for different boiler types.

Learning Objectives

1. Describe hot water boiler shutdown procedures.
2. Describe steam boiler shutdown and lockout procedures.
3. Describe extended period layup requirements for steam boilers.

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Topic 6 Boiler Plant Monitoring and Reporting

Learning Outcome

Describe the points and readings that need to be monitored and recorded in a plant.

Learning Objectives

1. Discuss recording requirements for operating and performance conditions.
2. Discuss the various systems required to conduct equipment repairs, and to manage the related maintenance records.
3. Describe the operational causes, consequences, and prevention of water hammer.
4. Describe the consequences and actions required for various equipment failures.
5. Describe the consequences, and actions required, in the event of boiler accidents.

Major Topic: Energy Plant Maintenance

Topic 1 Energy Plant Maintenance I

Learning Outcome

Describe the safe use of common hand tools in the powerhouse.

Learning Objectives

1. Describe the types and proper use of hacksaws, files, chisels, hammers, screwdrivers, and wrenches.
2. Describe the types and proper use of hand threading tools.
3. Describe the types and proper use of measuring tools.
4. Describe the proper layout of work and the use of layout tools.
5. Describe the types and proper use of portable and fixed grinders, hand drills, drill presses, and the care of drill bits.

Topic 2 Energy Plant Maintenance II

Learning Outcome

Discuss and describe the safe and proper setup of equipment for hoisting and working above ground.

Learning Objectives

1. Describe the requirements for setting up work platforms in general and ladders and scaffolding in particular.
2. Describe the general safety precautions and calculations used when rigging equipment.
3. Describe the general safety precautions used when hoisting equipment.
4. Discuss the correct use and limitations of wire cable and rope, including cable attachments and rope knots.
5. List and describe common types of metal fasteners, such as screws, bolts, studs, nuts, and washers.

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Topic 3 Boiler Maintenance

Learning Outcome

Describe the service and maintenance required for boilers.

Learning Objectives

1. Describe the general maintenance and service of packaged firetube and cast iron sectional boilers.
2. Identify the operational procedures for wet and dry boiler layups.
3. Describe ways of detecting firetube and tubesheet leaks.
4. Describe the general procedure for the removal and replacement of defective firetubes.

Topic 4 Boiler Cleaning

Learning Outcome

Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical and chemical boiler cleaning methods.

Learning Objectives

1. List the steps and precautions to prepare a boiler for inspection.
2. Describe the internal inspection of a boiler.
3. Describe the methods and tools used to mechanically clean boilers.
4. Describe two methods used to chemically clean boilers.

Major Topic: Water Treatment

Topic 1 External Boiler Water Treatment

Learning Outcome

Describe the general principle, methods, and equipment used in preparing raw feedwater for steam production.

Learning Objectives

1. Describe typical impurities and their effects on plant and boiler water pre-treatment systems, and their treatment process.
2. Describe the equipment requirements for pre-treatment of plant water systems.
3. Describe water filtration and the removal of suspended solids.
4. Describe the purpose, processes, and equipment used in water softening.
5. Describe the theory, process, and equipment used in deaeration.

Topic 2 Internal Boiler Water Treatment

Learning Outcome

Describe the general principles, methods, and equipment used for internal boiler water treatment.

Learning Objectives

1. Describe the types of problems, and associated treatments, related to internal boiler water contamination.
2. Describe internal boiler feedwater chemical feed systems.
3. Describe standard boiler water testing.

Topic 3 Condensate Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condensate.

Learning Objectives

1. Describe condensate treatment and the effects of non-treatment.
2. Describe the tests conducted on condensate.

Topic 4 Cooling Tower and Condenser Water Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condenser water, and their effects on the cooling tower.

Learning Objectives

1. Describe the effects of water on condensers and cooling tower materials.
2. Describe condenser and cooling tower water treatment.
3. Describe cooling tower and condenser water tests for common treatment methods.

Topic 5 Recirculating System Water Treatment

Learning Outcome

Describe recirculating water systems, their effects, treatment, and tests.

Learning Objectives

1. Describe recirculating water system corrosion and deposition.
2. Describe the use of sacrificial anodes, and measurement techniques to determine corrosion.
3. Describe glycol system testing requirements.
4. Discuss the monitoring tools, procedures, and tests used in recirculating water systems.

Major Topic: Types of Prime Movers and Heat Engines

Topic 1 Condensers and Cooling Towers

Learning Outcome

Describe the operation and maintenance of condensers and cooling towers.

Learning Objectives

1. Explain the construction and operation of condensers, and how they relate to the operation of cooling towers.
2. Explain the principle of operation, the purpose, and the major components of cooling towers.
3. Describe the construction and operation of natural draft cooling towers.
4. Describe the construction and operation of mechanical draft cooling towers.
5. Discuss cold climate operation for cooling towers.
6. Explain typical problems and resolutions required within the operation of cooling towers.

Chapter 2 Internal Combustion Engines

Learning Outcome

Describe the application, construction, and operation of internal combustion engines.

Learning Objectives

1. Discuss the fuels used in internal combustion engines.
2. Describe the working cycles of the 4-stroke and 2-stroke spark ignition engines.
3. Describe the working cycle of the 4-stroke compression ignition (diesel) cycle.
4. Describe the construction of basic spark and compression engines.
5. Explain the basic operating considerations for diesel engines.

Major Topic: Plant Auxiliary Systems

Topic 1 Lighting Systems

Learning Outcome

Explain the various lighting systems and some of the basic design considerations for lighting a space.

Learning Objectives

1. Describe the common types of lighting equipment and systems.
2. Discuss the different types of artificial light sources.
3. Explain the various methods of lighting control.
4. Describe the general requirements and criteria for emergency lighting in buildings.
5. Discuss the interrelationship between lighting, air conditioning, and energy conservation in buildings.

Topic 2 Building Water Systems

Learning Outcome

Explain the various water supply systems used in buildings.

Learning Objectives

1. Describe the cold water distribution system in a building.
2. Describe the hot water distribution system in a building.
3. Describe the construction and operation of building system hot water heaters, including temperature regulation.
4. List and describe the construction and operation of water system protective devices in buildings.
5. Explain what is meant by “backflow prevention” and describe the common methods used.
6. Describe the maintenance requirements for the components in a building water distribution system.

Topic 3 Drainage Systems

Learning Outcome

Describe the design and components of various drainage systems used in facilities.

Learning Objectives

1. Describe the overall layout of building drainage systems.
2. Describe storm water drainage systems for buildings.
3. Describe how surface runoff is managed in order to minimize environmental impact.

Major Topic: HVAC Fundamentals for Facility Operators

Topic 1 Conditioning the Air

Learning Outcome

Explain the methods and techniques for conditioning air in plants and buildings.

Learning Objectives

1. Discuss the process to condition air for human comfort and health.
2. List the categories and functions of HVAC systems.
3. Describe the operation of air-handling units.
4. Define the terms humidity, relative humidity, and dewpoint.
5. Define the terms dry-bulb temperature, wet-bulb temperature, wet-bulb depression, and how they relate to relative humidity.

Topic 2 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and warm air types of humidifiers.
3. Describe industrial and commercial types of humidifiers.

Topic 3 Fans for Air Distribution Systems

Learning Outcome

Describe the airflow behaviour and movement of air through distribution systems.

Learning Objectives

1. Discuss the theory of airflow and pressure conversions.
2. Describe the major types of air handling fans, their construction, and operation.
3. Interpret fan performance curves.
4. Describe fan motors, drives, and belt guards.
5. Describe fan volume controls.

Topic 4 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems, including various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the various contaminants found in air.
3. Describe the types of air cleaning devices used in industrial/commercial buildings.

Topic 5 HVAC Duct Systems

Learning Outcome

Describe the designs and components of duct systems used in HVAC applications.

Learning Objectives

1. Explain how air duct systems are classified.
2. Describe air duct materials, system layout, fabrication, and installation.
3. Describe air duct leakage.
4. List and describe the types of liners, dampers, and louvres used in air duct systems.
5. Discuss terminal air distribution devices, and the principles of diffusion, induction, entrainment, and aspiration.

Topic 6 Types of Coils and Operation

Learning Outcome

Describe the various types and operation of coils used in HVAC systems.

Learning Objectives

1. Explain how steam, hot water, and glycol coils are sized, configured, and operated to reduce the chance of freezing.
2. Describe the installation recommendations for coils, piping, steam traps, control valves, air vents, and vacuum relief devices.

Major Topic: Building Environmental Systems and Control

Topic 1 Steam Heating

Learning Outcome

Describe the components, operating principles, and maintenance procedures of steam heating systems.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. Describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.
3. Describe standard types of piping and equipment layout for steam heating systems.
4. Describe the general operation and maintenance of steam heating systems.
5. Apply a steam heating system troubleshooting guide.

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Topic 2 Hot Water Heating

Learning Outcome

Describe the various designs, equipment, and operation of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe various types of special hot water heating systems.
4. Describe the purpose and function of standard hot water heating system accessories.
5. Explain how the location of the hot water circulating pump and the expansion tank are determined.
6. Describe the routine operation of hot water heating systems, including cleaning, filling, starting, and use of glycol/antifreeze.
7. Apply a hot water heating troubleshooting guide.

Topic 3 Other Heating Systems

Learning Outcome

Describe common heating systems encountered by Power Engineers.

Learning Objectives

1. Describe natural gas fueled warm air heating systems.
2. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
3. Discuss the concept and application of infrared heating.
4. Describe the different methods of electric heating, and their advantages and disadvantages as compared to other types of systems.

Topic 4 Cooling Systems and Combination Systems

Learning Outcome

Describe central, unitary and combined HVAC systems.

Learning Objectives

1. Describe the general layout and operation of unitary air conditioning systems.
2. Describe the general layout and operation of central air conditioning systems.
3. Describe the general layout and operation of combined air conditioning systems.
4. Discuss how HVAC systems should be operated under different situations.

Topic 5 Heat Gains and Losses, and Heat Recovery Methods

Learning Outcome

Describe heat gains and losses, and common methods for energy recovery.

Learning Objectives

1. Define heat transmission terminology.
2. Describe heat gain and heat loss analysis in a building or plant.
3. Describe the general principles of HVAC heat recovery.

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Topic 6 HVAC Control Strategy

Learning Outcome

Describe the control systems strategies used in HVAC systems.

Learning Objectives

1. Describe a basic ventilation control strategy for HVAC systems.
2. Describe heating control strategies for HVAC systems.
3. Describe humidification, dehumidification, and cooling control strategies for HVAC systems.
4. Describe volume control with static pressure regulation for HVAC systems.

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REFERENCE CURRICULUM

For

Facility Engineer (3rd Class)

National Institute for the Uniform Licensing of Power Engineers, Inc.
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Introduction

This Curriculum is intended to assist candidates studying for the Facility Engineer (3rd Class) Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Facility Engineer (3rd Class) Examination Candidates

Major Topic: Low Pressure Boiler Components and Operation

Topic 1 Watertube Boilers (Heating, Power, and Tubular)

Learning Outcome

Describe the various types of watertube boilers used in small industrial and heating systems.

Learning Objectives

1. Describe the construction of watertube and copper-tubular boilers.
2. Describe the water circulation in a longitudinal drum straight tube boiler.
3. Describe two-drum bent tube boilers, and the advantages of a bent tube boiler compared to a straight tube boiler.
4. Describe the construction of the "A" type, "D" type, and "O" type and the advantages of packaged watertube boilers.

Topic 2 Cast-Iron Sectional and Modular Boilers

Learning Outcome

Describe and explain the uses of cast-iron boilers.

Learning Objectives

1. Describe the general construction of cast-iron sectional boilers.
2. List the advantages of cast-iron sectional boilers over watertube and firetube boilers.
3. Describe the arrangement of equipment in a multiple cast-iron sectional boiler heating plant.
4. Describe the construction and operation of cast-iron modular boilers.

Topic 3 Firetube Boilers (Heating and Power)

Learning Outcome

Describe the various types of firetube boilers used in power and heating systems.

Learning Objectives

1. Explain the difference between power and heating boilers.
2. Describe the historical significance, the construction, and application of the early types of firetube boilers: the HRT, or horizontal return tubular, locomotive, and firebox boilers.
3. Describe the construction and application of wetback and dryback Scotch boilers.
4. Describe the construction and application of vertical firetube boilers and tubeless boilers used in heating plant service.
5. Describe the construction of packaged firetube boilers.

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Topic 4 Electric Boilers

Learning Outcome

Describe electric boilers with regard to their use and general design.

Learning Objectives

1. Compare electric boilers to fuel-fired boilers.
2. Describe the construction and operating principle of electrode-type electric boilers.
3. Describe the construction and operating principle of immersion-type electric boilers.

Topic 5 Basic Fittings for Steam Boilers

Learning Outcome

Name, identify, and explain the operating principles and the differences, if any, between the following low and high pressure boiler fittings: pressure gauges, gauge siphons, safety valves, gauge glasses and water columns, safety shutoff valves, quick opening valves, stop valves, check valves, and vent valves.

Learning Objectives

1. Describe the construction, purpose, and operation of pressure gauges and gauge siphons (pigtails).
2. Describe the testing of pressure gauges.
3. Describe the construction, operation, installation, and testing of low-pressure (safety relief) and high-pressure (safety or pop) valves.
4. Describe the purpose, function, and testing of gauge glasses and water columns.
5. Explain how to change a gauge glass.
6. Describe the construction, operation, and purpose of the following valves: gauge glass safety shutoff valves, gauge glass quick closing valves, stop valves, check valves, blowoff (blowdown) valves, and vent valves.

Topic 6 Basic Fittings for Hot Water Boilers

Learning Outcome

Name, identify and explain the operating principles of the following hot water boiler fittings and equipment: pressure, altitude or combination gauges, thermometers, safety relief valves, temperature relief devices, stop valves or drain valves, backflow preventers, and expansion tanks.

Learning Objectives

1. Identify the required instruments, fittings, and controls on a hot water boiler system.
2. Explain how to change a gauge glass on an expansion tank.
3. Describe the construction and operation of the “auto fill valve.”
4. List the usual devices and fittings that are used in hot water heating boiler systems.

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Topic 7 Low Water Fuel Cut-Offs and Feedwater Controls

Learning Outcome

Discuss the design, operation and testing of low-water fuel cutoffs and describe feedwater control methods and devices used on low-pressure boilers.

Learning Objectives

1. Describe the construction and operation of float and electrode low water level fuel cut-off equipment.
2. Describe the testing and maintenance of float and electrode low water level fuel cut-offs.
3. Describe the operation of a feedwater float switch operating a valve and a float switch operating a pump.
4. Explain the purpose and function of heating boiler feedwater and condensate piping connections.

Topic 8 Heating Boiler Operating Controls

Learning Outcome

Name and describe the various operating controls found on low-pressure boilers.

Learning Objectives

1. Describe the operation of the on-off control, the high-low fire control, the modulating control, and the high limit control found on low-pressure steam boilers and hot water heating boilers.
2. Explain the operation of the common control switches found on a low-pressure heating boiler.
3. Describe the operation of the safety switches or interlocks found on the fuel supplies of low-pressure heating boilers.
4. Explain the required testing and maintenance of heating boiler controls.

Topic 9 Boiler Combustion Controls

Learning Outcome

Explain the design and operation of various combustion controls on heating boilers.

Learning Objectives

1. List and discuss the various types of boiler flame failure detectors.
2. Describe the testing of boiler flame failure safety devices.

Topic 10 Boiler Programming Controls

Learning Outcome

Describe the basic operation of boiler programming controls.

Learning Objectives

1. Describe the operation of equipment that is used to automatically start up and shut down boilers.
2. List a typical sequence of startup and shutdown events.
3. Describe common 5th Class Power Engineer responses to a boiler programmer startup or shutdown.

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Topic 11 Basic Boiler Operation

Learning Outcome

Describe the preparation, start-up and shutdown, abnormal conditions, and routine operational checks in the operation of steam and hot water boilers.

Learning Objectives

1. Explain the preparation required before starting a steam or hot water boiler.
2. Explain the startup steps once the boiler has been prepared.
3. State possible abnormal conditions during startup and the cautions required to avoid uneven expansion and thermal shock.
4. Describe the procedure required when "cutting in" an additional boiler.
5. Describe the operating conditions for hot water and steam boilers that must be checked daily, and state the required monthly checks.
6. Explain the procedure for removing a hot water boiler from service.
7. Describe the procedure for removing a steam boiler from service.
8. Explain the emergency conditions that can occur during the operation of a steam boiler. Explain the causes and prevention of furnace and pressure explosions.
9. Explain the reasons for boiler accidents, and describe the role and design of operating logs in the safe operation of a boiler.
10. Operator traits, good operating practice, curiosity, using your senses, (sense-interpret-analyze-perform = SIAP), trusting your instincts, experience and due diligence.

Topic 12 Routine Boiler Maintenance and Inspection

Learning Outcome

Describe the service and maintenance required for boilers. Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical boiler cleaning methods.

Learning Objectives

1. Describe the general servicing and routine maintenance of packaged firetube and cast-iron sectional boilers.
2. Explain the importance of layups and state the procedures to be followed for wet and dry boiler layups.
3. Describe the symptoms of a leaking firetube.
4. List the steps and precautions to be taken to prepare a boiler for inspection.
5. Describe the inspection of a boiler.
6. Describe the methods and tools used for mechanical and chemical cleaning of a boiler.
7. Discuss the standard procedure for a hydrostatic test and the reason for doing the test.

Topic 13 Combustion and Draft

Learning Outcome

Discuss the characteristics of common fuels used in heating boilers, conditions for complete and incomplete combustion, draft methods, and the application of flue gas analysis.

Learning Objectives

1. Explain natural and mechanical draft arrangements.
2. Describe draft measurement using U-tube and inclined draft gauges.
3. Describe the use, advantages, and characteristics of common boiler fuels.
4. State the requirements and reactions for complete and incomplete combustion.
5. Explain the difference between a pressure explosion and a furnace explosion.

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Topic 14 Burners for Boilers

Learning Outcome

Describe the operation of the various types of gas and oil burners used on boilers.

Learning Objectives

1. Describe the operation of atmospheric and ring gas burners.
2. Describe the construction and operation of automatic valves.
3. Describe the principle of oil atomizing burners for boilers.
4. List and describe the auxiliary equipment needed for an oil combustion system.
5. Describe the overall components and operation of fuel oil systems.

Topic 15 Piping Materials and Connections

Learning Outcome

Discuss the various construction materials, size classification, and connection methods for the piping in a plant.

Learning Objectives

1. Explain the characteristics and applications of the various materials used to manufacture piping and fittings.
2. Explain pipe size, schedules, and classifications.
3. Identify screwed, flanged, and welded pipe connections.

Topic 16 Piping Expansion, Support, and Insulation

Learning Outcome

Discuss piping expansion, support, and insulation.

Learning Objectives

1. Explain pipe expansion and the principle of expansion bends and joints.
2. Explain the purpose of pipe supports and describe various pipe support designs.
3. Explain the purposes for pipe insulation and describe the use of the common insulation materials.

Topic 17 Steam Traps

Learning Outcome

Explain the purpose of steam traps and describe the installation and operating principles of the various steam traps found on piping systems.

Learning Objectives

1. Describe the designs and operating principles of mechanical traps.
2. Describe the designs and operating principles of thermostatic steam traps.
3. Describe the correct piping arrangement and procedures for a steam trap.
4. Explain the purpose and design of a strainer.
5. Explain the causes, effects, and prevention of water hammer.

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Topic 18 Introduction to Valves

Learning Outcome

Discuss the design, application, and maintenance of common types of valves used in piping systems.

Learning Objectives

1. Describe five standard valve designs: gate, globe, butterfly, ball, and plug.
2. Describe the design and operation of check and non-return valves.
3. Describe the function of a pressure-reducing valve.
4. Describe valve identification markings.
5. Describe typical valve maintenance requirements.

Major Topic: Elements of Human Comfort in Facility Operation

Topic 1 Heat Gains and Losses

Learning Outcome

Describe the various ways a building gains and loses heat.

Learning Objectives

1. Define heat transmission terminology and identify conversions or related units.
2. Describe the heat gains that occur in a building due to conduction, infiltration, ventilation, and radiation.
3. Describe the heat gains that occur in a building due to people, lighting, electric motors, appliances, and cooking.
4. Describe the heat losses that occur in a building due to conduction, convection, radiation, infiltration, and ventilation.

Topic 2 Steam Heating Equipment

Learning Outcome

Describe the operating principles of steam heating equipment and components.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. List and describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.

Topic 3 Steam Heating Systems

Learning Outcome

Describe the operating principles and maintenance procedures of steam heating systems and the components of these systems.

Learning Objectives

1. Describe standard types of piping and equipment layout for steam heating systems.
2. Describe the general operation and maintenance of steam heating systems.
3. Apply a steam heating system troubleshooting guide.

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Topic 4 Hot Water Heating Systems

Learning Outcome

Describe the various designs of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe radiant panel and snow melting hot water systems.

Topic 5 Hot Water Heating System Equipment and Operation

Learning Outcome

Describe accessories, operation and troubleshooting of a hot water heating system.

Learning Objectives

1. Describe the purpose and function of standard hot water heating system components such as diverter fittings, air vents, air separators, flow control valves, balancing valves and fittings, riser stop valves, pressure reducing valves, circulating pumps, expansion tanks, and steam to hot water converters.
2. Explain how the location of the hot water circulating pump and the expansion tank are determined.
3. Describe the cleaning, filling, starting, routine operation, and troubleshooting of hot water heating systems.
4. Apply a hot water heating system troubleshooting guide.

Topic 6 Warm Air Heating System Equipment

Learning Outcome

Describe the operating principles of warm air heating sources.

Learning Objectives

1. Compare the advantages and disadvantages of forced air and gravity warm air systems.
2. List and describe the common sources of warm air heat.
3. List and describe the operational characteristics of directly fired space heaters.

Topic 7 Warm Air Furnace Components and Maintenance

Learning Outcome

Describe the components and maintenance requirements of typical warm air heating and ventilating systems.

Learning Objectives

1. Describe the operation of furnace components.
2. Describe and discuss the relative merits of three types of air distribution and duct systems.
3. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
4. Apply a troubleshooting guide for forced warm air systems and components.

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Topic 8 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems found in buildings, as well as describe the various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the types of contaminants found in air.
3. Describe the types of air cleaning devices used in buildings.

Topic 9 Infrared and Electric Heating

Learning Outcome

Describe infrared and electric heating systems.

Learning Objectives

1. Discuss the concept and application of infrared heating.
2. Describe the construction and operation of gas-fired and electric infrared heaters.
3. List the advantages of electric heating systems compared to other types of heating systems.
4. Describe the different methods of electric heating.

Topic 10 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and commercial types of humidifiers.
3. Describe industrial types of humidifiers.

Topic 11 Electric Controls for Heating Systems

Learning Outcome

Describe and explain the function of the various components of an electric control circuit.

Learning Objectives

1. Discuss the various terms associated with electric control systems.
2. Describe the basic construction and operation of electric thermostats, humidity controllers, and pressure controllers.
3. Describe the function and operation of the controlled devices in electric control systems.
4. Explain the operating sequence of a basic electric control circuit.

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Topic 12 Building Water Supply Systems

Learning Outcome

Explain the various water supply systems in a building.

Learning Objectives

1. Describe the cold water distribution system in a building.
2. Describe the hot water distribution system in a building.
3. Describe the construction and operation of building system hot water heaters.
4. Explain what is meant by "backflow prevention" and describe the common methods used.
5. List and describe the construction and operation of water system protective devices in buildings.

Topic 13 Sanitary Drainage Systems

Learning Outcome

Describe various sanitary drainage systems employed in buildings.

Learning Objectives

1. Describe the overall layout of building drainage systems.
2. Describe storm water drainage systems for buildings.
4. List the steps to take in the routine maintenance of building sanitary drainage system devices.
5. Apply a troubleshooting guide for sanitary drainage systems.

Topic 14 Lighting Systems

Learning Outcome

Explain the various lighting systems and some of the basic design considerations for lighting a space.

Learning Objectives

1. Describe the common types of lighting equipment and systems.
2. Explain the various methods of lighting control.
3. Describe the general requirements and criteria for emergency lighting in buildings.
4. Discuss the interrelationship between lighting, air conditioning, and energy conservation in buildings.

Topic 15 Air Conditioning Systems

Learning Outcome

Describe the operation of various air conditioning systems.

Learning Objectives

1. List the functional components and categories of air conditioning systems.
2. Describe the operation of air handling units.
3. Describe the general layout and operation of unitary air conditioning systems.
4. Describe the general layout and operation of central air conditioning systems.

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Topic 16 Air Compression

Learning Outcome

Describe the operating principles of the different types of air compressors.

Learning Objectives

1. Describe the main classifications and types of air compressors.
2. Describe air compressor auxiliary equipment, including capacity control systems.
3. Discuss preventive maintenance for reciprocating air compressors.

Topic 17 Types of Pumps

Learning Outcome

Describe the various types of pumps found in buildings and industrial plants.

Learning Objectives

1. List the common applications of pumps in the power industry.
2. Define the terms associated with pump performance.
3. Describe the common types of pumps used in the power industry.

Topic 18 Pump Operation and Maintenance

Learning Outcome

Describe all details pertaining to pump operation and various maintenance procedures performed on pumps.

Learning Objectives

1. Describe the construction and function of pump wear rings.
2. Discuss pump shaft sealing and describe the process that is followed when replacing compression type packing.
3. Sketch and describe the standard types of mechanical seals.
4. Describe pump bearing and shaft alignment equipment and procedures.
5. Describe pump startup and priming procedures.
6. Identify pump troubles and their possible causes.

Topic 19 Lubrication

Learning Outcome

Describe the importance and the principles of lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and applications.
3. List the properties of lubricating oils and the additives used.

Topic 20 Types of Bearing Lubrication

Learning Outcome

Describe the methods for simple care and maintenance of bearings and their related lubrication systems.

Learning Objectives

1. Define boundary and fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of thrust bearings.
4. Describe how to clean and replace roller and ball bearings.
5. List the causes of bearing failure.

Topic 21 Internal Combustion (IC) Engine Gen-Sets

Learning Outcome

Describe the application and operation of IC gen-sets.

Learning Objectives

1. Explain startup and shutdown procedures.
2. Explain the proper routine pre-start and operational checks.
3. Identify the three main methods of starting gen-sets.

Major Topic: Basic Physical Science, Safety, and Regulation for Facility Operations

Topic 1 Fire Safety and Site Hazards

Learning Outcome

Discuss acceptable methods of extinguishing various classifications of fire. Briefly describe site hazards awareness.

Learning Objectives

1. Explain the overall need for and the intent of fire protection standards, laws, and regulations.
2. Explain the different fire classifications and describe the extinguishing methods for each.
3. Explain the application and operation of standpipes, hoses, and sprinklers in buildings.
4. Explain the various types of fire and smoke detectors.
5. Describe the operation, placement, and maintenance of the common types of portable extinguishers.
6. Discuss the need for and use of a fire pump.
7. Briefly describe safety aspects of common site hazards.
8. Explain how to perform a pre-job hazard assessment.

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Topic 2 Building Safety

Learning Outcome

Describe how the building operator can prevent accidental situations to protect the occupants of their facility.

Learning Objectives

1. Explain the personal safety responsibilities and precautions that must be applied by the building operator.
2. Describe the general safety precautions required in the maintenance and operation of buildings.
3. Identify common scenarios where the building operator can prevent accidents, and explain the importance of first aid and CPR training.

Topic 3 Confined Space Entry

Learning Outcome

Describe procedures needed to enter into, or work safely in confined spaces.

Learning Objectives

1. Define confined space, list some confined spaces, and describe the hazards of being in a confined space.
2. Refer to local jurisdictional regulations and describe procedures to be followed when performing a confined space entry, including completion of an entry checklist.

Topic 4 Introduction to Occupational Health and Safety Legislation

Learning Outcome

Discuss the provincial legislation addressing occupational health and safety.

Learning Objectives

1. Explain the general intent of occupational health and safety standards.
2. Discuss some of the responsibilities, according to the Act, of workers, employers, and others in relation to health and safety.
3. Describe the conditions that must exist before a worker can refuse to work.
4. Identify jurisdictional regulations related to health and safety.
5. List the two different types of logs kept in boiler plants and the importance of each.

Topic 5 Introduction to Heating Plant Safety

Learning Outcome

Describe general plant safety as it relates to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may exist in an energy plant, and the basic personal protective equipment that may be required.
3. Define, give examples of, and describe common workplace hazards. (Note that additional training will be required beyond this course material.)
4. Describe equipment isolation and lockout procedures.

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Topic 6 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous goods and materials.

Learning Objectives

1. Discuss the WHMIS.
2. Describe the Safety Data Sheets (SDS) and Material Safety Data Sheets (MSDS) required in the WHMIS.
3. Identify the labels required in the WHMIS.
4. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
5. Discuss the safe handling of hydrocarbons.

Topic 7 Water Treatment

Learning Outcome

Explain the purpose of the common external and internal water treatment methods.

Learning Objectives

1. Explain the four general sources of impurities and the three general treatment methods.
2. Explain the purpose of external filtration and describe the design of pressure, filter-aid, and cartridge filters.
3. Explain boiler blowoff/blowdown.
4. Describe the operating principles of a sodium zeolite water softener.
5. Explain troubleshooting and common operating problems associated with water softeners.
6. Describe methods of feeding treatment chemicals into a boiler.
7. Define potable water and explain the importance of backflow prevention.
8. Describe the testing of potable water.

Topic 8 Monitoring and Testing

Learning Outcome

Explain general sampling and testing procedures and equipment, and describe specific testing procedures, plus interpret test results for a boiler water treatment monitoring and testing program.

Learning Objectives

1. List the four classes of impurities and three general treatment methods.
2. Explain how to obtain a representative water sample.
3. Discuss testing methods.
4. Describe the principles and procedures for testing for hardness, dissolved solids, phosphate, molybdate, pH, sodium sulfite, and alkalinity.

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REFERENCE CURRICULUM

For

Plant Management Engineer

National Institute for the Uniform Licensing of Power Engineers, Inc.
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Introduction

This Curriculum is intended to assist candidates studying for the NIULPE Plant Management Engineer Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Reference Curriculum for Plant Management Engineer Examination Candidates

Topic 1 Boiler and Pressure Vessel Legislation

Learning Outcome

Describe the components and application of boiler and pressure vessel legislation within jurisdictions.

Learning Objectives

1. Identify the types and sources of laws and the levels and scope of the courts.
2. Define statutory delegation of powers as they apply to the Boilers and Pressure Vessels Act.
3. Describe the authority that safety officers (inspectors) have within their jurisdiction.
4. Determine what are the offences and penalties under the Act and the appeal process.
5. Describe the typical regulations under the Boilers and Pressure Vessels Act.
6. Describe the typical codes and standards referenced by the Boilers and Pressure Vessels Act.

Topic 2 Plant Design and Installation

Learning Outcome

Explain the codes and procedures involved in the design and construction of a new plant.

Learning Objectives

1. State the codes and standards, which must be followed when designing and building a new plant.
2. Describe the steps involved in developing specifications and contracts for new installations and modifications.
3. Explain the major steps involved in the design and construction of a new plant.
4. Explain the roles and responsibilities in the design and construction of a new plant.
5. Explain how the design and construction of a new plant are administered and controlled.

Topic 3 Management and Supervision

Learning Outcome

Describe the roles and basic competencies of a supervisor and manager.

Learning Objectives

1. Define management and explain the general functions of management.
2. Explain how management goals and objectives are developed through planning.
3. Describe how business decisions are made.
4. Describe methods of selecting new employees.
5. Explain how employees are trained.
6. Explain how to provide leadership and motivate employees.
7. Explain how to manage employee performance and behaviors.
8. Demonstrate proper communication skills by writing a formal report.

Topic 4 Safety

Learning Outcome

Explain the components and application of safety programs, safety audits, and safety training.

Learning Objectives

1. Describe the elements of a comprehensive safety program for a power plant.
2. Explain the purpose of and the process used for safety checklists, inspections, audits and reviews.
3. Explain the purpose of and the process used for safety orientation, education, and training.

Topic 5 Loss Control

Learning Outcome

Describe the design, components, and implementation of a loss control program.

Learning Objectives

1. Explain the purpose, benefits, and typical components of a loss control program.
2. Explain the process of developing a comprehensive loss control program, including the typical responsibilities and accountabilities of the program.
3. Describe the factors affecting insurance rates and the authority, role, and interaction of insurance inspectors with plant staff.
4. Describe the tools and techniques used to develop a positive attitude towards the components of a loss control program.
5. Describe the tools and techniques used to develop safety awareness in consumers.

Topic 6 Safety Legislation

Learning Outcome

Identify the authority and application of federal and state safety legislation to the work place.

Learning Objectives

1. Explain the ultimate responsibility and requirement, in the work place, to enforce all relevant safety legislation and regulations, and to respond to regulatory directives.
2. Describe the legal and ethical obligations of managers, supervisors, and employees for personnel safety.
3. Explain the significance, components, and applications of Canada Labour Occupational Health and Safety legislation.
4. Explain the authority, significance, components, and applications of provincial safety regulations, including the role and interactions of the provincial safety inspectors with plant staff.
5. Explain the requirements for safety compliance training.
6. Explain right to refuse work legislation and its legal implications.
7. Explain the authority, significance and applications of Workers' Compensation Board regulations, including the role and interactions of the Board with plant staff.
8. Describe roles and responsibilities for, and functioning of, a worksite health and safety committee.

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Topic 7 Safe Work Programs

Learning Outcome

Describe comprehensive safe work programs.

Learning Objectives

1. Identify the components and explain the management of a comprehensive safe work program.
2. Explain the components and management of a safety training program.
3. Explain the process of hazard identification, risk assessment, and mitigation.
4. Explain the significance and procedure for safe work planning.
5. Explain the significance and procedure for safe work permits, including lockouts.
6. Explain the significance and procedure for confined space entry.
7. Explain the significance and procedure for hot work.
8. Explain the significance and procedure for excavations.
9. Explain the significance and procedure for working at heights.
10. Explain the significance and components of a contractor safety program.
11. Explain the components and management of a safety audit program, including roles and responsibilities.
12. Explain the purpose, components, and procedure for a hazard and operability study.

Topic 8 Emergency Response and Incident Investigation

Learning Outcome

Describe emergency response and incident investigation programs.

Learning Objectives

1. Identify the benefits and typical stakeholders of an emergency response program.
2. Explain the typical components of an emergency response program.
3. Explain the process of developing and maintaining an emergency response program, including typical responsibilities and accountabilities.
4. Explain the procedure for emergency response testing.
5. Explain the typical components of an incident reporting and investigation program.
6. Define categories of incidents.
7. Describe roles and responsibilities for incident initial reporting, investigation, final reporting, and corrective actions.
8. Explain the significance of and steps required in incident investigation.
9. Describe a system for managing incident report data, including the communication process and its significance.
10. Apply an incident reporting and investigation procedure to a case study.

Topic 9 Environmental Legislation

Learning Outcome

Identify the authority and application of federal and provincial safety legislation and permits.

Learning Objectives

1. Explain the ultimate responsibility and requirement to enforce all relevant environmental legislation and regulations and to respond to regulatory directives.
2. Explain the authority, significance, components, and applications of provincial environmental legislation and regulations, including the role and interactions of the provincial environmental inspectors with plant staff.
3. Explain the authority, significance, components, and applications of federal environmental legislation and regulations, including the role and interactions of the federal environmental inspectors with plant staff.
4. Explain the significance and process of identifying and working with typical stakeholders for environmental programs – the Environmental Impact Assessment (EIA) process.
5. Explain typical compliance requirements for an environmental monitoring program, including equipment calibration and uptime requirements.

Topic 10 Environmental Management

Learning Outcome

Explain environmental management programs, including reporting, clean-up, disposal, and reclamation.

Learning Objectives

1. Explain the purpose, significance, and components of an Environmental Management System.
2. Describe the ISO 14000 - 14002 standards for an Environmental Management System.
3. Describe requirements for environmental routine, excursion, and exceedance reporting.
4. Explain the compliance tests for Continuous Emission Monitoring Systems (CEMS) and the significance and procedures for Relative Accuracy Test Audits (RATA).
5. Explain the responsibilities and procedures for spill containment and cleanup.
6. Explain the components and development of an environmental audit program.
7. Explain the procedure for an environmental audit including the roles and responsibilities for performing and responding to the audit.
8. Explain the significance, procedures, and regulatory requirements of waste segregation and disposal.
9. Identify waste streams that require special disposal procedures, including recognition of hazardous wastes.
10. Explain the significance and general components of Transportation of Dangerous Goods Acts.
11. Explain the significance and general requirements of hazardous waste transportation.
12. Describe the purpose, significance, requirements, and general process of land reclamation.

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Topic 11 Business Management

Learning Outcome

Explain general concepts in plant budgeting, finance, accounting, and inventory control.

Learning Objectives

1. Explain the concept and significance of the following accounting terms: accounting cycle, dual entry accounting, debits and credits, accrual accounting, revenue and expenses, assets and liabilities, and debt and equity.
2. Explain the concept and significance of financial statements, including Income Statement, Balance Sheet, Statements of Retained Earnings, and Cash Flow Statement.
3. Explain budget development, control, and reporting processes.
4. Explain typical types of budgets and their significance, including revenue, expense, capital expenditure, and production budgets.
5. Explain the components of plant and department budgets.
6. Explain the significance of a cost / benefit analysis.
7. Explain the "time value of money" concept and calculate the Net Present Value (NPV) and Internal Rate of Return (IRR) of a proposed investment.
8. Calculate the Return on Investment (ROI) of a proposed investment.
9. Explain depreciation, including straight-line and declining balance depreciation, and the concept and significance of Capital Cost Allowance (CCA).
10. Describe the components and use of a typical automated inventory system.
11. Explain the purpose and operation of typical inventory management systems, including fixed-point, fixed-interval, max/min, ABC, Just In Time (JIT), and Economic Order Quantity (EOQ.)
12. Explain the concepts and significance of periodic and perpetual inventory systems, and LIFO and FIFO.
13. Describe the role of a supplier and the use of strategic partnerships in an inventory management system.

Topic 12 Contract Management

Learning Outcome

Explain general concepts and management of contracts.

Learning Objectives

1. Explain the content and significance of a typical code of ethics of a professional association.
2. Explain the importance and application of ethical practices in the work place.
3. Define and explain the legal significance of contract, offer, and acceptance.
4. Explain the significance of contract documentation, and the rights and obligations of a contractor and contractee.
5. Compare contract types, including: fixed price; cost plus/shared risk; fixed price/cost plus incentive; bonus/penalty; time/material; product/service/resource; and enforceable/unenforceable contracts.
6. Describe methods of discharging a contract, including: agreement, performance, impossibility, operation of law, breach, failure to perform and specific performance.
7. Explain tort and its legal significance; the three basic types of torts, including: intentional, fault-based or negligent, and strict liability, the distinction between legal and ethical liability.
8. Explain due diligence and its legal and ethical significance.
9. Explain force majeure and its legal significance.
10. Explain what is involved in issuing and then completing a tendering process.

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Topic 13 Problem Solving and Decision Making

Learning Outcome

Explain techniques for structured problem solving and decision making.

Learning Objectives

1. Explain the importance and application of a structured decision making process.
2. Describe the eight steps in a rational decision making process.
3. Compare analytic, conceptual, directive, and behavioral decision making styles.
4. Explain the advantages and disadvantages of group decision making.
5. Describe the common methods of group decision making, including brainstorming, storyboarding, nominal group technique (NGT), and the Delphi technique.
6. Apply a problem solving and decision making approach to a typical plant case study.

Topic 14 Leadership

Learning Outcome

Discuss models of leadership and motivation.

Learning Objectives

1. Explain leadership responsibilities and the significance of an effective leadership style.
2. Explain the managerial grid and its significance.
3. Explain situational leadership and its significance.
4. Compare the concept and significance of traditional objective setting and management by objectives (MBO).
5. Compare methods of communicating goals and objectives.
6. Explain the motivation process.
7. Compare the basic models of individual motivation, including the hierarchy of needs, motivation–hygiene theory, goal-setting theory, reinforcement theory, equity theory, and expectancy theory.
8. Explain the concept and significance of the social styles matrix.

Topic 15 Communication and Conflict Resolution

Learning Outcome

Discuss models of leadership and motivation.

Learning Objectives

1. Compare linear, interactive, and transactive communications and their significance.
2. Explain the common communication shortcuts and their significance including selectivity, assumed similarity, stereotyping, and the halo effect.
3. Explain the significance and effects of conflict in an organization.
4. Describe interpersonal and intergroup conflict.
5. Explain the lose/lose, lose/win, win/lose and win/win outcomes of conflict.
6. Explain assertiveness and cooperativeness and their significance.
7. Compare avoiding, accommodating, forcing, collaborating and compromising as conflict resolution strategies.
8. Explain the stages in assertive behavior for conflict resolution.
9. Describe the concept, significance, responsibilities, and typical steps and tactics of a grievance process.
10. Explain the process of labour/management conflict resolution.
11. Describe the typical public stakeholders for an organization's business, and the typical communication processes used in dealing with the public.
12. Explain the public concerns that an organization must address, and the appropriate communication methods used in addressing them.

Topic 16 Labor Relations

Learning Outcome

Explain principles and models in the management of labor relations and change.

Learning Objectives

1. Explain management's rights and responsibilities in the enforcement of federal and provincial labor legislation.
2. Compare management interactions between union and non-union work forces.
3. Explain the concept, preparation, and tactics of collective bargaining, including the use of a problem-solving approach.
4. Explain the concepts, significance, roles, and responsibilities during conciliation, arbitration, strike or lockout.
5. Compare the benefits and significances of permanent and contingent employees.
6. Explain the purpose and process of human resource planning and capacity planning.
7. Explain the facilitation of labour relations with a contractor's workforce.
8. Describe the types of changes that occur in the workplace, the relationship between workplace change and employee attitude, the psychic costs and benefits of change, and management's role and responsibilities.
9. Explain the concept and significance of homeostasis.
10. Describe the three types of resistance to change (logical, psychological, and sociological), the potential benefits of resistance to change, and the three basic steps to overcome resistance (unfreezing, changing, refreezing.)
11. Explain the typical strategies used to build support for change, including; use of group forces, leadership for change, participation, shared rewards, negotiation, employee security, and communication.
12. Explain the purposes and processes of benchmarking.

Topic 17 Recruitment and Employee Development

Learning Outcome

Explain principles and models in the management of employee recruitment and development.

Learning Objectives

1. Explain the purpose and components of a human management process.
2. Explain the legal and ethical constraints on recruitment and selection.
3. Explain the types and processes of pre-employment testing.
4. Explain the purpose, procedure, and limitations of typical interviewing techniques, including behavioral descriptive interviews.
5. Explain the significance and components of a training and development program including training standards, roles, and responsibilities.
6. Explain the significance and components of an orientation process.
7. Explain the purpose and process of a needs assessment and gap analysis.
8. Explain the purpose and process of competency profiling.
9. Explain the significance and selection of typical training methods and their relationship to learning styles.
10. Explain the significance of progression and cross-training methods.
11. Explain the purpose and components of a performance management program, including coaching.
12. Explain typical models of performance reviews.
13. Explain the process of corrective and progressive discipline.

Topic 18 Management Structures and Organization

Learning Outcome

Discuss principles of organizational structure and the application of work teams.

Learning Objectives

1. Compare the design and benefits of typical organizational structures, including: scalar, functional, tall/flat and matrix.
2. Explain the concept and significance of organizational culture.
3. Explain the significance of a team-based organizational structure and methods to develop and promote teamwork.
4. Compare the significance, benefits, and limitations of supervised and self-directed work teams.
5. Describe the characteristics and functioning of a successful work team.
6. Explain the concept and significance of cross-functional work teams.

REFERENCE CURRICULUM

For

Plant Environmental Manager

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the NIULPE Plant Environmental Manager Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Plant Environmental Manager Examination Candidates

Major Topic: Environmental Management

Topic 1 Environmental Introduction

Learning Outcome

Describe the interaction and interdependency between the various elements of the environment.

Learning Objectives

1. Describe the cycles that make up our environment.
2. Describe the interdependency of the "ecosystem".

Topic 2 Environmental Monitoring

Learning Outcome

Explain the significance of environmental parameters and methods of monitoring.

Learning Objectives

1. Explain the significance of the following air quality parameters: particulates, stack opacity, SO_2 concentration, SO_2 mass flow, NO_X concentration, NO_X mass flow, mercury, O_2, CO_2, and hydrocarbons.
2. Explain the basic principles of operation for Continuous Emissions Monitoring Systems (CEMS) measurement instruments.
3. Explain the general requirements for Continuous Emissions Monitoring Systems (CEMS).
4. Explain the significance of the following water quality parameters: iron, phosphorous, biological oxygen demand (BOD), chemical oxygen demand (COD), hydrocarbons, temperature, flow, pH, and nitrogen.
5. Explain the general requirements for wastewater monitoring.
6. Explain how data that is received from environmental monitoring equipment is interpreted.
7. Explain the significance of environmental monitoring equipment failure.
8. Describe the procedures used for troubleshooting environmental monitoring equipment.

Topic 3 Environmental Control Methods

Learning Outcome

Explain the methods used to remove SO_2, NO_X, CO_2, and particulates from boiler flue gases.

Learning Objectives

1. Describe the purpose, design, operation, and application of Flue Gas Desulfurization (FGD) systems.
2. Describe the purpose, design, operation, and application of Selective Catalytic Reduction (SCR) systems.
3. Explain the significance of NO_X reduction in a power plant, and the procedures and equipment used to reduce NO_X emission from a boiler and from a gas turbine.
4. Explain the purpose, effects, and application of flue gas chemical conditioning in a power plant.
5. Explain the significance, procedures, and equipment for reduction of CO_2 emission from a boiler.
6. Describe the purpose, design, operation, and application of a baghouse.
7. Describe the purpose, design, operation, and application of an electrostatic precipitator.

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Topic 4 Environmental Management

Learning Outcome

Explain environmental management programs, including reporting, clean-up, disposal, and reclamation.

Learning Objectives

1. Explain the purpose, significance, and components of an Environmental Management System.
2. Describe the ISO 14000 - 14002 standards for an Environmental Management System.
3. Describe requirements for environmental routine, excursion, and exceedance reporting.
4. Explain the compliance tests for Continuous Emission Monitoring Systems (CEMS) and the significance and procedures for Relative Accuracy Test Audits (RATA).
5. Explain the responsibilities and procedures for spill containment and cleanup.
6. Explain the components and development of an environmental audit program.
7. Explain the procedure for an environmental audit including the roles and responsibilities for performing and responding to the audit.
8. Explain the significance, procedures, and regulatory requirements of waste segregation and disposal.
9. Identify waste streams that require special disposal procedures, including recognition of hazardous wastes.
10. Explain the significance and general components of the DOT's regulations for the classification (Hazmat) and transportation of hazardous materials.
11. Explain the significance and general requirements of hazardous waste transportation.
12. Describe the purpose, significance, requirements, and general process of land reclamation.
13. Describe the general components of a Waste Management Plan.

Major Topic: Environmental Impact Control

Topic 1 Potential Environmental Impact of Liquids

Learning Outcome

Explain the impact of liquid waste on the environment.

Learning Objectives

1. List the common sources and effects of liquid waste and thermal pollution.
2. Describe the preventive measures that can be taken to prevent liquid pollution.
3. Describe current and alternate methods of liquid waste disposal.

Topic 2 Potential Environmental Impact of Vapors

Learning Outcome

Explain the impact of gases and vapors on the environment.

Learning Objectives

1. List and identify the sources of the common domestic, industrial, and naturally occurring gases and vapors that have environmental impact.
2. Identify the various gases that create the formation of acid rain.
3. Discuss the makeup and effect of greenhouse gases.
4. Describe current and alternative methods of reducing gas and vapor pollution.

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Topic 3 Potential Environmental Impacts of Operating Facilities

Learning Outcome

Explain the environmental impacts of industrial operating facilities.

Learning Objectives

1. List the types of impacts that operating facilities can have on the environment.
2. Discuss how plant personnel are alerted to the environmental problems of operating facilities.
3. Discuss the overall noise implications of operating facilities.
4. Discuss and give examples of the importance of "attitude" in limiting the environmental impact of operating facilities.
5. Describe the long term environmental impact after the decommissioning and abandonment of operating facilities.

Topic 4 Gaseous and Noise Pollutants

Learning Outcome

Name gaseous pollutants related to power plants, describe their effect upon the environment, and discuss some methods used for their control as well as describe noise pollution related to power plants.

Learning Objectives

1. Describe the adverse effects of, and the associated control systems for, various gaseous pollutants.
2. Describe how noise pollution is measured and controlled.
3. Describe typical devices and systems for monitoring gaseous and noise pollutants.

Topic 5 Solid and Liquid Thermal Pollutants

Learning Outcome

Discuss methods of handling solid pollutants produced by power plants and the problems and solutions in regard to liquid thermal pollutants.

Learning Objectives

1. Describe the construction and operation of various types of mechanical collectors.
2. Describe the construction and operation of electrostatic precipitators.
3. Describe how flyash is removed from a steam generator and the operation of a cooling pond.

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REFERENCE CURRICULUM

Engineer (1^{st} Class)

Massachusetts

Preparation

National Institute for the Uniform Licensing of Power Engineers, Inc.
PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Engineer (1^{st} Class) Massachusetts Preparation Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Engineer (1st Class) Massachusetts Preparation Examination Candidates

Major Topic: Applied Thermodynamics and Plant Cycles

Topic 1 Rankine and Brayton Cycles

Learning Outcome

Discuss the application of the Rankine and Brayton cycles to a power plant.

Learning Objectives

1. Explain heat engines and their application to a steam power plant.
2. Explain the Rankine Cycle using a steam temperature-entropy diagram.
3. Evaluate a Rankine Cycle power plant in terms of efficiency, work ratio, specific steam consumption, isentropic efficiency and efficiency ratio.
4. Explain the Rankine Cycle improvements that can be incorporated into a power plant.
5. Explain the Brayton Cycle and its application to a gas turbine.
6. Explain the Brayton Cycle using pressure-volume and temperature-entropy diagrams.
7. Evaluate a Brayton Cycle power plant in terms of temperatures, work output, and efficiency.
8. Explain the Brayton Cycle improvements that can be incorporated into a power plant.
9. Describe the design, layout, and advantages of a gas turbine/steam turbine combined cycle plant.
10. Explain the total energy concept as it applies to a power plant.

Topic 2 Thermodynamics of Steam

Learning Outcome

Perform calculations for thermodynamic cycles of steam.

Learning Objectives

1. Describe the basis for non-flow processes of vapours.
2. Explain the constant volume process for steam and calculate heat supplied, work done and internal energy.
3. Explain the constant pressure process for steam and calculate heat supplied, work done and internal energy.
4. Explain the constant temperature process for steam and calculate heat supplied and work done.
5. Calculate steam entropy given the steam conditions.
6. Explain the significance of a Temperature-Entropy diagram for steam.
7. Explain the reversible adiabatic process for steam and calculate work done and internal energy.
8. Explain the significance of a Mollier chart for steam.

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Topic 3 Steady-Flow Process Calculations

Learning Outcome

Perform steady flow process calculations for vapours and gases.

Learning Objectives

1. Describe the steady-flow energy equation and calculate the work done in a steady-flow process.
2. Calculate the power consumed in a steady-flow process.
3. Explain the principle of conservation of energy and supersaturation as they apply to a nozzle and calculate nozzle inlet and outlet velocities.
4. Calculate the initial dryness fraction of steam in a throttling process.
5. Determine, using a Mollier Chart, the quality, enthalpy, and entropy of steam entering a calorimeter.
6. Calculate energy transfer, work done, and power produced in a steam turbine.
7. Calculate the heat lost, surface area, required cooling water flow, and heat transfer coefficient in a steam condenser.
8. Define and calculate availability and effectiveness in the context of the steady-flow processes.

Major Topic: Boiler Principles of Applied and Fluid Mechanics

Topic 1 Lifting Machines

Learning Outcome

Perform calculations for lifting machines.

Learning Objectives

1. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load for lifting machines.
2. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a differential pulley block.
3. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a worm gear and worm wheel.
4. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a worm-driven screw jack.
5. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a turnbuckle.
6. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a hydraulic jack.

Topic 2 Energy and Momentum

Learning Outcome

Perform calculations involving potential energy, kinetic energy, and momentum of bodies in linear and rotating motion.

Learning Objectives

1. Define potential and kinetic energy.
2. Calculate the potential energy of a compressed spring.
3. Describe the behaviour of a spring-mass system and calculate the maximum compression of a spring caused by contact with a moving mass.
4. Describe the effect of friction losses on potential and kinetic energy.
5. Define linear momentum and calculate the coefficient of restitution.
6. Calculate the kinetic energy and velocity of an elastic head-on collision.
7. Define angular momentum and calculate the changes in momentum of rotating shafts.
8. Calculate the kinetic energy and velocity of a rotating shaft.
9. Calculate the time required to change the rotational velocity of a shaft.

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Topic 3 Centripetal Force and Acceleration

Learning Outcome

Perform calculations involving centripetal and centrifugal forces.

Learning Objectives

1. Calculate the centripetal acceleration of a rotating body in uniform circular motion.
2. Calculate the centrifugal force on a rotating body in uniform circular motion.
3. Calculate the tension in an attachment cord for vertically revolving masses.
4. Calculate the speed and period of a conical pendulum.
5. Calculate the positions of balancing masses to equalize centrifugal forces.
6. Calculate the stress in a rotating flywheel rim.
7. Calculate the velocity, acceleration, and accelerating force of a reciprocating component such as a piston driving, or driven from, a crankshaft.

Topic 4 Torque and Torsion

Learning Outcome

Perform calculations involving torque and torsion.

Learning Objectives

1. Calculate angular velocity given the angular momentum of a rotating shaft.
2. Calculate strain in a solid bar under torsion load.
3. Calculate the stress at a given radius in a solid shaft.
4. Calculate torsional stress and strain in a hollow shaft.
5. Calculate modulus of rigidity and torsional resilience for a solid shaft.
6. Calculate the power consumed by torque acting on a rigid body rotating about a fixed axis.
7. Calculate maximum and mean torque for solid and hollow shafts of circular cross section.
8. Calculate the deflection of a closely coiled helical spring.

Topic 5 Stress and Strain

Learning Outcome

Perform calculations involving stress, strain, shear forces, and bending moments.

Learning Objectives

1. Explain the behaviour of stress and strain in solids.
2. Calculate single and double shear stress in a solid bar subject to oblique loading.
3. Define the modulus of elasticity.
4. Calculate stress, strain, and the equivalent modulus of elasticity for a compound bar.
5. Calculate stress due to restricted thermal expansion.
6. Calculate the elastic strain energy of a solid bar.
7. Calculate the instantaneous compression and stress of a solid bar subjected to suddenly applied and shock loads.
8. Calculate stresses in pressure vessels due to internal pressure.
9. Using the fundamental bending equation, calculate bending moment, moment of inertia, modulus of elasticity, radius of curvature, maximum stress, and location of neutral axis.
10. Compare the strengths of beams using the modulus of section.
11. Calculate the deflection of a beam under load.

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Topic 6 Static Fluids

Learning Outcome

Perform calculations involving fluids at rest.

Learning Objectives

1. Calculate the relative density of a liquid mixture.
2. Calculate the pressure indicated by a manometer.
3. Calculate the energy transmitted by a pressurized liquid.
4. Calculate the pressure and force on the surfaces of a tank containing non-mixing liquids.
5. Calculate the position of the centre of pressure of a tank containing non-mixing liquids.
6. Explain Archimedes' principle.
7. Calculate the relative density from the buoyant force on a submerged body and its true and apparent weights.
8. Calculate the tension and stress in the cable or wire supporting a submerged solid body.
9. Calculate the density of a floating body, given the volume of liquid that it displaces.

Topic 7 Fluids in Motion

Learning Outcome

Perform calculations involving fluids in motion.

Learning Objectives

1. Explain the equation of continuity.
2. Calculate the fluid flow through a valve, given the valve diameter and lift.
3. Calculate flow through rectangular and triangular notches.
4. Calculate the total energy of a liquid in motion.
5. Calculate the pressure in a pipe given the cross-sectional area and liquid flow rate.
6. Calculate the diameter, velocity, and flow through an orifice given the coefficient of discharge.
7. Calculate flow through horizontal and vertical venturi given the discharge coefficient.
8. Compare the resistance to flow of various liquids due to their viscosity using the velocity gradient and coefficient of viscosity.
9. Explain the significance of steady and unsteady liquid flows with regard to Reynold's number.
10. Using Poiseuille's equation, calculate liquid flow in a pipe and the pressure required for the liquid flow to overcome viscosity.
11. Calculate the theoretical head imparted to water by a centrifugal pump.
12. Calculate the manometric head and efficiency, and power consumed by a centrifugal pump.
13. Calculate the power available from a hydraulic turbine.
14. Explain the design and significance of convergent and convergent-divergent nozzles and calculate the critical pressure of a steam nozzle.

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Major Topic: Power Plant Operations Topic 1

Plant and Equipment Efficiencies Learning Outcome

Explain and calculate power plant and equipment efficiencies.

Learning Objectives

1. Describe methods used to maximize efficiency of steam power plants and minimize energy losses.
2. Calculate boiler gross efficiency using input-output method and heat loss method.
3. Calculate turbine performance and efficiency.
4. Calculate the condensate savings and heat gained through improvements in condenser efficiency.
5. Describe the components and significant parameters of a typical computerized plant performance management system, including a program to reduce controllable losses.
6. Describe the efficiencies of a simple cycle gas turbine and various cycle improvements that can be made.
7. Describe different methods for waste heat recovery and the resultant improvement of efficiency.
8. Compare the inherent efficiencies of Once-Through Steam Generators (OTSG) with Heat Recovery Steam Generators (HRSG).
9. Calculate the steam generated and efficiency of a combined cycle plant, given system data.

Topic 2 Power Plant Construction

Learning Outcome

Explain the regulations, processes, and procedures pertaining to the design, construction, and modification of plant facilities.

Learning Objectives

1. Describe the general criteria, including economics, which must be considered in determining the need for additional facilities and in deciding between new plant construction and existing plant expansion.
2. Describe the general criteria to be considered in the design of a new plant.
3. Describe the regulatory permitting processes for a construction project, including environmental feasibility study.
4. Describe a quality assurance/quality control (QA/QC) program for pressure equipment, including the process for accepting, receiving, and approving new and used vessels.
5. Describe the major considerations and steps involved in the construction of a new plant, from design to completion.
6. Explain the role of the Chief Power Engineer and regulatory inspectors in a plant construction project.
7. Explain the components and management of a construction health and safety program.
8. Explain the process of coordinating plant expansion activities with the operation of the existing plant, including tie-in of the old and new facilities.
9. Interpret, in detail, the information provided in construction drawings.

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Major Topic: Inspection, Maintenance and Repair Practices

Topic 1 Maintenance Management Practices

Learning Outcome

Explain management practices for typical maintenance programs.

Learning Objectives

1. Describe how equipment is managed through the concept of asset management.
2. Explain the purpose, components, and management of a maintenance program including preventive, predictive and corrective maintenance approaches.
3. Explain the concepts and importance of reliability centred maintenance (RCM) in developing a maintenance program.
4. Describe the major steps in performing an RCM analysis.
5. Provide an example of how RCM is applied.
6. Explain the purpose and process of root cause failure analysis (RCFA).
7. Describe how maintenance can be optimized.
8. Describe how a plant turnaround is planned and effectively executed.
9. Explain the concept, process, and benefits of outsourcing maintenance.
10. Explain the setting up and management of short-term maintenance contracts and long-term service agreements.
11. Explain the purpose and process of maintenance planning and scheduling.

Topic 2 Boiler Repairs

Learning Outcome

Explain quality control programs and specific boiler repair procedures.

Learning Objectives

1. Explain the National Board of Boiler Inspectors (NBBI) requirements for owner inspection and quality control programs.
2. Describe in detail the components of owner inspection and quality control programs, including roles and responsibilities, records and reporting procedures.
3. Describe the roles, responsibilities, and personnel qualifications regarding repairs to boilers.
4. Explain the detailed procedure for repairs to cracks in boiler parts, including drums and headers.
5. Explain the detailed procedure for repairs to ruptured boiler tubes.
6. Explain the management, responsibilities, and procedures for safety valve repairs.

Topic 3 Non-Destructive Examination

Learning Outcome

Explain the methods, applications, and control of non-destructive examination.

Learning Objectives

1. Explain the significance and application of ASME Section V.
2. Describe the process of radiographic examination.
3. Describe the process of ultrasonic examination.
4. Describe the process of dye penetrant examination.
5. Describe the process of magnetic particle examination.
6. Describe the process of eddy current examination.
7. Describe the process of acoustic emission examination.
8. Explain the selection, management, and control of a non-destructive examination contractor.

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Topic 4 Rotating Equipment Maintenance

Learning Outcome

Explain specific maintenance procedures for, and typical maintenance problems of, rotating equipment.

Learning Objectives

1. Explain the typical maintenance problems of a large steam turbine.
2. Explain the procedures for inspection and overhaul of a large steam turbine.
3. Explain the typical maintenance problems of a gas turbine.
4. Explain the procedures for inspection and overhaul of a gas turbine.
5. Explain the typical maintenance problems of a large multi-stage pump.
6. Explain the procedures for inspection and overhaul of a large multi-stage pump.
7. Explain the typical maintenance problems of a large generator.
8. Explain the procedures for inspection and overhaul of a large generator.

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REFERENCE CURRICULUM

Engineer (2nd Class)

Massachusetts

Preparation

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Introduction

This Curriculum is intended to assist candidates studying for the Engineer (2nd Class) Massachusetts Preparation Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Engineer (2nd Class) Massachusetts Preparation Examination Candidates

Major Topic: Applied Mechanics, Thermodynamics and Chemistry

Topic 1 Steam Properties and Calculations

Learning Outcome

Define properties of saturated and superheated steam and, using information from the steam tables, calculate the heat required to produce steam at various conditions; determine the equivalent and factor of evaporation for steam boilers.

Learning Objectives

1. Define and explain the following terms: saturation temperature, saturated steam, dry saturated steam, wet saturated steam, dryness fraction, superheated steam, enthalpy.
2. Identify, from the pressure-based and temperature-based steam tables, the properties of saturated steam at specified conditions.
3. Identify, from the superheated steam tables, the properties of superheated steam at specified conditions.
4. Calculate the heat required to produce dry saturated or superheated steam at given conditions, from feedwater at given conditions.
5. Calculate the dryness fraction of wet steam and/or the heat required to produce wet steam at a given dryness fraction.
6. Explain the properties of steam on a temperature-enthalpy diagram.
7. Define and calculate heat rate, equivalent evaporation and factor of evaporation for a boiler.

Major Topic: Boiler Codes, Electrical and Instrumentation Theory

Topic 1 AC Theory and Machines

Learning Outcome

Explain formation and characteristics of AC power, and describe the design, construction and operating principles of AC generators, motors and transformers.

Learning Objectives

1. Explain the creation of single phase and three-phase alternating power; define cycle, frequency and phase relationships (voltage/current) for AC sine waves.
2. Define the following terms and explain their relationships in an ac circuit: capacitance, inductance, reactance, impedance, power factor, alternator ratings (kVA and kW).
3. Describe the stator and rotor designs, operation, and applications for salient pole and cylindrical rotor alternators
4. Describe water, air and hydrogen cooling systems for large generators.
5. Explain parallel operation of alternators and state the requirements for synchronization. Describe manual and automatic synchronization.
6. Describe the design, applications and operating principles for large three-phase squirrel cage and wound rotor induction motors.
7. Describe the design and operating principle of synchronous motors.
8. Explain variable speed control, variable speed starting, and step starting for large induction motors.
9. Explain the principles and applications of power transformation. Perform transformer calculations.
10. Describe the designs and components of typical core and shell type transformers, including cooling components.

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Topic 2 AC Systems, Switchgear, Safety

Learning Outcome

Identify the components of typical AC systems and switchgear and discuss safety around electrical systems and equipment.

Learning Objectives

1. Using a one-line electrical drawing, identify the layout of a typical industrial AC power system with multiple generators, and explain the interaction of the major components.
2. Explain the function of the typical gages, meters, and switches on an AC generator panel.
3. Explain the purpose and function of the circuit protective and switching equipment associated with an AC generator: fuses, safety switches, circuit breakers, circuit protection relays, automatic bus switchover, grounding and lightning arrestors.
4. Explain the components and operation of a typical Uninterruptible Power Supply (UPS) system.
5. Explain safety procedures and precautions that must be exercised when working around and operating electrical system components. Explain grounding.

Major Topic: Thermodynamics and Metallurgy

Topic 1 Thermodynamics of Steam

Learning Outcome

Perform calculations related to properties of steam.

Learning Objectives

1. Describe the basic properties of water and steam.
2. Perform calculations involving specific enthalpy, dryness fraction, specific heat, and specific volume using steam tables.
3. Explain the principles and use of calorimeters to measure the dryness fraction of wet steam.
4. Calculate the dryness fraction of steam based on calorimeter data.
5. Calculate the internal energy of steam under given conditions.
6. Explain entropy and calculate the change in entropy for a particular water/steam process.
7. Determine steam properties using a Mollier Chart.
8. Calculate boiler thermal efficiency using test data.

Topic 2 Practical Thermodynamic Cycles

Learning Outcome

Explain the concepts and use of common thermodynamic cycles, using pressure-volume and temperature- entropy diagrams.

Learning Objectives

1. Explain the concept of a heat engine and describe the different types of heat engines.
2. Describe the Carnot cycle and calculate Carnot cycle efficiency.
3. Explain the Rankine cycle using pressure-volume and temperature-entropy diagrams and calculate Rankine cycle efficiency.
4. Explain the Otto cycle using pressure-volume and temperature-entropy diagrams and calculate Otto cycle efficiency.
5. Explain the Diesel cycle using pressure-volume and temperature-entropy diagrams and calculate Diesel cycle efficiency.
6. Explain the Brayton cycle using pressure-volume and temperature-entropy diagrams and calculate Brayton cycle efficiency.
7. Calculate the heat balance at different points in a Rankine cycle system using test data provided.

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Major Topic: Boilers and Water Treatment

Topic 1 Boiler and Steam Generator Components and Design

Learning Outcome

Discuss the components and design considerations of a steam generator.

Learning Objectives

1. Explain how the ratings of boilers and steam generators are calculated.
2. Explain the factors to be considered in designing a steam generator.
3. Contrast the influence of solid fuel, liquid fuel, and gas fuel on steam generator design.
4. Explain the principles of natural water circulation in a steam generator. Explain why forced circulation is used in a steam generator and how it is attained.
5. Explain the design, placement, and installation considerations for water walls, superheaters, desuperheaters, reheaters, economizers, and air heaters.
6. Explain the purpose and placement of screen tubes, division walls, water-cooled stringer tubes in superheaters, and wall-mounted radiant superheaters.
7. Describe top and bottom support systems for a steam generator.
8. Describe furnace casing design considerations.
9. Describe the purpose and use of specialized steam generator duct arrangements, including air heater bypass, economizer bypass, and air heater recirculation.
10. Describe the methods used to insulate different parts of a steam generator.
11. Explain the general steps used to construct a steam generator.

Topic 2 Boiler and Steam Generator Operation

Learning Outcome

Describe in detail the typical procedures for operation of a large steam generator.

Learning Objectives

1. Describe the detailed hot and cold startup procedures for a steam generator including safety precautions.
2. Describe the detailed shutdown procedure for a steam generator including safety precautions.
3. Describe the detailed lay-up procedures for a steam generator including safety precautions.
4. Describe the detailed refractory dry out procedure for a new steam generator including safety precautions.
5. Describe the detailed boil out procedure for a new steam generator including safety precautions.

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Topic 3 Boiler and Steam Generator Maintenance and Inspection

Learning Outcome

Describe in detail the typical procedures for boiler maintenance and inspection.

Learning Objectives

1. Describe the mechanical cleaning procedures for a boiler including safety precautions.
2. Describe the detailed chemical cleaning procedures for a watertube boiler including safety precautions.
3. Describe the detailed hydrostatic testing procedure for a boiler including safety precautions.
4. Describe standard shutdown activities and preventive maintenance procedures required for a boiler.
5. Describe the detailed procedure for complete inspection of a boiler including waterside, fireside, and auxiliary equipment.
6. Describe boiler inspection techniques and equipment.
7. Describe the required inspection records and reporting procedures.

8 Describe the roles and responsibilities for an inspection including engineering staff, operators, and boiler inspector.

9. Describe the safety requirements during a boiler inspection.

Topic 4 Pumps

Learning Outcome

Discuss the application of large centrifugal pumps.

Learning Objectives

1. Explain selection criteria for pump applications.
2. Interpret pump operating characteristics and performance curves.
3. Describe the procedure for the installation of a large multi-stage centrifugal pump.
4. Describe the typical repairs and preventive maintenance procedures required for a multi-stage centrifugal pump.
5. Describe the methods of control for a multi-stage centrifugal pump including recirculation control.
6. Describe the selection criteria for seal types and materials in a centrifugal pump.
7. Describe the methods of counteracting thrust in a large centrifugal pump.

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Major Topic: Prime Movers

Topic 1 Steam Turbine Theory and Construction

Learning Outcome

Explain the design and components of a large steam turbine, and perform nozzle and steam velocity calculations.

Learning Objectives

1. Explain selection criteria for a turbine application.
2. Describe the design and components of steam turbine casings and casing drains.
3. Describe the design and components of steam turbine rotors, blading, and diaphragms.
4. Describe shaft seal designs, including stuffing boxes, carbon rings, labyrinth, and water seals.
5. Describe the design and components of steam turbine bearings.
6. Describe the ways in which steam turbines are designed to counteract thrust.
7. Describe the purpose and design of expansion and anchoring components.
8. Explain the principles of steam turbine nozzle design.
9. Explain a steam turbine blade velocity diagram.
10. Calculate the steam velocity and angle of entry for impulse and reaction turbine blading.
11. Calculate the work done on steam turbine blades and the resulting power developed.
12. Calculate steam turbine Rankine cycle thermal efficiency.

Topic 2 Steam Turbine Auxiliaries and Control

Learning Outcome

Explain the purpose and design of steam turbine auxiliaries, control, and monitoring equipment.

Learning Objectives

1. Describe the purpose, design and components of a turning gear.
2. Describe the purpose, design and components of an adjusting gear.
3. Explain critical speed.
4. Describe the design and components of lubricating oil and jacking oil systems.
5. Describe the design of speed reducing gears.
6. Describe the design and components of flexible couplings.
7. Describe the purpose and design of steam turbine governors and governor systems.
8. Describe the purpose and design of steam turbine stop valves and control valves.
9. Describe the purpose and design of steam turbine grid type extraction valves.
10. Describe the purpose and design of steam turbine casing pressure relief systems including rupture diaphragms.
11. Describe the purpose and design of steam turbine overspeed trips.
12. Describe the purpose and design of steam turbine supervisory equipment.

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Topic 3 Steam Turbine Operation and Maintenance

Learning Outcome

Discuss procedures for operation and maintenance of a large steam turbine.

Learning Objectives

1. Describe the detailed hot and cold start-up procedures for a large steam turbine, including safety precautions.
2. Describe the detailed shutdown procedure for a large steam turbine including safety precautions.
3. Explain what checks are performed on a large steam turbine during normal operation.
4. Sketch the flow of steam and condensate through a condensing steam turbine and a non-condensing steam turbine.
5. Explain the preventive maintenance requirements for a large steam turbine. Include shaft alignment, bearings, clearances for thrust, blades, shaft seals, correction of blade fouling, erosion and cleaning.
6. Describe the purpose of and procedure for static and dynamic balancing.

Topic 4 Steam Condensers

Learning Outcome

Discuss condenser principles, performance, operation and auxiliaries.

Learning Objectives

1. Describe the principles and design of jet, air cooled, and surface condensers.
2. Describe the purpose, principle and design of surface condenser support and expansion systems.
3. Explain the significant parameters in condenser performance.
4. Calculate condenser thermal efficiency from the test data.
5. Explain the procedures used to troubleshoot condenser performance.
6. Explain the procedures used to backwash and clean a condenser.
7. Describe the purpose, principle and design of air ejectors and vacuum pumps.
8. Describe the purpose and flow of cooling water systems.
9. Describe the purpose, principle and design of cooling water intake screens, circulating pumps, cooling towers, and cooling ponds.
10. Describe the purpose, principle and design of condenser atmospheric exhaust (relief) valves.
11. Describe the purpose, principle and design of condensate pumps.

Topic 5 Lubrication

Learning Outcome

Explain the components of a lubrication application and maintenance program.

Learning Objectives

1. Describe the methods of manufacture and the different classifications of lubricants.
2. Describe the significance and measurement of lubricating oil characteristics, including viscosity, relative density, API (American Petroleum Institute) gravity, pour point, and dielectric strength.
3. Explain the typical causes of lubricating oil deterioration.
4. Describe the types of lubrication additives.
5. Describe a typical power plant lubrication program, including a lubrication survey.
6. Explain the different types of lubricating/governing/seal oil systems.
7. Describe the components and operation of a typical lubricating oil purification system.
8. Describe the various applications of ball-and-roller bearings and their lubrication, including bearing seals.

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Major Topic: Legislation and Codes for Industrial Equipment

Topic 1 Codes, Acts and Regulations

Learning Outcome

Explain the significance and application, at the Chief Engineer level, of boiler and pressure vessel legislation and regulations.

Learning Objectives

1. Describe the typical duties of the chief engineer as set out in boiler and pressure vessel legislation.
2. Describe the legal foundation for the boiler and pressure vessel legislation.
3. Define statutory delegation of powers as they apply to the Boiler and Pressure Vessels Act.
4. Describe the authority that safety officers (inspectors) have within their jurisdiction.
5. Determine what the offences and penalties are under the act and the appeal process.
6. Describe the typical regulations under the Boiler and Pressure Vessels Act.
7. Describe the typical codes and standards referenced by the Boiler and Pressure Vessels Act.

Topic 2 ASME Section 1

Learning Outcome

Demonstrate familiarity with the content of A.S.M.E. Section I, and perform calculations involving cylindrical components, openings, compensations, safety and safety relief valves, and stays in boilers.

Learning Objectives

1. Describe the organization of ASME Section I and its application.
2. Calculate the required thickness or maximum allowable working pressure of a cylindrical shell.
3. Calculate the required thickness or maximum allowable working pressure of a seamless, unstayed dished head, flat head, and formed head.
4. Calculate the maximum dimensions of openings, and the strength of compensation required for reinforcement of openings in cylindrical shells, headers, or heads.
5. Calculate the requirements for braced surfaces and support stays.
6. Calculate the required tubesheet thickness and maximum allowable working pressure for firetube and watertube boilers.
7. Calculate required wall thicknesses of plain circular furnaces, circular flues, Adamson ring reinforced and corrugated furnaces.
8. Calculate the required size and capacity of pressure relief valves.

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Topic 3 ASME Sections VIII and IX

Learning Outcome

Demonstrate familiarity with the content of A.S.M.E. Sections VIII and IX, and perform calculations involving cylindrical components, openings, compensations, safety and safety relief valves, and stays in pressure vessels.

Learning Objectives

1. Describe the organization of ASME Section VIII Division 1 and its application
2. Calculate the required thickness or maximum allowable working pressure of a cylindrical shell in a pressure vessel.
3. Calculate the required thickness or maximum allowable working pressure of a seamless dished head, flat head and formed head in a pressure vessel.
4. Calculate the reinforcement requirements of openings in a pressure vessel.
5. Calculate the minimum required thickness of a cylinder using ligament efficiency.
6. Calculate the required dimensions and locations of staybolts and braced surfaces in a pressure vessel.
7. Calculate the required size and capacity of pressure relief valves for a pressure vessel.
8. Explain the significance of A.S.M.E. Section IX.

Topic 4 Piping and API Codes

Learning Outcome

Explain the significance and application, at the A.S.M.E. B31.1, A.S.M.E. B31.3, A.P.I. 510 and A.P.I. 570.

Learning Objectives

1. Explain the significance and applications of ASME B31.1 Power Piping.
2. Describe the general content of ASME B31.1 Power Piping.
3. Explain the significance and applications of ASME B31.3 Process Piping.
4. Describe the general content of ASME B31.3 Process Piping.
5. Explain the significance and applications of API 510 Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair and Alteration.
6. Describe the general content of API 510 Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair and Alteration.
7. Explain the significance and applications of API 570 Piping Code: In-service Inspection, Rating, and Alteration of Piping Systems.
8. Describe the general content of API 570 Piping Code: In-service Inspection, Rating, and Alteration of Piping Systems.
9. Explain the role and responsibilities of the chief engineer with regard to the ASME and API Codes.

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REFERENCE CURRICULUM

Engineer (3rd Class)

Massachusetts
Preparation

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Introduction

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Reference Curriculum for Engineer (3rd Class) Massachusetts Preparation Examination Candidates

Major Topic: Applied Mechanics, Thermodynamics and Chemistry

Topic 1 Algebraic Operations, Logarithms and Problem Solving

Learning Outcome

Solve problems using algebraic operations, including equations and logarithms.

Learning Objectives

1. Apply the rules for addition, subtraction, multiplication and division of positive and negative quantities.
2. Simplify algebraic expressions and operations involving the removal or insertion of brackets.
3. Apply the rules for powers and roots to the multiplication and division of quantities and expressions.
4. Apply the rules of transposition to solve simple equations involving addition, subtraction, multiplication and division.
5. Solve equations involving powers, roots, and fractions.
6. Explain common and Naperian (natural) logarithms. Using a calculator, perform mathematical operations and solve equations that contain logarithms.
7. Apply an organized, systematic approach to solving a problem and presenting the solution.

Topic 2 Gas Laws and Calculations

Learning Outcome

Explain the laws of perfect gases and perform calculations involving the expansion and compression of gases.

Learning Objectives

1. Explain Boyle's Law, Charles' Law, Gay-Lussac's Law, and the General Gas Law and use these to calculate pressure, temperature and/or volume changes for perfect gases.
2. Explain the Characteristic Gas Constant and use the Characteristic Gas Equation to determine the mass, the conditions, and the constant for a gas.
3. Explain isothermal, adiabatic, and polytropic processes (expansion and compression) for a gas, state the formula for each process, and compare the processes on a pressure/volume diagram.
4. Calculate unknown pressures, volumes and temperatures for gases during isothermal adiabatic, and polytropic processes.
5. Explain and calculate the work done in a cylinder under constant pressure.
6. Explain and calculate the work done in a cylinder during an isothermal expansion or compression.
7. Explain and calculate the work done in a cylinder during an adiabatic expansion or compression.
8. Explain and calculate the work done in a cylinder during a polytropic expansion or compression.

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Topic 3 Corrosion Principles

Learning Outcome

Explain the mechanisms that cause corrosion and the methods used to monitor and control corrosion.

Learning Objectives

1. Define corrosion terms and explain the causes and characteristics of corrosion types, including galvanic, atmospheric, stray current, biological, stress cracking, hydrogen induced, sulphide stress cracking and chloride stress cracking.
2. Explain specifically the nature and sources of corrosion on the water side of boilers, including caustic corrosion, hydrogen damage, and pitting.
3. Explain the environmental factors that affect corrosion.
4. Explain the principles of corrosion inhibitor mechanisms, including adsorbed films, passivation, cathodic precipitates, and neutralization.
5. Describe the principles and applications of cathodic protection devices or systems, including sacrificial anodes, galvanic anodes, impressed current, and groundbeds.
6. Describe the principles and applications of corrosion monitoring devices, including coupons, electrical resistance probes, galvanic probes, and hydrogen probes.
7. Describe corrosion inspection procedures, including ultrasonics and radiography.

Topic 4 Industrial Drawings

Learning Outcome

Identify and interpret components of typical engineered drawings used in industry.

Learning Objectives

1. State the purpose of a Process Flow Diagram (PFD), and identify the major information available on a typical PFD.
2. State the purpose of a Piping & Instrumentation Diagram (P&ID), and identify the major information available on a typical P&ID. Explain the naming and symbol conventions for items found on a P&ID.
3. State the purpose and interpret information provided on a Material Balance Drawing.
4. Interpret information provided on a typical, approved Construction Drawing for a pressure vessel and other equipment.
5. State the purpose and identify the components of a typical Equipment Layout Drawing.

Major Topic: Boiler Codes, Electrical and Instrumentation Theory

Topic 1 Legislation and Codes for Power Engineers

Learning Outcome

Explain the purpose of, general content of, and interaction with the legislation and codes that pertain to the design and operation of boilers and related equipment.

Learning Objectives

1. Explain Codes and Standards.
2. Explain the purpose and scope of the National Board of Boiler Inspectors (NBBI).
3. Explain the scope of the ASME and state the purpose and general content of the following sections of the the ASME Codes: Section I, II, IV, V, VI, VII, VIII, IX.

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Topic 2 Code Calculations - ASME Section I

Learning Outcome

Using the ASME Code - Section I, and ASME Section II D. Table 1A, calculate the design thickness and pressure of boiler tubes, drums, and piping, and calculate the capacities of pressure relief valves.

Learning Objectives

1. Given the tube material specification numbers, and other necessary parameters, use the formulae in PG-27.2.1 to calculate either the minimum required wall thickness or the maximum allowable working pressure for a boiler tube.
2. Given the material specification, construction method, and other necessary parameters, use the formulae in PG-27.2.2 to determine the minimum required thickness and or maximum allowable working pressure for boiler drums, headers, or piping.
3. Given the required specifications and operating conditions, use formula PG-29.1 to calculate the minimum required thickness of a seamless, unstayed dished head.
4. Given the required specifications and operating conditions, use formulae in paragraphs PG-29.11 and PG-29.12 to calculate the minimum required thickness of an unstayed, full-hemispherical head.
5. Using ASME Section I, Paragraphs PG-67 to PG-73, identify code information with respect to pressure relief valves and, using Table A-44, calculate the required pressure relief valve capacity for a given boiler.

Topic 3 Control Loops and Strategies

Learning Outcome

Explain the operation and components of pneumatic, electronic and digital control loops, and discuss control modes and strategies.

Learning Objectives

1. Describe the operation, components and terminologies for a typical control loop.
2. Describe the operation and components of a purely pneumatic control loop. Explain the function of each component.
3. Describe the operation and components of an analog/electronic control loop. Explain the function of each component.
4. Describe the operation and components of a digital control loop. Explain the function of each component.
5. Explain the purpose, operation, and give examples of on-off, proportional, proportional-plus-reset, and proportional-plus-reset-plus-derivative control. Define proportional band and gain.
6. Describe and give typical examples of feed forward, feed back, cascade, ratio, split-range, and select control.
7. Explain, with examples, the purpose and incorporation of alarms and shutdowns into a control loop/ system.
8. Explain the interactions that occur and the interfaces that exist between an operator and the various components of a control loop/system, including the components of a controller interface.

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Topic 4 Instrument and Control Devices

Learning Outcome

Explain the operating principles of various instrument devices that are used to measure and control process conditions.

Learning Objectives

1. Describe the design, operation and applications for the following temperature devices: bimetallic thermometer, filled thermal element, thermocouple, RTD, thermistor, radiation and optical pyrometers
2. Describe the design, operation and applications for the following pressure devices: bourdon tubes, bellows, capsules, diaphragms, and absolute pressure gage.
3. Describe the design, operation and applications for the following flow devices: orifice plate, venturi tube, flow nozzle, square root extractor, pitot tube, elbow taps, target meter, variable area, nutating disc, rotary meter and magnetic flowmeter.
4. Describe the design, operation and applications for the following level devices: atmospheric and pressure bubblers, diaphragm box, differential pressure transmitter, capacitance probe, conductance probes, radiation and ultrasonic detectors and load cells.

Topic 5 Safety Management Systems

Learning Outcome

Discuss typical legislation and programs that manage safety in the industrial workplace.

Learning Objectives

1. Explain the general intent, power and scope of Occupational and Safety Health Act (OSHA) legislation.
2. Explain the intent and scope of a workplace OSHA program and state the responsibilities of company, employees, and the OH&S Committee within the program.
3. Define and give examples of typical workplace hazards and describe a system of hazard identification and control.
4. Explain the purpose of work permits and describe typical hot and cold work permit systems.
5. Explain the purpose of equipment lockout, describe lockout devices, and describe a typical equipment lockout procedure.
6. Define and identify a confined space and a permit-required confined space, describe a typical confined space permit and entry procedure.
7. Explain the hazards of excavation and describe typical excavation procedures and permits.
8. Explain the purpose and describe the typical components of an emergency response plan.
9. State the purpose of OSHA Hazard Communication Standard, explain the use of labels and material safety data sheets, and explain the responsibilities of employer and employee.
10. Explain the purpose, requirements, and procedures for incident and accident investigation and reporting.

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Major Topic: Pumps and Boilers Topic 1 Boiler

Heat Transfer Components Learning Outcome

Explain the purpose, location, design and operating conditions for the major heat transfer components of a large watertube boiler or steam generator.

Learning Objectives

1. Describe baffle designs and locations and explain their significance to boiler heat transfer.
2. Describe the designs of integral furnace sidewall and header arrangements, including tube-and-tile, tangent tube, and membrane.
3. Define primary, secondary, convection, radiation, platen, and pendant as they apply to superheaters. Describe the locations of superheaters within a steam generator and state the operating characteristics of convection and radiant superheaters.
4. Explain the purpose and design of a separately-fired superheater.
5. Explain the purpose and describe the locations of reheaters. Explain the position of and flow through the reheater in relation to the superheaters.
6. Describe designs and locations for integral and separate economizers.
7. Describe the designs, operation, and location of plate, tubular, and rotary regenerative air heaters.
8. Explain operating care and considerations that must be given to the various heat transfer sections of the boiler.
9. Explain a typical water and gas temperature profile through a large steam generating unit.

Topic 2 High Pressure Boiler Fittings

Learning Outcome

Describe the design and operation of common external and internal fittings attached to the pressure side of a high-pressure boiler.

Learning Objectives

1. Describe the design, installation, operation, and setting of a high-pressure pressure relief valve. Explain the Code requirements for size, capacity and locations of the pressure relief valves on a boiler.
2. Describe the code requirements for boiler pressure gages, including attachment and locations.
3. Describe common designs, connections and components of high-pressure water columns and flat gage glasses, including illumination and quick shut-off devices and bulls-eye glasses. Explain testing and maintenance of a high-pressure gage glass.
4. Describe the float and probe designs for low-water fuel cutoffs and explain how these are tested.
5. Describe boiler steam outlet arrangements and fittings including gate, angle, and globe stop valves and globe, Y, angle, and spring-cushioned non-return valves.
6. Describe manual blowoff piping arrangements. Describe the design and operation of sliding disc, seatless sliding plunger, seat and disc, and combination valves. Explain manual blowoff procedures. Describe the requirements for a blowoff tank.
7. Explain the components of the steam drum internals of a watertube boiler. Describe the design and operation of various steam separation devices, including baffles, primary and secondary separators, and scrubbers.

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Topic 3 Boiler Draf t and Flue Gas Equipment

Learning Outcome

Explain boiler draft systems and fans and describe the equipment used to remove ash from flue gas.

Learning Objectives

1. Define and explain the applications and designs of natural, forced, induced and balanced draft.
2. Explain how draft is measured, monitored, and controlled in a large, balanced draft boiler. Explain the position of control dampers.
3. Describe typical draft fan designs, single and double inlet arrangements, and explain methods used to control fan output.
4. Explain the start-up and running checks that must be made on draft fans.
5. Describe typical windbox and air louver arrangements and distinguish between primary and secondary air.
6. Describe the design and operation of flue gas particulate clean-up equipment, including mechanical and electrostatic precipitators and baghouse filters.
7. Describe the design and operation of ash handling systems, including hydro and air systems, bottom ash systems, and scraper conveyor systems.
8. Describe the designs and operation of SO_2 recovery systems, including lime and wet gas scrubbing.

Topic 4 Boiler Control Systems

Learning Outcome

Explain the components and operation of automatic control systems for boiler water level, combustion, steam temperature, and start-up.

Learning Objectives

1. Describe on-off and single element control of boiler feedwater.
2. Explain swell and shrinkage in a boiler. Describe the components and operation of a two-element feedwater control system, explaining the interaction of the controllers.
3. Describe the components and operation of a three-element feedwater control system.
4. Describe the components and operation of a direct combustion control system.
5. Describe the components and operation of a ‘steam flow – airflow’ combustion control system.
6. Describe the components and operation of a ‘fuel flow – airflow’ combustion control system.
7. Describe the components and operation of an ‘airflow – fuel flow’ combustion control system.
8. Describe the components and operation of a multi-element combustion control system.
9. Describe steam temperature control methods and equipment, including attemperation (desuperheating), gas recirculation, gas bypass, and tilting burners.
10. Describe the automatic, programmed start-up sequence for a gas-fired boiler.

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Topic 5 Boiler Procedures

Learning Outcome

Describe common procedures in the operation and maintenance of high pressure boilers.

Learning Objectives

1. Explain the steps involved in the commissioning of a new boiler or before starting a boiler after major repairs, including:
   a) hydrostatic test
   b) external and internal inspections
   c) drying out refractory
   d) boiling out
   e) testing shutdowns and safety devices
2. Describe the wet and dry methods when laying up a boiler for an extended time, including nitrogen blanketing.
3. Describe the proper shut down and preparation of a boiler for internal inspection.
4. Describe a thorough inspection of the water and furnace sides of a boiler.
5. Describe typical equipment and procedures for cleaning the water side of a boiler:
   a) mechanically
   b) chemically
6. Explain routine tasks and visual monitoring that the operator must perform on a large operating boiler.
7. Explain the procedures and precautions that an operator must exercise to avoid furnace and pressure-side explosions.
8. Describe sootblowing systems and describe the procedures for operating sootblowers.

Topic 6 Internal Water Treatment for Boilers

Learning Outcome

Discuss internal water treatment methods and systems for the control of scale, corrosion, and carryover and explain testing and monitoring strategies.

Learning Objectives

1. Explain the causes and effects of boiler scale; explain the most common internal methods of scale control, including phosphate treatment, chelate treatment, sludge conditioning and dispersion.
2. Explain the causes and effects of boiler and condensate return line corrosion; explain treatment methods for acidic, caustic, oxygen, and carbon dioxide corrosion, including sulphite, hydrazine, and amine treatment.
3. Explain the mechanical and chemical causes, effects and types of carryover; explain methods of carryover control, including the use of antifoam and blowdown.
4. Describe the design and explain the operation of simple blowdown, heat recovery, and automatic blowdown systems.
5. Explain, in general terms, the sampling and testing strategies for boiler internal conditions; describe typical sampling and automatic monitoring equipment.
6. Describe typical chemical feed systems, including pot feeders, continuous feed with day tanks, and continuous feed with pump tanks.

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Topic 7 Boiler Water Pretreatment

Learning Outcome

Explain the purpose, principles, equipment, and monitoring of boiler water pretreatment processes.

Learning Objectives

1. Describe the design and explain the terms, purpose and operation of a clarifier, using coagulation, flocculation, and subsidence.
2. Describe the design and explain the terms, purpose and operation of gravity and pressure filters.
3. Describe the design and explain the terms, purpose and operation, including chemical reactions for a cold lime softener.
4. Describe the design and explain the terms, purpose and operation of a hot lime softener.
5. Explain the principles of ion exchange softening in general, identifying the common anions and cations in untreated water.
6. Describe the design, components, and operation of a sodium zeolite softening system including chemical reactions.
7. Describe the design, components, and operation of a hydrogen zeolite softening system including chemical reactions.
8. Describe the design, components, and operation of a dealkalization system including chemical reactions.
9. Describe the design, components, and operation of a demineralizer system, including mixed bed and degasification.
10. Explain the principle and operation of a reverse osmosis system.
11. Describe the design, principle, and operation controls of a typical deaerator.

Major Topic: Prime Movers and Refrigeration Topic 1

Steam Turbine Principles and Design Learning Outcome

Describe designs, operating principles and major components of steam turbines.

Learning Objectives

1. Explain impulse turbine operating principles. Describe convergent and divergent nozzles, and the pressure-velocity profiles through an impulse section.
2. Explain reaction turbine operating principles and describe the pressure-velocity profiles through reaction blading.
3. Explain pressure, velocity, and pressure-velocity compounding of impulse turbines. Describe the pressure-velocity profiles and the purpose and applications of each.
4. Explain the purpose, general operating principles and arrangement for each of the following turbine types: condensing, condensing-bleeder, backpressure, extraction, topping, mixed-pressure, cross-compounded, tandem compounded, double flow and reheat.
5. Describe the designs of typical turbine casings and state the purpose and location of casing fittings, including drains and sentinel valves. Describe the designs and principles of casing/shaft seals.
6. Describe the designs and applications of disc and drum rotors. Describe methods of rotor and casing blade attachment and explain blade-sealing arrangements.
7. Explain thrust in a large turbine and describe methods to offset thrust, including thrust bearings, dummy piston, and thrust-adjusting gear.
8. Identify typical designs and components for small and large industrial turbines. Explain typical size/ capacity rating specifications and explain typical applications.
9. Explain the use and design of reducing gears attached to steam turbines.

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Topic 2 Steam Turbine Auxiliaries and Operation

Learning Outcome

Describe auxiliary support and control systems for steam turbines and explain start-up and shutdown procedures.

Learning Objectives

1. Describe typical lube oil systems for small and large steam turbines.
2. Explain the purpose and describe the design and operation of barring gear and jacking oil systems on a large turbine.
3. Describe a condensing turbine circuit and explain typical operating parameters.
4. Explain and state the applications, where applicable, of the following governor types: speed-sensitive, pressure-sensitive, nozzle, throttle, and bypass. Explain governor droop and isochronous control.
5. Explain the operation and the major components of the three main speed-sensitive governor systems: mechanical, mechanical-hydraulic, and electronic-hydraulic.
6. Explain the operation and describe the components of typical mechanical and electronic overspeed trip systems.
7. Explain the sequence followed for the cold start-up and the shutdown of a non-condensing steam turbine.
8. Explain the sequence followed for the cold start-up and the shutdown of a condensing and extracting steam turbine.

Topic 3 Turbine Condenser Systems

Learning Outcome

Explain typical designs, components and operating principles of steam turbine condensers.

Learning Objectives

1. Explain the purposes of a turbine condenser in a steam plant cycle and describe a typical condensing circuit, with operating temperatures and pressures.
2. Explain the design, operation and applications of the jet condenser, including the ejector type.
3. Explain the design, operation and applications of the surface condenser, including air cooled and water-cooled, down flow and central flow.
4. Describe construction details for surface condensers, including shells, tube attachment, supports, and allowances for expansion.
5. Explain the effects of air in a condenser and describe the design and operation of single and two-stage air ejectors. Explain the detection of condenser air leaks. Explain vacuum pumps.
6. Explain the devices and operating considerations used to protect a condenser against high backpressure, high condensate level, and cooling water contamination. Describe a cooling water leak test.
7. Describe the operating conditions and corresponding design considerations for condensate extraction pumps and cooling water pumps.
8. Describe a feed water heater system in conjunction with a steam condenser and explain the designs of low-pressure and high-pressure feed water heaters.

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Topic 4 Gas Turbine Principles and Designs

Learning Outcome

Explain common designs, major components, operating principles, and arrangements for industrial gas turbines.

Learning Objectives

1. Explain gas turbine advantages and disadvantages, background and industrial applications. Identify the types of gas turbines, their major components and describe the operating principles of a simple gas turbine.
2. Explain single and dual shaft arrangements for gas turbines. Describe open cycle and closed cycle operation.
3. Describe a typical open cycle gas turbine installation, including buildings or enclosures, intake and exhaust systems, auxiliary systems, and reducing gear.
4. Explain the efficiency and rating of gas turbines and describe the purpose and applications of gas turbine cycle improvements, including intercooling, regenerating, reheating and combined cycle.
5. Describe various aspects of compressor design and centrifugal and axial types of compressors.
6. Describe the types, operation, components and arrangements of combustors.
7. Describe turbine section design and operation especially with respect to blading and materials.
8. Explain the types and functions of the control systems and instrumentation needed for gas turbine operation.
9. Explain the typical operating parameters of a gas turbine; describe the effects of compressor inlet temperature, compressor discharge pressure, and turbine inlet temperature on gas turbine performance.

Topic 5 Gas Turbine Auxiliaries and Operation

Learning Outcome

Describe the support auxiliaries for a gas turbine and explain common operational, control and maintenance procedures.

Learning Objectives

1. Describe the types of bearings used in a gas turbine and explain the components, operation, protective devices and routine maintenance of a typical lube oil system.
2. Describe and explain the operation and routine maintenance of a typical fuel gas supply system for a gas turbine.
3. Describe and explain the operation and routine maintenance of a typical fuel oil supply system for a gas turbine.
4. Explain the control of NO_X from a gas turbine and describe the purpose and operation of water/steam injection and dry low NO_X systems.
5. Explain the purpose, location and operation of the gas turbine starting motor and turning gear.
6. Describe the compressor intake and the turbine exhaust components.
7. Describe the preparation and complete start-up sequence for a gas turbine.
8. Describe the shutdown sequence and procedure for a gas turbine.
9. Explain the purpose and describe typical on-line and off-line waterwash procedures for gas turbine blades.

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REFERENCE CURRICULUM

Fireman (1st Class)
Massachusetts
Preparation

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PO BOX 16369

Pittsburgh, PA 15242-0369

Introduction

This Curriculum is intended to assist candidates studying for the Fireman (1st Class) Massachusetts Preparation Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Fireman (1st Class) Massachusetts Preparation Examination Candidates

Major Topic: Introduction to Plant Operations and the Environment

Topic 1 Introduction to the Environment

Learning Outcome

Identify environmental considerations and how they relate to an operating plant.

Learning Objectives

1. Describe four important Biogeochemical Cycles that operate within the environment.
2. Describe typical interdependencies seen among elements within an “ecosystem.”
3. List the types of impacts that operating facilities can have on the environment.
4. Describe the alert processes related to environmental problems of plants.
5. Explain the importance of “attitude” in limiting environmental impacts of plants.
6. Describe the long-term environmental impacts after the decommissioning and abandonment of plants.

Topic 2 Gas and Noise Emissions

Learning Outcome

Explain how gas and noise emissions affect plant operations.

Learning Objectives

1. Identify the sources and effects of common gases and vapors that have an adverse environmental impact.
2. Identify the common greenhouse and acid rain causing gases and describe their effects.
3. Describe the common methods for monitoring and reducing gaseous pollutants.
4. Describe the effects of noise pollution and methods of identifying, measuring, and controlling it.

Topic 3 Liquid and Solid Emissions

Learning Outcome

Explain how liquid and solid emissions affect plant operation.

Learning Objectives

1. Describe the sources and effects of solid pollutants from energy plants.
2. Describe the theory of operation of separators/collectors and monitoring of flue gas particulates.
3. Describe the disposal methods of solid waste from energy plants.
4. List sources and effects of liquid and thermal pollution.
5. Describe the preventive measures that can be taken to prevent liquid and thermal pollution.
6. Describe methods of liquid waste disposal.

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Major Topic: Types of Prime Movers and Heat Engines

Topic 1 Steam Turbines

Learning Outcome

Describe the construction and operation of steam turbines.

Learning Objectives

1. Describe the principle of operation and major components of a steam turbine.
2. Describe the lubrication and sealing of steam turbine shafts.
3. Describe how the rotational speed of a steam turbine is governed and controlled.
4. List the steps to follow in a typical steam turbine start-up and shut-down.

Topic 2 Condensers and Cooling Towers

Learning Outcome

Describe the operation and maintenance of condensers and cooling towers.

Learning Objectives

1. Explain the construction and operation of condensers, and how they relate to the operation of cooling towers.
2. Explain the principle of operation, the purpose, and the major components of cooling towers.
3. Describe the construction and operation of natural draft cooling towers.
4. Describe the construction and operation of mechanical draft cooling towers.
5. Discuss cold climate operation for cooling towers.
6. Explain typical problems and resolutions required within the operation of cooling towers.

Major Topic: Lubrication and Bearings

Topic 1 Lubrication Principles

Learning Outcome

Describe the importance of lubrication and the principles concerned with lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and application.
3. List the properties of lubricating oils, the additives used, and their selection criteria.

Topic 2 Types of Bearings and Lubrication

Learning Outcome

Describe bearing types, methods for care and maintenance of bearings, and bearing lubrication systems.

Learning Objectives

1. Define boundary and full fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of antifriction and thrust bearings.
4. Describe how to clean and replace roller and ball type bearings.
5. Explain the causes of bearing failure.

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Major Topic: Energy Plant Instrumentation and Controls Topic 1

Introduction to Energy Plant Controls and Instrumentation Learning Outcome

Describe the overall purpose and function of plant instrumentation systems.

Learning Objectives

1. Describe the concept and basic components of a control loop.
2. Describe the various means by which control signals are transmitted, and the function of transducers.
3. List and describe the types of instruments that are not control loop components.

Topic 2 Introduction to Process Measurement

Learning Outcome

Describe the construction and operation of common devices used to measure pressure, level, flow, temperature, humidity, and composition.

Learning Objectives

1. Describe the types of pressure sensing and measuring devices.
2. Describe the types of level sensing and measuring devices.
3. Describe the types of flow sensing and measuring devices.
4. Describe the types of temperature sensing and measuring devices.
5. Describe the types of humidity sensing and measuring devices.
6. Describe the types of gas sensing and measuring devices.

Major Topic: Introduction to Plant Operations and the Environment

Topic 1 Liquid and Solid Emissions

Learning Outcome

Explain how liquid and solid emissions affect plant operation.

Learning Objectives

1. Describe the sources and effects of solid pollutants from energy plants.
2. Describe the theory of operation of separators/collectors and monitoring of flue gas particulates.
3. Describe the disposal methods of solid waste from energy plants.
4. List sources and effects of liquid and thermal pollution.
5. Describe the preventive measures that can be taken to prevent liquid and thermal pollution.
6. Describe methods of liquid waste disposal.

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Major Topic: Boiler Safety Devices

Topic 1 Combustion Safety

Learning Outcome

Explain the design and operation of combustion safety controls on burners and boilers.

Learning Objectives

1. Describe the operation of control and safety devices found on boiler fuel supplies.
2. Describe the construction and operation of flame detectors.
3. Describe the combustion safety controls for boilers and burner systems.
4. Describe burner management systems.
5. Interpret burner operating sequence charts, and provide a typical sequence of startup and shutdown events.

Topic 2 Water Level Safety Controls

Learning Outcome

Describe feedwater devices, and control methods used on boilers.

Learning Objectives

1. Describe the construction and operation of boiler low water level fuel cut-off equipment.
2. List the ASME code requirements regarding low water fuel cut-off devices.
3. Describe direct and indirect type boiler water level indicators.

Topic 3 Firing Rate Controls

Learning Outcome

Describe the operating and safety controls found on boilers.

Learning Objectives

1. Describe basic boiler firing rate controls.
2. Discuss various operating controls for steam and hot water boilers.

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REFERENCE CURRICULUM

Fireman (2nd Class)
Massachusetts
Preparation

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Pittsburgh, PA 15242-0369

Introduction

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Recommended Study Program:

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Reference Curriculum for Fireman (2nd Class) Massachusetts Preparation Examination Candidates

Major Topic: Preparatory Math Topics for Power Engineering

Topic 1 Basic Arithmetic Operations

Learning Outcome

Perform basic arithmetic operations without the use of a calculator.

Learning Objectives

1. Add and subtract integers.
2. Multiply and divide whole and decimal numbers.
3. Perform arithmetic operations involving combinations of addition, subtraction, multiplication, division, and powers in the proper order of operation.

Topic 2 Fractions, Decimals, and Percentages

Learning Outcome

Perform basic arithmetic operations involving fractions, decimals, and percentages.

Learning Objectives

1. Identify proper and improper fractions and mixed numbers.
2. Add, subtract, and multiply fractions, and reduce them to lowest terms.
3. Convert fractions to decimal numbers and decimal numbers to fractions.
4. Analyze percentage problems.

Topic 3 Ratio and Proportion

Learning Outcome

Describe the concepts of ratio and proportion.

Learning Objectives

1. Convert ratios of one quantity to another quantity.
2. Solve word problems involving ratios and proportions.

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Major Topic: Elementary Physical, Chemical, and Thermodynamic Principles

Topic 1 Introduction to Thermodynamics

Learning Outcome

Explain the principles and laws of thermodynamics.

Learning Objectives

1. Describe the laws and different temperature scales used in thermodynamics.
2. Define heat and specific heat, and perform sensible heat calculations.
3. Describe the expansion of solids and liquids.

Topic 2 Thermodynamics of Steam

Learning Outcome

Apply the thermodynamics principles through practical applications using the steam tables and the temperature-enthalpy chart.

Learning Objectives

1. Describe heat as it relates to steam, water, and ice.
2. Explain the various columns of the steam tables.
3. Explain the thermodynamic principles of steam, using the steam tables.

Major Topic: Introduction to Boiler Designs

Topic 1 Introduction to Boilers

Learning Outcome

Describe the historical development of boilers, boiler design, components, and configuration.

Learning Objectives

1. Describe the history of boiler applications, boiler design, and modern boiler improvements.
2. Describe packaged boilers.
3. Describe the construction of shop-assembled and field-erected boilers.
4. Describe components and design aspects common to all boiler vessels.

Topic 2 Firetube Boilers

Learning Outcome

Describe the design, components, and characteristics of firetube boilers.

Learning Objectives

1. Differentiate the Scotch Boiler from the other firetube boilers, and describe its development history.
2. Describe circulation patterns in firetube boilers.
3. Discuss construction details of firetube boilers.

Topic 3 Watertube Boilers

Learning Outcome

Describe the design, components, and characteristics of watertube boilers.

Learning Objectives

1. Describe the design and operating principles of watertube boilers.
2. Describe watertube boiler components.
3. Explain the design and application of packaged watertube boilers.
4. Describe the design, construction, and components of large-scale steam generating units.

Topic 4 Electric Boilers

Learning Outcome

Explain the general design and application of electric boilers.

Learning Objectives

Discuss the advantages and disadvantages of electric boilers. Describe the construction and operating principle of electric boilers.

Major Topic: Elements of Boiler Systems

Topic 1 Combustion

Learning Outcome

Discuss the basic theory of combustion, and the equipment used to provide proper combustion conditions within a boiler.

Learning Objectives

1. Discuss combustion, combustion equations, and the relationship between theoretical and excess air.
2. Discuss the characteristics of solid, liquid, and gaseous fuels.
3. Explain the effects of fuels and combustion on refractory materials.

Topic 2 Draft

Learning Outcome

Describe basic concepts and equipment used to supply combustion air to boiler furnaces.

Learning Objectives

1. Describe the various air streams that deliver combustion air to a furnace.
2. Relate differential pressure to the creation of draft.
3. Describe forced, induced, and balanced mechanical draft.
4. Discuss common methods of controlling combustion airflow.

Discuss common methods of measuring furnace pressures.

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Topic 3 Blowof f and Blowdown Systems

Learning Outcome

Describe the equipment, operation, and purpose of boiler blowoff and blowdown systems.

Learning Objectives

1. Describe blowoff, blowoff equipment, and blowoff procedures.
2. Describe continuous blowdown, blowdown equipment, and blowdown procedures.
3. Describe the maintenance and repair of blowoff systems.

Major Topic: Boiler Safety Devices **Topic 1**

Pressure Relief Valves Learning Outcome

Explain the code requirements, design, and operation of pressure relief valves for power boilers, heating boilers, and pressure vessels.

Learning Objectives

1. Discuss the code requirements, construction, and operation of ASME Section I Pressure Relief Valves and Devices.
2. Discuss the code requirements, construction, and operation of ASME Section IV Pressure Relief Valves and Devices.
3. Describe the testing and repair of pressure relief valves.
4. Describe the construction and operation of temperature and pressure relief valves.

Major Topic: Boiler Plant Operation and Management

Topic 1 Boiler Plant Startup

Learning Outcome

Describe the operational procedures related to starting up auxiliary equipment in a boiler plant.

Learning Objectives

1. Describe the basic auxiliaries that need to be checked, prepared, or placed in service before starting a boiler plant.
2. Describe the general procedures for starting a plant for the first time, or restarting after an outage or turnaround.
3. Discuss basic operating practices for starting pumps and fans.
4. Describe the general preparation for a hot water boiler startup.
5. Describe the general preparation for a steam boiler startup.
6. Describe the safety and housekeeping preparation requirements for boiler plant startup.

Topic 2 Boiler Startup

Learning Outcome

Describe procedures for safely starting boiler systems.

Learning Objectives

1. Describe operating considerations when warming a cold boiler.
2. Describe how to start and cut-in a hot water boiler.
3. Describe how to start a single boiler steam plant.
4. Describe how to cut-in a steam boiler in a multiple boiler plant.
5. Describe semi-automatic burner ignition systems.
6. Discuss the post startup inspection for boilers returning to service after a major outage.

Topic 3 Shutdown Procedures

Learning Outcome

Describe generic shutdown and layup procedures for different boiler types.

Learning Objectives

1. Describe hot water boiler shutdown procedures.
2. Describe steam boiler shutdown and lockout procedures.
3. Describe extended period layup requirements for steam boilers.

Major Topic: Basic Concepts of Compression and Absorption Refrigeration

Topic 1 Refrigeration System Control and Operation

Learning Outcome

Describe the purposes and operating principles of refrigeration system operational and safety controls.

Learning Objectives

1. Describe refrigeration system controls.
2. List the safety shutdown devices specific to centrifugal compressor water chillers.
3. Describe typical refrigeration system safety shutdown devices.
4. Describe the construction and operation of refrigerant metering devices.
5. Describe the different methods used to control evaporator capacity.
6. Describe the different methods used to control the capacity of refrigeration compressors.

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Topic 2 Refrigeration System Operation and Maintenance

Learning Outcome

Describe the operating principles and maintenance of refrigeration systems.

Learning Objectives

1. Discuss refrigeration auxiliaries.
2. Describe refrigeration system leak test procedures.
3. Describe how a refrigeration system is dried and charged prior to start-up.
4. List the steps for adding oil to an in-service refrigeration compressor.
5. Describe the start-up and shut-down procedure for a compression refrigeration system.
6. Describe operational log sheets and preventative maintenance procedures for refrigeration systems.
7. Describe how a refrigeration system is purged of noncondensable gases.
8. Discuss refrigeration condenser operation and maintenance requirements.
9. Explain typical problems and resolutions related to refrigeration systems.

Major Topic: Water Treatment

Topic 1 External Boiler Water Treatment

Learning Outcome

Describe the general principle, methods, and equipment used in preparing raw feedwater for steam production.

Learning Objectives

1. Describe typical impurities and their effects on plant and boiler water pre-treatment systems, and their treatment process.
2. Describe the equipment requirements for pre-treatment of plant water systems.
3. Describe water filtration and the removal of suspended solids.
4. Describe the purpose, processes, and equipment used in water softening.
5. Describe the theory, process, and equipment used in deaeration.

Topic 2 Internal Boiler Water Treatment

Learning Outcome

Describe the general principles, methods, and equipment used for internal boiler water treatment.

Learning Objectives

1. Describe the types of problems, and associated treatments, related to internal boiler water contamination.
2. Describe internal boiler feedwater chemical feed systems.
3. Describe standard boiler water testing.

Topic 3 Condensate Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condensate.

Learning Objectives

1. Describe condensate treatment and the effects of non-treatment.
2. Describe the tests conducted on condensate.

Major Topic: Pumps and Compressors

Topic 1 Types of Pumps

Learning Outcome

Describe the construction and operating principles of various types of pumps used in plants.

Learning Objectives

1. List common pump applications.
2. Define the terms associated with pump performance.
3. Describe the common pumps found in plants.

Topic 2 Pump Operation and Maintenance

Learning Outcome

Describe the major considerations and procedures for pump operation and maintenance.

Learning Objectives

1. Discuss the components of a driver and pump assembly.
2. Discuss pump shaft sealing, compression packing, and the replacement of compression packing.
3. Describe the standard types of mechanical seals.
4. Describe pump bearings, shaft alignment procedures, and the equipment used to align shafts.
5. Describe centrifugal pump startup and priming procedures.
6. Describe positive displacement pump operating characteristics, priming, startup, and routine checks.

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REFERENCE CURRICULUM

For

Stationary Engineer (1st Class)
Michigan
Preparation

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Introduction

This Curriculum is intended to assist candidates studying for the Stationary Engineer (1st Class) Michigan Preparation Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Stationary Engineer (1st Class) Michigan Preparation Examination Candidates

Major Topic: Applied Thermodynamics and Plant Cycles

Topic 1 Rankine and Brayton Cycles

Learning Outcome

Discuss the application of the Rankine and Brayton cycles to a power plant.

Learning Objectives

1. Explain heat engines and their application to a steam power plant.
2. Explain the Rankine Cycle using a steam temperature-entropy diagram.
3. Evaluate a Rankine Cycle power plant in terms of efficiency, work ratio, specific steam consumption, isentropic efficiency and efficiency ratio.
4. Explain the Rankine Cycle improvements that can be incorporated into a power plant.
5. Explain the Brayton Cycle and its application to a gas turbine.
6. Explain the Brayton Cycle using pressure-volume and temperature-entropy diagrams.
7. Evaluate a Brayton Cycle power plant in terms of temperatures, work output, and efficiency.
8. Explain the Brayton Cycle improvements that can be incorporated into a power plant.
9. Describe the design, layout, and advantages of a gas turbine/steam turbine combined cycle plant.
10. Explain the total energy concept as it applies to a power plant.

Topic 2 Thermodynamics of Steam

Learning Outcome

Perform calculations for thermodynamic cycles of steam.

Learning Objectives

1. Describe the basis for non-flow processes of vapours.
2. Explain the constant volume process for steam and calculate heat supplied, work done and internal energy.
3. Explain the constant pressure process for steam and calculate heat supplied, work done and internal energy.
4. Explain the constant temperature process for steam and calculate heat supplied and work done.
5. Calculate steam entropy given the steam conditions.
6. Explain the significance of a Temperature-Entropy diagram for steam.
7. Explain the reversible adiabatic process for steam and calculate work done and internal energy.
8. Explain the significance of a Mollier chart for steam.

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Topic 3 Steady-Flow Process Calculations

Learning Outcome

Perform steady flow process calculations for vapours and gases.

Learning Objectives

1. Describe the steady-flow energy equation and calculate the work done in a steady-flow process.
2. Calculate the power consumed in a steady-flow process.
3. Explain the principle of conservation of energy and supersaturation as they apply to a nozzle and calculate nozzle inlet and outlet velocities.
4. Calculate the initial dryness fraction of steam in a throttling process.
5. Determine, using a Mollier Chart, the quality, enthalpy, and entropy of steam entering a calorimeter.
6. Calculate energy transfer, work done, and power produced in a steam turbine.
7. Calculate the heat lost, surface area, required cooling water flow, and heat transfer coefficient in a steam condenser.
8. Define and calculate availability and effectiveness in the context of the steady-flow processes.

Topic 4 Thermodynamics of Perfect Gases

Learning Outcome

Perform calculations for thermodynamic cycles of perfect gases.

Learning Objectives

1. Review the behaviour of perfect gases.
2. Explain Joule's law and its significance.
3. Calculate the heat added or rejected by a mass of perfect gas under changing temperature and pressure conditions.
4. Explain the isothermal cycle using a pressure-volume diagram and calculate heat rejected and work done using a perfect gas as the working fluid.
5. Explain the reversible adiabatic cycle using a pressure-volume diagram and calculate work done, final volume, and final temperature using a perfect gas as the working fluid.
6. Calculate work done in a polytropic cycle using a perfect gas as the working fluid.
7. Using the heat energy equation, calculate the efficiency of a polytropic compression process for a perfect gas.
8. Explain the Gibbs-Dalton law and calculate the work done and heat flow per kilogram when a gas mixture is expanded.

Topic 5 Expansion and Heat Transfer

Learning Outcome

Perform calculations for expansion and heat transfer.

Learning Objectives

1. Explain how thermal expansion and contraction is allowed for in boiler and piping design.
2. Calculate the linear and volumetric expansion of a header or pipe, given internal temperature conditions.
3. Calculate heat transfer by conduction.
4. Calculate the heat flow through a compound insulated wall.
5. Calculate the thickness of insulation required to maintain a given temperature gradient.

Topic 6 Refrigeration Calculations

Learning Outcome

Perform thermodynamic calculations for a refrigeration system.

Learning Objectives

1. Explain the Carnot Cycle as it applies to refrigeration using temperature-entropy and pressure-enthalpy diagrams.
2. Calculate the Carnot coefficient of performance of a refrigeration system and a heat pump system.
3. Calculate the refrigerating effect of a refrigeration system.
4. Calculate the coefficient of performance of a refrigeration system and a heat pump system.
5. Demonstrate graphically, using temperature-enthalpy diagrams, the effect on refrigeration capacity of using a throttle valve in place of an expansion machine, of superheating at the compressor inlet, of undercooling the condensed refrigerant, and of using a flash chamber.
6. Calculate the mass flow of refrigerant in a system.
7. Calculate the swept volume of a compressor cylinder, given its volumetric efficiency.
8. Calculate the power requirement of a refrigerant compressor.

Major Topic: Boiler Principles of Applied and Fluid Mechanics

Topic 1 Lifting Machines

Learning Outcome

Perform calculations for lifting machines.

Learning Objectives

1. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load for lifting machines.
2. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a differential pulley block.
3. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a worm gear and worm wheel.
4. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a worm-driven screw jack.
5. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a turnbuckle.
6. Calculate velocity ratio, mechanical advantage, efficiency, effort and maximum load of a hydraulic jack.

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Topic 2 Energy and Momentum

Learning Outcome

Perform calculations involving potential energy, kinetic energy, and momentum of bodies in linear and rotating motion.

Learning Objectives

1. Define potential and kinetic energy.
2. Calculate the potential energy of a compressed spring.
3. Describe the behaviour of a spring-mass system and calculate the maximum compression of a spring caused by contact with a moving mass.
4. Describe the effect of friction losses on potential and kinetic energy.
5. Define linear momentum and calculate the coefficient of restitution.
6. Calculate the kinetic energy and velocity of an elastic head-on collision.
7. Define angular momentum and calculate the changes in momentum of rotating shafts.
8. Calculate the kinetic energy and velocity of a rotating shaft.
9. Calculate the time required to change the rotational velocity of a shaft.

Topic 3 Centripetal Force and Acceleration

Learning Outcome

Perform calculations involving centripetal and centrifugal forces.

Learning Objectives

1. Calculate the centripetal acceleration of a rotating body in uniform circular motion.
2. Calculate the centrifugal force on a rotating body in uniform circular motion.
3. Calculate the tension in an attachment cord for vertically revolving masses.
4. Calculate the speed and period of a conical pendulum.
5. Calculate the positions of balancing masses to equalize centrifugal forces.
6. Calculate the stress in a rotating flywheel rim.
7. Calculate the velocity, acceleration, and accelerating force of a reciprocating component such as a piston driving, or driven from, a crankshaft.

Topic 4 Torque and Torsion

Learning Outcome

Perform calculations involving torque and torsion.

Learning Objectives

1. Calculate angular velocity given the angular momentum of a rotating shaft.
2. Calculate strain in a solid bar under torsion load.
3. Calculate the stress at a given radius in a solid shaft.
4. Calculate torsional stress and strain in a hollow shaft.
5. Calculate modulus of rigidity and torsional resilience for a solid shaft.
6. Calculate the power consumed by torque acting on a rigid body rotating about a fixed axis.
7. Calculate maximum and mean torque for solid and hollow shafts of circular cross section.
8. Calculate the deflection of a closely coiled helical spring.

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Topic 5 Stress and Strain

Learning Outcome

Perform calculations involving stress, strain, shear forces, and bending moments.

Learning Objectives

1. Explain the behaviour of stress and strain in solids.
2. Calculate single and double shear stress in a solid bar subject to oblique loading.
3. Define the modulus of elasticity.
4. Calculate stress, strain, and the equivalent modulus of elasticity for a compound bar.
5. Calculate stress due to restricted thermal expansion.
6. Calculate the elastic strain energy of a solid bar.
7. Calculate the instantaneous compression and stress of a solid bar subjected to suddenly applied and shock loads.
8. Calculate stresses in pressure vessels due to internal pressure.
9. Using the fundamental bending equation, calculate bending moment, moment of inertia, modulus of elasticity, radius of curvature, maximum stress, and location of neutral axis.
10. Compare the strengths of beams using the modulus of section.
11. Calculate the deflection of a beam under load.

Topic 6 Static Fluids

Learning Outcome

Perform calculations involving fluids at rest.

Learning Objectives

1. Calculate the relative density of a liquid mixture.
2. Calculate the pressure indicated by a manometer.
3. Calculate the energy transmitted by a pressurized liquid.
4. Calculate the pressure and force on the surfaces of a tank containing non-mixing liquids.
5. Calculate the position of the centre of pressure of a tank containing non-mixing liquids.
6. Explain Archimedes' principle.
7. Calculate the relative density from the buoyant force on a submerged body and its true and apparent weights.
8. Calculate the tension and stress in the cable or wire supporting a submerged solid body.
9. Calculate the density of a floating body, given the volume of liquid that it displaces.

Topic 7 Fluids in Motion

Learning Outcome

Perform calculations involving fluids in motion.

Learning Objectives

1. Explain the equation of continuity.
2. Calculate the fluid flow through a valve, given the valve diameter and lift.
3. Calculate flow through rectangular and triangular notches.
4. Calculate the total energy of a liquid in motion.
5. Calculate the pressure in a pipe given the cross-sectional area and liquid flow rate.
6. Calculate the diameter, velocity, and flow through an orifice given the coefficient of discharge.
7. Calculate flow through horizontal and vertical venturi given the discharge coefficient.
8. Compare the resistance to flow of various liquids due to their viscosity using the velocity gradient and coefficient of viscosity.
9. Explain the significance of steady and unsteady liquid flows with regard to Reynold's number.
10. Using Poiseuille's equation, calculate liquid flow in a pipe and the pressure required for the liquid flow to overcome viscosity.
11. Calculate the theoretical head imparted to water by a centrifugal pump.
12. Calculate the manometric head and efficiency, and power consumed by a centrifugal pump.
13. Calculate the power available from a hydraulic turbine.
14. Explain the design and significance of convergent and convergent-divergent nozzles and calculate the critical pressure of a steam nozzle.

Major Topic: Applied Engineering Technologies

Topic 1 Metallurgy

Learning Outcome

Discuss the selection, properties, and stress effects of steel.

Learning Objectives

1. Describe the structure of metals.
2. Explain the nature and significance of phase changes in iron and steel due to temperature change.
3. Explain how alloying elements affect phase changes in steel and state the major alloying elements used in steel.
4. Explain the effect of temperature on the tensile strength of steel.
5. Explain the criteria for the assessment of materials.
6. Explain what creep is, and why it is important to monitor its effects on equipment.
7. Explain the methods of stress analysis.
8. Explain failure analysis.

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Topic 2 Corrosion Chemistry and Processes

Learning Outcome

Explain the chemistry and processes of corrosion mechanisms.

Learning Objectives

1. Explain how atomic and molecular structures affect corrosion.
2. Explain the anodic and cathodic processes of corrosion.
3. Explain the electromotive force series and galvanic series.
4. Explain the effect of polarization
5. Explain corrosion of single metals.
6. Explain the processes of crevice corrosion and pitting corrosion.
7. Explain the process of microbiologically influenced corrosion.
8. Explain the process of stress induced corrosion.
9. Explain the processes of erosion-corrosion.

Topic 3 Boiler Corrosion

Learning Outcome

Discuss the mechanisms of corrosion in boilers.

Learning Objectives

1. Explain the impact of corrosion
2. Explain the agents of corrosion found in water
3. Explain the mechanisms and significance of magnetite formation and magnetite depletion on boiler tube surfaces.
4. Explain the mechanisms and significance of economizer and superheater corrosion.
5. Explain the mechanism, identification, and significance of flue-gas side corrosion of boiler components.
6. Explain the mechanism, identification, and significance of low temperature corrosion of boiler components.
7. Explain the relationship between boiler water chemistry and corrosion of copper alloys in feedwater systems.
8. Explain the mechanisms and significance of deaerator cracking and corrosion.

Topic 4 Corrosion Monitoring and Prevention Techniques

Learning Outcome

Explain techniques used to monitor and prevent corrosion.

Learning Objectives

1. Describe the methods of monitoring and analyzing corrosion.
2. Explain the design, applications, and operation of cathodic protection systems.
3. Explain the use of protective coatings for corrosion control.
4. Describe the regulatory and safety requirements relating to corrosion monitoring.
5. Describe chemical control of corrosion.

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Topic 5 Corrosion Prevention Programs

Learning Outcome

Explain corrosion prevention programs.

Learning Objectives

1. Explain the corrosion characteristics and susceptibility of engineering materials and their selection for various purposes.
2. Describe the chemical, mechanical, and operational factors that are considered in controlling corrosion in steels.
3. Describe the chemical, mechanical, and operational factors that are considered in controlling corrosion in copper alloys.
4. Explain the risks and required precautions involved with chemical cleaning of boiler surfaces.
5. Explain the steps taken to reduce waterside and fireside corrosion during dry and wet storage of a boiler.
6. Explain the development, components, and management of a corrosion prevention program for cooling water systems, including the selection, application and characteristics of biocides.
7. Explain the development, components and management of a corrosion prevention program for piping and pressure vessels.
8. Explain the development, components and management of a corrosion prevention program for rotating equipment.

Topic 6 Fuel Types

Learning Outcome

Discuss the characteristics and applications of coal, oil, and non-conventional gaseous and liquid fuels.

Learning Objectives

1. Explain the factors involved in the selection of primary and secondary fuel for a new installation.
2. Describe the fuel handling considerations and fuel burning characteristics for non-conventional solid fuels including municipal waste, petroleum coke and biomass.
3. Compare the fuel burning characteristics of non-conventional gaseous fuels, including refinery gas, landfill gas, digester gas, carbon monoxide, liquid petroleum gases (LPGs) and acid gases.
4. Compare the fuel burning characteristics of black liquor.
5. Compare the physical properties and fuel burning characteristics of different grades of oil.
6. Describe the considerations for coal cleaning and blending.
7. Describe the purpose and process of coal gasification.
8. Differentiate between low heating value and high heating value fuels.
9. Describe the design and operational considerations for the use of low heating value fuels.
10. Explain the economic considerations for fuel selection for multifuel burners.

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Topic 7 Burner Design

Learning Outcome

Explain the criteria for burner design and selection.

Learning Objectives

1. Describe the general criteria for effective burner design.
2. Describe the classes of burner designs, based on the fuel in use.
3. Compare the design strategies for mixing fuel and air including: co-flow, cross-flow, flow stream disruption and entrainment.
4. Describe the design considerations for a duct burner.
5. Sketch a typical multi-nozzle duct burner layout.
6. Describe the relationship of burner selection to furnace design.
7. Describe the relationship between coal pulverizer selection and burner design.
8. Describe burner design methods to reduce noise.
9. Explain the principle, significance, application, and design of staged combustion burners, including staged fuel flow and staged air flow burners.

Topic 8 Combustion Optimization

Learning Outcome

Explain the considerations for obtaining optimum efficiency and operation of burners.

Learning Objectives

1. Explain the inherent assumptions and factors considered when determining combustion efficiency.
2. Explain the methods and limitations for obtaining maximum efficiency from the combustion of gaseous fuels.
3. Explain the methods and limitations for obtaining maximum efficiency from the combustion of liquid fuels.
4. Explain the methods and limitations for obtaining maximum efficiency from the combustion of solid fuels.
5. Explain the economic and efficiency factors for fuel and burner management in real time operating conditions for a multifuel system.
6. Describe the use of electronic instruments to continuously monitor combustion efficiency.
7. Explain the significance of flame shape, colour and temperature.
8. Explain the effect of excess air on combustion stability and boiler efficiency.
9. Explain the symptoms, significance and corrective action for common combustion problems.

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Topic 9 Combustion Safety and Emissions

Learning Outcome

Discuss safety and environmental considerations in burner operation, including strategies for NO_X control.

Learning Objectives

1. Describe the requirements for safe operation of a combustion system.
2. Compare the significance of burner safety devices for different fuel types.
3. Explain the cause and prevention of furnace explosions in boilers and fired heaters.
4. Describe the processes for dust reduction in coal handling systems.
5. Describe the procedures for dealing with coalbunker and pulverizer fires.
6. Explain the effect of excess air and combustion efficiency on emissions parameters.
7. Explain pre-treatment as a strategy for NO_X reduction (fuel switching, additives and fuel pre-treatment).
8. Explain combustion and operational modification as a strategy for NO_X reduction (low NO_X burners, staged combustion, water/steam injection, burners out of service, low excess air and air preheat and furnace temperature reduction.
9. Explain process modification as a strategy for NO_X reduction (reduced production, electrical heating, improved thermal efficiency and product switching).
10. Explain post treatment as a strategy for NO_X reduction (SCR and SNCR).
11. Explain the effect on NO_X emissions of boiler design, boiler condition and boiler loading characteristics.
12. Explain the reasons for and significance of flue gas recirculation.

Topic 10 Water Pre-Treatment

Learning Outcome

Describe the processes used to treat raw water for power plants, including detailed chemistry where applicable.

Learning Objectives

1. Describe the mechanisms of coagulation and flocculation.
2. Describe the chemical processes and reactions of oxidation of organic contaminants.
3. Describe the chemical processes and reactions of iron and manganese removal from raw water.
4. Describe the chemical processes and reactions in a lime-soda softener.
5. Describe the chemical processes and reactions in a sodium zeolite softener.
6. Describe the chemical processes and reactions in a hydrogen zeolite softener.
7. Describe the chemical processes and reactions in a demineralizer.
8. Describe the chemical processes and reactions in a dealkalizer.
9. Describe the mechanisms of membrane technology, including chemical and mechanical cleaning methods and clean-in-place design.
10. Describe the chemical processes and mechanisms of electrodialysis (ED) and electrodeionization (EDI.)
11. Describe the chemical processes and reactions of oxygen scavenging and metal passivation.
12. Describe the methods by which silica is removed from feedwater and condensate.

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Topic 11 Internal Water Treatment

Learning Outcome

Describe the processes used to treat boiler water and condensate, including detailed chemistry where applicable.

Learning Objectives

1. Explain the principles, reactions and control of chelation.
2. Explain the principles, reactions and control of a coordinated phosphate program.
3. Explain the phenomenon of phosphate hideout.
4. Explain the principles, reactions and control of a congruent phosphate program.
5. Explain the principles, reactions and control of an equilibrium phosphate program.
6. Explain the principles, reactions and control of an all-volatile treatment program.
7. Explain the principles, reactions and control of a polymer treatment program.
8. Explain the principles, reactions and control of an oxygenated water treatment program.
9. Describe the mechanism of sludge conditioning.
10. Describe the mechanism of antifoam conditioning.
11. Describe the chemical processes and reactions of condensate treatment, including corrosion prevention, deaeration and polishing.

Topic 12 Water Treatment Management

Learning Outcome

Explain the monitoring, management, and maintenance of water treatment systems.

Learning Objectives

1. Explain the financial management of the costs and benefits of water treatment.
2. Apply raw water analysis to the selection of a water treatment system.
3. Explain monitoring and control of cycle chemistry.
4. Describe the troubleshooting process when a cycle chemistry parameter deviates from the acceptable range.
5. Describe the selection and maintenance of resins for zeolite, demineralizer, dealkalizer and condensate polisher service.
6. Describe the procedures and interpretation for tube deposit analyses.
7. Explain the inspection procedure for internal boiler components in relation to water treatment.
8. Describe a typical maintenance program for components of water treatment systems, including: water filters, clarifiers and lime-soda softeners, sodium zeolite softeners, demineralizers, mixed bed and condensate polishers, reverse osmosis units, microfiltration, electrodialysis and electrodeionization units and deaerators.
9. Describe the selection, responsibilities, and management of water treatment consultants.

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Topic 13 Non-Boiler Water Treatment

Learning Outcome

Explain the monitoring and management of potable water and cooling water treatment systems.

Learning Objectives

1. Describe the regulatory requirements for potable water quality and monitoring.
2. Describe the parameters and interpretation of potable water analyses.
3. Describe the selection and mechanism of oxidation agents.
4. Describe the mechanism of ultraviolet sterilization.
5. Explain the components and management of a cooling water treatment program.
6. Describe the use and chemistry of biocides in cooling water.
7. Describe the use and chemistry of corrosion inhibitors in cooling water.
8. Explain the use of chelants in cooling water.
9. Explain the use of threshold scale inhibitors in cooling water.
10. Explain the use of surfactants, dispersants and biodispersants in cooling water.

Major Topic: Power Plant Operations Topic 1

Electrical Energy Management Learning Outcome

Discuss the concepts and techniques of electrical energy management.

Learning Objectives

1. Explain the concept of energy management and identify the operational factors that are included in an energy management program.
2. Describe the significance, components, responsibilities and procedure of an energy audit.
3. Explain the significance and application of power factor management, including the effects of: capacitor banks, synchronous motors, inductive and resistive loads, transformers, voltage regulation for synchronous generators and synchronous compensators.
4. Calculate capacitor ratings required for power factor correction.
5. Explain, using a sketch, the purpose, applications, design and operation of a static uninterruptible power supply (UPS).
6. Explain the concept and significance of distributed generation, including the design implications for electrical distribution systems.
7. Describe the benefits of UPS in a distributed generation system, including the use of UPS as a bridge between utility and internal power.
8. Explain the benefits of motor-generator sets, internal combustion engines and micro-turbines in a distributed generation system.
9. Explain the design, operating principle, and benefits of a fuel cell in a distributed generation system.
10. Explain the purpose, components, and operation of emergency power systems, including the physical interconnection between emergency power and main power.
11. Explain the concept, significance, and management of peak load reduction, including utility contract obligations and use of internal generation.
12. Explain the concept and principles of generation load dispatch including contract obligations.

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Topic 2 Plant and Equipment Efficiencies

Learning Outcome

Explain and calculate power plant and equipment efficiencies.

Learning Objectives

1. Describe methods used to maximize efficiency of steam power plants and minimize energy losses.
2. Calculate boiler gross efficiency using input-output method and heat loss method.
3. Calculate turbine performance and efficiency.
4. Calculate the condensate savings and heat gained through improvements in condenser efficiency.
5. Describe the components and significant parameters of a typical computerized plant performance management system, including a program to reduce controllable losses.
6. Describe the efficiencies of a simple cycle gas turbine and various cycle improvements that can be made.
7. Describe different methods for waste heat recovery and the resultant improvement of efficiency.
8. Compare the inherent efficiencies of Once-Through Steam Generators (OTSG) with Heat Recovery Steam Generators (HRSG).
9. Calculate the steam generated and efficiency of a combined cycle plant, given system data.

Topic 3 Power Plant Construction

Learning Outcome

Explain the regulations, processes, and procedures pertaining to the design, construction, and modification of plant facilities.

Learning Objectives

1. Describe the general criteria, including economics, which must be considered in determining the need for additional facilities and in deciding between new plant construction and existing plant expansion.
2. Describe the general criteria to be considered in the design of a new plant.
3. Describe the regulatory permitting processes for a construction project, including environmental feasibility study.
4. Describe a quality assurance/quality control (QA/QC) program for pressure equipment, including the process for accepting, receiving, and approving new and used vessels.
5. Describe the major considerations and steps involved in the construction of a new plant, from design to completion.
6. Explain the role of the Chief Power Engineer and regulatory inspectors in a plant construction project.
7. Explain the components and management of a construction health and safety program.
8. Explain the process of coordinating plant expansion activities with the operation of the existing plant, including tie-in of the old and new facilities.
9. Interpret, in detail, the information provided in construction drawings.

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Topic 4 Commissioning and De-Commissioning

Learning Outcome

Explain the regulations, processes, and procedures pertaining to the commissioning and de-commissioning of plant facilities.

Learning Objectives

1. Explain the sequence for commissioning a new plant.
2. Explain the detailed procedures for commissioning a boiler.
3. Explain the detailed procedures for commissioning a steam turbine.
4. Explain the detailed procedures for commissioning a gas turbine.
5. Explain the detailed procedures for commissioning a piping system.
6. Explain the detailed procedures for commissioning a large fan.
7. Describe the content and significance of a performance contract/guarantee for new equipment or a new plant.
8. Explain the specific procedures for re-commissioning a plant after a major outage.
9. Explain the obligations and liabilities of de-commissioning a plant, including regulatory requirements.
10. Explain the specific procedures for de-commissioning a plant.

Topic 5 Retrofitting

Learning Outcome

Explain the benefits, applications, and processes of retrofitting power plant equipment.

Learning Objectives

1. Explain the considerations that are used to determine whether replacement, re-powering, retrofitting or upgrading should be undertaken.
2. Explain the regulatory requirements for modifications to equipment and systems, including pressure equipment, electrical systems and environmental impact.
3. Explain the overall process and responsibilities when modifying or retrofitting plant systems.
4. Describe the benefits of control system retrofitting with smart instrumentation.
5. Describe the retrofitting methods used to improve boiler efficiency and capacity including superheater upgrades, economizer upgrades, combustion system upgrades, improved air heater seals, improved waterwall design, environmental enhancements and control upgrades.
6. Describe the retrofitting methods used to improve steam turbine efficiency including improved turbine blades and diaphragms, turbine stage additions and improved blade tip sealing.
7. Describe the retrofitting methods used to improve gas turbine efficiency including upgrading inlet guide vanes, improved seals, tighter clearances, improved combustion liners, improved turbine blades and vanes, thermal barrier coatings, compressor blade coatings, compressor stage additions and compressor supercharging.

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Major Topic: Legislation and Codes for Industrial Equipment

Topic 1 Codes, Acts and Regulations

Learning Outcome

Explain the significance and application, at the Chief Engineer level, of boiler and pressure vessel legislation and regulations.

Learning Objectives

1. Describe the typical duties of the chief engineer as set out in boiler and pressure vessel legislation.
2. Describe the legal foundation for the boiler and pressure vessel legislation.
3. Define statutory delegation of powers as they apply to the Boiler and Pressure Vessels Act.
4. Describe the authority that safety officers (inspectors) have within their jurisdiction.
5. Determine what the offences and penalties are under the act and the appeal process.
6. Describe the typical regulations under the Boiler and Pressure Vessels Act.
7. Describe the typical codes and standards referenced by the Boiler and Pressure Vessels Act.

Topic 2 ASME Section I

Learning Outcome

Demonstrate familiarity with the content of A.S.M.E. Section I, and perform calculations involving cylindrical components, openings, compensations, safety and safety relief valves, and stays in boilers.

Learning Objectives

1. Describe the organization of ASME Section I and its application.
2. Calculate the required thickness or maximum allowable working pressure of a cylindrical shell.
3. Calculate the required thickness or maximum allowable working pressure of a seamless, unstayed dished head, flat head, and formed head.
4. Calculate the maximum dimensions of openings, and the strength of compensation required for reinforcement of openings in cylindrical shells, headers, or heads.
5. Calculate the requirements for braced surfaces and support stays.
6. Calculate the required tubesheet thickness and maximum allowable working pressure for firetube and watertube boilers.
7. Calculate required wall thicknesses of plain circular furnaces, circular flues, Adamson ring reinforced and corrugated furnaces.
8. Calculate the required size and capacity of pressure relief valves.

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Topic 3 ASME Sections VIII and IX

Learning Outcome

Demonstrate familiarity with the content of A.S.M.E. Sections VIII and IX, and perform calculations involving cylindrical components, openings, compensations, safety and safety relief valves, and stays in pressure vessels.

Learning Objectives

1. Describe the organization of ASME Section VIII Division 1 and its application
2. Calculate the required thickness or maximum allowable working pressure of a cylindrical shell in a pressure vessel.
3. Calculate the required thickness or maximum allowable working pressure of a seamless dished head, flat head and formed head in a pressure vessel.
4. Calculate the reinforcement requirements of openings in a pressure vessel.
5. Calculate the minimum required thickness of a cylinder using ligament efficiency.
6. Calculate the required dimensions and locations of staybolts and braced surfaces in a pressure vessel.
7. Calculate the required size and capacity of pressure relief valves for a pressure vessel.
8. Explain the significance of A.S.M.E. Section IX.

Topic 4 CSA B51 & B52

Learning Outcome

Describe the content and requirements, and interct with C.S.A. B-51 and C.S.A. B-52

Learning Objectives

1. Describe the content and requirements of C.S.A. B-51
2. Describe the content and requirements of C.S.A. B-52
3. Explain the role and interactions of regulatory authorities and the Chief Engineer with regard to C.S.A. B-51 and B-52.

Topic 5 Piping and API Codes

Learning Outcome

Explain the significance and application, at the A.S.M.E. B31.1, A.S.M.E. B31.3, A.P.I. 510 and A.P.I. 570.

Learning Objectives

1. Explain the significance and applications of ASME B31.1 Power Piping.
2. Describe the general content of ASME B31.1 Power Piping.
3. Explain the significance and applications of ASME B31.3 Process Piping.
4. Describe the general content of ASME B31.3 Process Piping.
5. Explain the significance and applications of API 510 Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair and Alteration.
6. Describe the general content of API 510 Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair and Alteration.
7. Explain the significance and applications of API 570 Piping Code: In-service Inspection, Rating, and Alteration of Piping Systems.
8. Describe the general content of API 570 Piping Code: In-service Inspection, Rating, and Alteration of Piping Systems.
9. Explain the role and responsibilities of the chief engineer with regard to the ASME and API Codes.

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Major Topic: Safety, Loss and Environmental Management

Topic 1 Loss Control

Learning Outcome

Describe the design, components, and implementation of a loss control program.

Learning Objectives

1. Explain the purpose, benefits, and typical components of a loss control program.
2. Explain the process of developing a comprehensive loss control program, including the typical responsibilities and accountabilities of the program.
3. Describe the factors affecting insurance rates and the authority, role, and interaction of insurance inspectors with plant staff.
4. Describe the tools and techniques used to develop a positive attitude towards the components of a loss control program.
5. Describe the tools and techniques used to develop safety awareness in consumers.

Topic 2 Safety Legislation

Learning Outcome

Identify the authority and application of federal and state safety legislation to the work place.

Learning Objectives

1. Explain the ultimate responsibility and requirement, in the work place, to enforce all relevant safety legislation and regulations and to respond to regulatory directives.
2. Describe the legal and ethical obligations of managers, supervisors, and employees for personnel safety.
3. Explain the significance, components, and applications of Canada Labour Occupational Health and Safety legislation.
4. Explain the authority, significance, components, and applications of provincial safety regulations, including the role and interactions of the provincial safety inspectors with plant staff.
5. Explain the requirements for safety compliance training.
6. Explain right to refuse work legislation and its legal implications.
7. Explain the authority, significance and applications of Workers' Compensation Board regulations, including the role and interactions of the Board with plant staff.
8. Describe roles and responsibilities for, and functioning of, a worksite health and safety committee.

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Topic 3 Safe Work Programs

Learning Outcome

Describe comprehensive safe work programs.

Learning Objectives

1. Identify the components and explain the management of a comprehensive safe work program.
2. Explain the components and management of a safety training program.
3. Explain the process of hazard identification, risk assessment and mitigation.
4. Explain the significance and procedure for safe work planning.
5. Explain the significance and procedure for safe work permits, including lockouts.
6. Explain the significance and procedure for confined space entry.
7. Explain the significance and procedure for hot work.
8. Explain the significance and procedure for excavations.
9. Explain the significance and procedure for working at heights.
10. Explain the significance and components of a contractor safety program.
11. Explain the components and management of a safety audit program, including roles and responsibilities.
12. Explain the purpose, components, and procedure for a hazard and operability study.

Topic 4 Emergency Response and Incident Investigation

Learning Outcome

Describe emergency response and incident investigation programs.

Learning Objectives

1. Identify the benefits and typical stakeholders of an emergency response program.
2. Explain the typical components of an emergency response program.
3. Explain the process of developing and maintaining an emergency response program, including typical responsibilities and accountabilities.
4. Explain the procedure for emergency response testing.
5. Explain the typical components of an incident reporting and investigation program.
6. Define categories of incidents.
7. Describe roles and responsibilities for incident initial reporting, investigation, final reporting, and corrective actions.
8. Explain the significance of and steps required in incident investigation.
9. Describe a system for managing incident report data, including the communication process and its significance.
10. Apply an incident reporting and investigation procedure to a case study.

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Topic 5 Environmental Legislation

Learning Outcome

Identify the authority and application of federal and provincial safety legislation and permits.

Learning Objectives

1. Explain the ultimate responsibility and requirement to enforce all relevant environmental legislation and regulations and to respond to regulatory directives.
2. Explain the authority, significance, components, and applications of provincial environmental legislation and regulations, including the role and interactions of the provincial environmental inspectors with plant staff.
3. Explain the authority, significance, components, and applications of federal environmental legislation and regulations, including the role and interactions of the federal environmental inspectors with plant staff.
4. Explain the significance and process of identifying and working with typical stakeholders for environmental programs – the Environmental Impact Assessment (EIA) process.
5. Explain typical compliance requirements for an environmental monitoring program, including equipment calibration and uptime requirements.

Topic 6 Environmental Management

Learning Outcome

Explain environmental management programs, including reporting, clean-up, disposal, and reclamation.

Learning Objectives

1. Explain the purpose, significance and components of an Environmental Management System.
2. Describe the ISO 14000 - 14002 standards for an Environmental Management System.
3. Describe requirements for environmental routine, excursion and exceedance reporting.
4. Explain the compliance tests for Continuous Emission Monitoring Systems (CEMS) and the significance and procedures for Relative Accuracy Test Audits (RATA).
5. Explain the responsibilities and procedures for spill containment and cleanup.
6. Explain the components and development of an environmental audit program.
7. Explain the procedure for an environmental audit including the roles and responsibilities for performing and responding to the audit.
8. Explain the significance, procedures, and regulatory requirements of waste segregation and disposal.
9. Identify waste streams that require special disposal procedures, including recognition of hazardous wastes.
10. Explain the significance and general components of Transportation of Dangerous Goods Acts.
11. Explain the significance and general requirements of hazardous waste transportation.
12. Describe the purpose, significance, requirements and general process of land reclamation.

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Major Topic: Inspection, Maintenance and Repair Practices

Topic 1 Project Management

Learning Outcome

Demonstrate the application of project management practices.

Learning Objectives

1. Define a project, the role of project management, and the makeup of the project stakeholders.
2. Identify the roles and responsibilities of a typical project team.
3. Explain in detail the project planning step.
4. Describe the common tools that are used for project planning and management, including Work Breakdown Structures (WBS), Critical Path Method (CPM), and Gantt charts.
5. Explain in detail the project execution step, including control processes.
6. Explain in detail the project completion step, including assessment and reporting.

Topic 2 Maintenance Management Practices

Learning Outcome

Explain management practices for typical maintenance programs.

Learning Objectives

1. Describe how equipment is managed through the concept of asset management.
2. Explain the purpose, components, and management of a maintenance program including preventive, predictive and corrective maintenance approaches.
3. Explain the concepts and importance of reliability centred maintenance (RCM) in developing a maintenance program.
4. Describe the major steps in performing an RCM analysis.
5. Provide an example of how RCM is applied.
6. Explain the purpose and process of root cause failure analysis (RCFA).
7. Describe how maintenance can be optimized.
8. Describe how a plant turnaround is planned and effectively executed.
9. Explain the concept, process, and benefits of outsourcing maintenance.
10. Explain the setting up and management of short-term maintenance contracts and long-term service agreements.
11. Explain the purpose and process of maintenance planning and scheduling.

Topic 3 Boiler Repairs

Learning Outcome

Explain quality control programs and specific boiler repair procedures.

Learning Objectives

1. Explain the National Board of Boiler Inspectors (NBBI) requirements for owner inspection and quality control programs.
2. Describe in detail the components of owner inspection and quality control programs, including roles and responsibilities, records and reporting procedures.
3. Describe the roles, responsibilities, and personnel qualifications regarding repairs to boilers.
4. Explain the detailed procedure for repairs to cracks in boiler parts, including drums and headers.
5. Explain the detailed procedure for repairs to ruptured boiler tubes.
6. Explain the management, responsibilities, and procedures for safety valve repairs.

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Topic 4 Pressure Vessel and Piping Repairs

Learning Outcome

Explain specific pressure vessel and piping inspection and repair procedures.

Learning Objectives

1. Describe the management roles, responsibilities, and qualifications regarding repairs to pressure vessels and pressure piping.
2. Explain the concept of fitness for service.
3. Describe in detail a typical pressure vessel inspection, identifying common problem areas.
4. Describe in detail a typical pressure piping inspection, identifying common problem areas.
5. Explain the detailed procedure for typical repairs to cracks in pressure vessels.
6. Explain the methods and detailed procedures for typical repairs to corrosion in pressure vessels.
7. Explain the detailed procedure for typical repairs to cracks in pressure piping.
8. Explain the methods and detailed procedures for typical repairs to corrosion in pressure piping.

Topic 5 Non-Destructive Examination

Learning Outcome

Explain the methods, applications, and control of non-destructive examination.

Learning Objectives

1. Explain the significance and application of ASME Section V.
2. Describe the process of radiographic examination.
3. Describe the process of ultrasonic examination.
4. Describe the process of dye penetrant examination.
5. Describe the process of magnetic particle examination.
6. Describe the process of eddy current examination.
7. Describe the process of acoustic emission examination.
8. Explain the selection, management, and control of a non-destructive examination contractor.

Topic 6 Rotating Equipment Maintenance

Learning Outcome

Explain specific maintenance procedures for, and typical maintenance problems of, rotating equipment.

Learning Objectives

1. Explain the typical maintenance problems of a large steam turbine.
2. Explain the procedures for inspection and overhaul of a large steam turbine.
3. Explain the typical maintenance problems of a gas turbine.
4. Explain the procedures for inspection and overhaul of a gas turbine.
5. Explain the typical maintenance problems of a large multi-stage pump.
6. Explain the procedures for inspection and overhaul of a large multi-stage pump.
7. Explain the typical maintenance problems of a large generator.
8. Explain the procedures for inspection and overhaul of a large generator.

Topic 7 Rotating Equipment Monitoring

Learning Outcome

Describe the parameters and methods of turbine monitoring and oil analysis.

Learning Objectives

1. Describe the purpose, importance and types of rotating equipment monitoring.
2. Explain the concept and significance of turbine thermal expansion, the general principles and placement of measuring devices and the procedures to control.
3. Explain the concept and significance of turbine differential expansion, the general principle and placement of measuring devices and the procedures to control.
4. Explain the concept and significance of turbine eccentricity, the general principle and placement of measuring devices and the procedures to control.
5. Explain the concept of vibration, including typical causes, effects and locations of vibration in rotating equipment and how it is measured.
6. Explain the concept and significance of turbine critical speed.
7. Explain the concept and significance of oil whirl, oil whip and steam whirl, and the design and operational considerations to counter oil whirl.
8. Describe common oil problems and their effects on rotating equipment and a typical oil sampling and testing program.

Major Topic: Business and Workforce Management

Topic 1 Business Management

Learning Outcome

Explain general concepts in plant budgeting, finance, accounting, and inventory control.

Learning Objectives

1. Explain the concept and significance of the following accounting terms: accounting cycle, dual entry accounting, debits and credits, accrual accounting, revenue and expenses, assets and liabilities and debt and equity.
2. Explain the concept and significance of financial statements, including Income Statement, Balance Sheet, Statements of Retained Earnings and Cash Flow Statement.
3. Explain budget development, control and reporting processes.
4. Explain typical types of budgets and their significance, including revenue, expense, capital expenditure and production budgets.
5. Explain the components of plant and department budgets.
6. Explain the significance of a cost/benefit analysis.
7. Explain the “time value of money” concept and calculate the Net Present Value (NPV) and Internal Rate of Return (IRR) of a proposed investment.
8. Calculate the Return on Investment (ROI) of a proposed investment.
9. Explain depreciation, including straight-line and declining balance depreciation, and the concept and significance of Capital Cost Allowance (CCA).
10. Describe the components and use of a typical automated inventory system.
11. Explain the purpose and operation of typical inventory management systems, including fixed-point, fixed-interval, max/min, ABC, Just In Time (JIT) and Economic Order Quantity (EOQ.)
12. Explain the concepts and significance of periodic and perpetual inventory systems, and LIFO and FIFO.
13. Describe the role of a supplier and the use of strategic partnerships in an inventory management system.

Topic 2 Contract Management

Learning Outcome

Explain general concepts and management of contracts.

Learning Objectives

1. Explain the content and significance of a typical code of ethics of a professional association.
2. Explain the importance and application of ethical practices in the work place.
3. Define and explain the legal significance of contract, offer and acceptance.
4. Explain the significance of contract documentation, and the rights and obligations of a contractor and contractee.
5. Compare contract types, including: fixed price; cost plus/shared risk; fixed price/cost plus incentive; bonus/penalty; time/material; product/service/resource; and enforceable/unenforceable contracts.
6. Describe methods of discharging a contract, including: agreement, performance, impossibility, operation of law, breach, failure to perform and specific performance.
7. Explain tort and its legal significance; the three basic types of torts, including: intentional, fault-based or negligent, and strict liability, the distinction between legal and ethical liability.
8. Explain due diligence and its legal and ethical significance.
9. Explain force majeure and its legal significance.
10. Explain what is involved in issuing and then completing a tendering process.

Topic 3 Problem Solving and Decision Making

Learning Outcome

Explain techniques for structured problem solving and decision making.

Learning Objectives

1. Explain the importance and application of a structured decision making process.
2. Describe the eight steps in a rational decision making process.
3. Compare analytic, conceptual, directive and behavioural decision making styles.
4. Explain the advantages and disadvantages of group decision making.
5. Describe the common methods of group decision making, including brainstorming, storyboarding, nominal group technique (NGT) and the Delphi technique.
6. Apply a problem solving and decision making approach to a typical plant case study.

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Topic 4 Leadership

Learning Outcome

Discuss models of leadership and motivation.

Learning Objectives

1. Explain leadership responsibilities and the significance of an effective leadership style.
2. Explain the managerial grid and its significance.
3. Explain situational leadership and its significance.
4. Compare the concept and significance of traditional objective setting and management by objectives (MBO).
5. Compare methods of communicating goals and objectives.
6. Explain the motivation process.
7. Compare the basic models of individual motivation, including the hierarchy of needs, motivation–hygiene theory, goal-setting theory, reinforcement theory, equity theory and expectancy theory.
8. Explain the concept and significance of the social styles matrix.

Topic 5 Communication and Conflict Resolution

Learning Outcome

Apply principles of communication and conflict resolution in the work place.

Learning Objectives

1. Compare linear, interactive, and transactive communications and their significance.
2. Explain the common communication shortcuts and their significance including selectivity, assumed similarity, stereotyping and the halo effect.
3. Explain the significance and effects of conflict in an organization.
4. Describe interpersonal and intergroup conflict.
5. Explain the lose/lose, lose/win, win/lose and win/win outcomes of conflict.
6. Explain assertiveness and cooperativeness and their significance.
7. Compare avoiding, accommodating, forcing, collaborating and compromising as conflict resolution strategies.
8. Explain the stages in assertive behaviour for conflict resolution.
9. Describe the concept, significance, responsibilities and typical steps and tactics of a grievance process.
10. Explain the process of labour/management conflict resolution.
11. Describe the typical public stakeholders for an organization's business, and the typical communication processes used in dealing with the public.
12. Explain the public concerns that an organization must address, and the appropriate communication methods used in addressing them.

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Topic 6 Labour Relations

Learning Outcome

Explain principles and models in the management of labour relations and change.

Learning Objectives

1. Explain management’s rights and responsibilities in the enforcement of federal and provincial labour legislation.
2. Compare management interactions between union and non-union work forces.
3. Explain the concept, preparation, and tactics of collective bargaining, including the use of a problem-solving approach.
4. Explain the concepts, significance, roles, and responsibilities during conciliation, arbitration, strike or lockout.
5. Compare the benefits and significances of permanent and contingent employees.
6. Explain the purpose and process of human resource planning and capacity planning.
7. Explain the facilitation of labour relations with a contractor’s workforce.
8. Describe the types of changes that occur in the workplace, the relationship between workplace change and employee attitude, the psychological costs and benefits of change, and management’s role and responsibilities.
9. Explain the concept and significance of homeostasis.
10. Describe the three types of resistance to change (logical, psychological, and sociological), the potential benefits of resistance to change, and the three basic steps to overcome resistance (unfreezing, changing, refreezing.)
11. Explain the typical strategies used to build support for change, including; use of group forces, leadership for change, participation, shared rewards, negotiation, employee security and communication.
12. Explain the purposes and processes of benchmarking.

Topic 7 Recruitment and Employee Development

Learning Outcome

Explain principles and models in the management of employee recruitment and development.

Learning Objectives

1. Explain the purpose and components of a human management process.
2. Explain the legal and ethical constraints on recruitment and selection.
3. Explain the types and processes of pre-employment testing.
4. Explain the purpose, procedure, and limitations of typical interviewing techniques, including behavioural descriptive interviews.
5. Explain the significance and components of a training and development program including training standards, roles and responsibilities.
6. Explain the significance and components of an orientation process.
7. Explain the purpose and process of a needs assessment and gap analysis.
8. Explain the purpose and process of competency profiling.
9. Explain the significance and selection of typical training methods and their relationship to learning styles.
10. Explain the significance of progression and cross-training methods.
11. Explain the purpose and components of a performance management program, including coaching.
12. Explain typical models of performance reviews.
13. Explain the process of corrective and progressive discipline.

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Topic 8 Management Structures & Organization

Learning Outcome

Discuss principles of organizational structure and the application of work teams.

Learning Objectives

1. Compare the design and benefits of typical organizational structures, including: scalar, functional, tall/flat and matrix.
2. Explain the concept and significance of organizational culture.
3. Explain the significance of a team-based organizational structure and methods to develop and promote teamwork.
4. Compare the significance, benefits, and limitations of supervised and self-directed work teams.
5. Describe the characteristics and functioning of a successful work team.
6. Explain the concept and significance of cross-functional work teams.

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REFERENCE CURRICULUM

For

Stationary Engineer (2nd Class)
Michigan
Preparation

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Introduction

This Curriculum is intended to assist candidates studying for the Stationary Engineer (2nd Class) Michigan Preparation Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Stationary Engineer (2nd Class) Michigan Preparation Examination Candidates

Major Topic: Code Calculations and Legislation Topic 1

ASME Code Calculations: Cylindrical Components Learning

Outcome

Apply the appropriate formulae from ASME Sections I and VIII to calculations involving cylindrical components, openings, and compensations in boilers and pressure vessels.

Learning Objectives

1. Calculate the minimum required thickness or the maximum allowable working pressure of ferrous tubing, up to and including 125 mm O.D.
2. Using ASME Sections I and VIII, calculate the required minimum thickness or the maximum allowable working pressure of ferrous piping, drums, and headers.
3. Calculate the required thickness or maximum allowable working pressure of a seamless, unstayed dished head.
4. Calculate the minimum required thickness or maximum allowable working pressure of unstayed flat heads and welded covers.
5. Determine whether or not reinforcement is required for openings in a cylindrical shell, header, or head.
6. Using the ligament efficiency method, calculate the minimum required thickness of a cylindrical drum with two or more openings in the pressure boundary.

Topic 2 ASME Code Calculations: Stayed Surfaces, Pressure Relief Valves and Furnaces

Learning Outcome

Apply the appropriate formulae from A.S.M.E. Sections 1 and 8 to calculations involving pressure vessel stayed surfaces, safety and safety relief valves, and firetube boilers.

Learning Objectives

1. Calculate the required thickness and maximum allowable working pressure for braced and stayed surfaces in pressure vessels.
2. Calculate the minimum required cross-sectional area of stays and staybolts in firetube boilers, including diagonal stays.
3. Calculate the required size and capacity of pressure relief valves.
4. Explain design considerations for various circular furnaces and calculate the required thickness of corrugated furnaces.

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Topic 3 Boiler and Pressure Vessel Legislation

Learning Outcome

Describe the components and application of boiler and pressure vessel legislation within Canadian jurisdictions.

Learning Objectives

1. Identify the types and sources of Laws and the levels and scope of the Courts.
2. Define Statutory Delegation of Powers as they apply to the Boilers and Pressure Vessels Act.
3. Describe the authority that Safety Officers (Inspectors) have within their jurisdiction.
4. Determine what are the offences and penalties under the Act and the appeal process.
5. Describe the typical Regulations under the Boilers and Pressure Vessels Act.
6. Describe the typical Codes and Standards referenced by the Boilers and Pressure Vessels Act.

Topic 4 Plant Design and Installation

Learning Outcome

Explain the codes and procedures involved in the design and construction of a new plant.

Learning Objectives

1. State the codes and standards that must be followed when designing and building a new plant.
2. Describe the steps involved in developing specifications and contracts for new installations and modifications.
3. Explain the major steps involved in the design and construction of a new plant.
4. Explain the roles and responsibilities in the design and construction of a new plant.
5. Explain how the design and construction of a new plant are administered and controlled.

Topic 5 Management and Supervision

Learning Outcome

Describe the roles and basic competencies of a supervisor and manager.

Learning Objectives

1. Define management and explain the general functions of management.
2. Explain how management goals and objectives are developed through planning.
3. Describe how business decisions are made.
4. Describe methods of selecting new employees.
5. Explain how employees are trained.
6. Explain how to provide leadership and motivate employees.
7. Explain how to manage employee performance and behaviours.
8. Describe proper communication skills by writing a formal report.

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Topic 6 Plant Maintenance

Learning Outcome

Describe plant maintenance management systems.

Learning Objectives

1. Describe the major aspects of managing maintenance activities including management of maintenance, maintenance program development, planning, scheduling, performing maintenance, assessment and improvement.
2. Describe the different approaches to maintenance including preventive and corrective.
3. Describe how routine maintenance activities are planned, scheduled, and controlled.
4. Describe the use of Gantt and PERT charts and the critical path method to schedule major maintenance activities.
5. Describe the steps involved in preparing for and conducting a pressure vessel inspection.
6. Describe the use of computerized systems in managing maintenance, including a work order system.
7. Describe various methods of monitoring equipment, including log sheets and trending.
8. Describe the steps involved in developing a plant budget and controlling maintenance costs.

Topic 7 Safety

Learning Outcome

Explain the components and application of safety programs, safety audits, and safety training.

Learning Objectives

1. Describe the elements of a comprehensive safety program for a power plant.
2. Explain the purpose of and the process used for safety checklists, inspections, audits and reviews.
3. Explain the purpose of and the process used for safety orientation, education, and training.

Topic 8 Static and Dynamic Forces

Learning Outcome

Perform calculations related to static and dynamic forces acting on a body.

Learning Objectives

1. Define and evaluate forces in terms of moments and couples.
2. Define and calculate centroids and first and second moments of areas.
3. Define and calculate the different types of stress.
4. Define strain, modulus of elasticity, Poisson's ratio and perform calculations.
5. Define the thermal expansion of bars, including reactions, under conditions of restricted expansion and reactions of bars composed of dissimilar metals.
6. Define and calculate shear forces and bending moments for simply supported beams and cantilevers.
7. Perform calculations involving the fundamental torsion equation and explain the relationship between torque and stress.
8. Explain the relationship between torque and power, and calculate maximum and mean torque for solid shafts of circular cross section.
9. Calculate stress in coupling bolts due to torque.

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Topic 9 Fluid Mechanics

Learning Outcome

Perform calculations related to fluid flows and pressure.

Learning Objectives

1. Describe the basics of fluid mechanics.
2. Perform calculations related to pressure in a fluid, including center of pressure.
3. Explain buoyancy and perform calculations involving buoyancy principles.
4. Define and calculate thermal expansion of a vessel and its liquid contents.
5. Describe flow in open channels and calculate fluid flow through a weir.
6. Describe liquid flow in a pipe using the continuity equation.
7. Apply the law of conservation of energy to fluid flow and define Bernoulli's equation.
8. Calculate fluid flow from a vessel orifice.
9. Calculate flow using a venturi meter.

Topic 10 Heat, Expansion of Solids, and Heat Transfer

Learning Outcome

Perform calculations to determine the thermal expansion of solids and basic heat transfer properties.

Learning Objectives

1. Perform heat calculations on solids, liquids, and vapours.
2. Explain the theory of thermal expansion and solve problems using the formula for linear thermal expansion.
3. Calculate the change in the area of an object, including holes, due to a temperature change.
4. Describe the principle of volumetric expansion and perform calculations involving the change in volume of solids, due to a change in temperature.
5. Describe the three basic modes of heat transfer (convection, conduction, and radiation) and perform simple calculations.
6. Perform calculations involving heat transfer at a surface.

Topic 11 Thermodynamics of Gases

Learning Outcome

Perform calculations related to expansion and compression of perfect gases.

Learning Objectives

1. Explain the behaviours of a perfect gas and the laws that govern gas behaviour, including Boyle's Law, Gay-Lussac's Law, Charles Law, the General Gas Law, and the Ideal Gas Law.
2. Explain Dalton's Law of Partial Pressures.
3. Define and calculate specific heats under constant volume and constant pressure conditions.
4. Explain the relationship between work and heat as expressed in the First and Second Laws of Thermodynamics.
5. Calculate the work done during expansion and compression under constant pressure and isothermal conditions.
6. Calculate the work done during adiabatic expansion and compression.
7. Calculate the work done during polytropic expansion and compression.

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Topic 12 Thermodynamics of Steam

Learning Outcome

Perform calculations related to properties of steam.

Learning Objectives

1. Describe the basic properties of water and steam.
2. Perform calculations involving specific enthalpy, dryness fraction, specific heat, and specific volume using steam tables.
3. Explain the principles and use of calorimeters to measure the dryness fraction of wet steam.
4. Calculate the dryness fraction of steam based on calorimeter data.
5. Calculate the internal energy of steam under given conditions.
6. Explain entropy and calculate the change in entropy for a particular water/steam process.
7. Determine steam properties using a Mollier Chart.
8. Calculate boiler thermal efficiency using test data.

Topic 13 Practical Thermodynamic Cycles

Learning Outcome

Explain the concepts and use of common thermodynamic cycles, using pressure-volume and temperature- entropy diagrams.

Learning Objectives

1. Explain the concept of a heat engine and describe the different types of heat engines.
2. Describe the Carnot cycle and calculate Carnot cycle efficiency.
3. Explain the Rankine cycle using pressure-volume and temperature-entropy diagrams and calculate Rankine cycle efficiency.
4. Explain the Otto cycle using pressure-volume and temperature-entropy diagrams and calculate Otto cycle efficiency.
5. Explain the Diesel cycle using pressure-volume and temperature-entropy diagrams and calculate Diesel cycle efficiency.
6. Explain the Brayton cycle using pressure-volume and temperature-entropy diagrams and calculate Brayton cycle efficiency.
7. Calculate the heat balance at different points in a Rankine cycle system using test data provided.

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Major Topic: Applied Mechanics, Thermodynamics and Chemistry

Topic 1 Heat, State Change, Calorimetry

Learning Outcome

Explain terminology regarding heat and perform calculations regarding heat during changes of state and calorimeter tests.

Learning Objectives

1. Define and explain internal energy, heat, specific heat, heat units, temperature and explain the relationship between the different temperature scales.
2. Define sensible heat and use the sensible heat equation to calculate the amount of heat required to change the temperature of a substance, the mass of the substance, and the temperature change, if no change of state occurs.
3. Explain the changes of state and define latent heat, latent heat of fusion, and latent heat of evaporation.
4. Given start and end conditions, calculate the heat required to change the states of water and other substances.
5. Determine the final temperatures and the original masses for mixtures of ice, water, steam, and other substances.
6. Explain the working principle of a simple calorimeter and use the calorimeter equation to determine specific heat and final temperature.
7. Explain water equivalent and perform calculations involving calorimetry and water equivalents.

Topic 2 Thermal Expansion and Heat Transfer

Learning Outcome

Explain concepts and perform calculations involving the thermal expansions of solids and liquids and heat transfer by conduction.

Learning Objectives

1. Explain the thermal conditions that cause expansion of solids and liquids and describe the relationship between linear, superficial (area) and volumetric expansion.
2. Given known conditions, calculate linear expansion or contraction, temperatures, and/or expansion coefficients for solids.
3. Given known conditions, calculate superficial expansion or contraction, temperatures, and/or expansion coefficients for solids.
4. Given known conditions, calculate volumetric expansion or contraction, temperatures, and/or expansion coefficients for solids or liquids.
5. Calculate the stress produced in a pipe or its supports when thermal expansion is restricted.
6. Explain the methods of heat transfer: conduction, convection, and radiation.
7. Define thermal conductivity and calculate the quantity of heat conducted, the temperature difference, or the material thickness when heat is transferred through flat walls and plates.

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Major Topic: Elementary Mechanics Topic 1

Introduction to Basic Mechanics **Learning**

Outcome

Define basic terms used in the study of mechanics.

Learning Objectives

1. Define mass, weight, force, acceleration, and velocity.
2. Define and perform simple calculations involving force, pressure, work, power and energy.

Topic 2 Forces and Moments

Learning Outcome

Perform calculations using forces and moments, and determine whether or not a system is in equilibrium.

Learning Objectives

1. Define the moment of a force and its units.
2. Determine the direction and calculate the magnitude of the moment of a force.

Topic 3 Simple Machines

Learning Outcome

Define simple machines and perform calculations relating to them.

Learning Objectives

1. Define the term 'simple machine' and calculate the mechanical advantage, velocity ratio and efficiency of simple machines.

Topic 4 Scalars and Vectors

Learning Outcome

Define and identify scalar and vector quantities and solve simple vector problems graphically.

Learning Objectives

1. Define scalar and vector quantities and draw a vector diagram to scale.

Topic 5 Linear Velocity and Acceleration

Learning Outcome

Define and solve simple problems involving speed, velocity, distance, displacement, and acceleration.

Learning Objectives

1. Solve distance, displacement, speed and velocity problems.
2. Draw graphs of velocity as a function of time.
3. Define acceleration, state its units, and perform simple acceleration calculations.
4. Use the mathematical formulas relating acceleration, velocity, distance and time to solve problems.

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Topic 6 Force, Work, Pressure, Power and Energy

Learning Outcome

Differentiate among force, work, power, pressure, and energy and perform calculations involving the relationships between these mechanical terms.

Learning Objectives

1. Perform calculations involving force and work.
2. Differentiate between and perform calculations involving gage, atmospheric and absolute pressure.
3. Differentiate between and perform calculations involving power and different forms of mechanical energy.

Topic 7 Friction

Learning Outcome

Describe and solve problems involving friction.

Learning Objectives

1. Define the types of friction and the laws governing them.
2. Define the coefficient of friction and solve problems involving friction forces on a horizontal plane.

Topic 8 Stress and Strain

Learning Outcome

Discuss the deformations of bodies, caused by externally applied forces, and the internal forces that resist these deformations; discuss the physical properties of materials and explain how these properties affect their behavior when external forces are applied.

Learning Objectives

1. Describe the significant characteristics of materials, including elasticity, stiffness, plasticity, ductility, toughness, brittleness and hardness.
2. Define stress and calculate tensile, compressive and shear stresses in rigid body members due to external loads.
3. Calculate the strain of members under load.

Topic 9 Power Transmission

Learning Outcome

Discuss the major types of power transmission systems.

Learning Objectives

1. Describe belt drive systems and calculate pulley speeds, transmitted power and efficiency.
2. Describe gear and chain drive systems and calculate gear speeds.

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REFERENCE CURRICULUM

For

Stationary Engineer (3rd Class)
Michigan
Preparation

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Introduction

This Curriculum is intended to assist candidates studying for the NIULPE Stationary Engineer (3rd Class) Michigan Preparation Examination.

Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

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Reference Curriculum for Stationary Engineer (3rd Class) Michigan Preparation Examination Candidates

Major Topic: Applied Mechanics, Thermodynamics and Chemistry

Topic 1 Forces and Friction

Learning Outcome

Explain concepts and solve problems involving vectors, force systems and friction.

Learning Objectives

1. Define, coplanar and concurrent vectors, and draw space diagrams for forces and displacements.
2. Draw a vector diagram and use it to graphically determine the resultant and equilibrant of a force system.
3. Use trigonometry to resolve forces into components and to calculate the resultant and equilibrant of a force system
4. Given a coplanar, concurrent force system, calculate any unknown forces.
5. Define static friction, sliding friction, and coefficient of friction; use the friction formula to calculate coefficient of friction
6. Explain friction angle and perform friction calculations for forces applied parallel to the horizontal plane.
7. Calculate the coefficient of friction, object weight, and applied forces for objects moved on a horizontal surface by forces that are NOT parallel to the plane.

Topic 2 Work, Power, Energy: Linear and Angular Motion

Learning Outcome

Explain concepts and solve problems involving velocity and acceleration, the Laws of Motion and work, power and energy.

Learning Objectives

1. Define force, force due to gravity, and work. Calculate the work done in moving objects horizontally and vertically.
2. Define power and mechanical efficiency. Calculate the power expended when work is done, plus the power developed and mechanical efficiency of a reciprocating engine.
3. Define potential and kinetic energy. Calculate the energies of stationary and moving objects.
4. Define, and show the relationships between, distance, displacement, speed, linear velocity, and linear acceleration.
5. Using linear motion relationships, calculate the displacements, velocities and accelerations of bodies moving in a straight line.
6. Define and calculate angular displacement, angular velocity and angular acceleration.

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Topic 3 Steam Properties and Calculations

Learning Outcome

Define properties of saturated and superheated steam and, using information from the steam tables, calculate the heat required to produce steam at various conditions; determine the equivalent and factor of evaporation for steam boilers.

Learning Objectives

1. Define and explain the following terms: saturation temperature, saturated steam, dry saturated steam, wet saturated steam, dryness fraction, superheated steam, enthalpy.
2. Identify, from the pressure-based and temperature-based steam tables, the properties of saturated steam at specified conditions.
3. Identify, from the superheated steam tables, the properties of superheated steam at specified conditions.
4. Calculate the heat required to produce dry saturated or superheated steam at given conditions, from feedwater at given conditions.
5. Calculate the dryness fraction of wet steam and/or the heat required to produce wet steam at a given dryness fraction.
6. Explain the properties of steam on a temperature-enthalpy diagram.
7. Define and calculate heat rate, equivalent evaporation and factor of evaporation for a boiler.

Topic 4 Gas Laws and Calculations

Learning Outcome

Explain the laws of perfect gases and perform calculations involving the expansion and compression of gases.

Learning Objectives

1. Explain Boyle's Law, Charles' Law, Gay-Lussac's Law, and the General Gas Law and use these to calculate pressure, temperature and/or volume changes for perfect gases.
2. Explain the Characteristic Gas Constant and use the Characteristic Gas Equation to determine the mass, the conditions, and the constant for a gas.
3. Explain isothermal, adiabatic, and polytropic processes (expansion and compression) for a gas, state the formula for each process, and compare the processes on a pressure/volume diagram.
4. Calculate unknown pressures, volumes and temperatures for gases during isothermal adiabatic, and polytropic processes.
5. Explain and calculate the work done in a cylinder under constant pressure.
6. Explain and calculate the work done in a cylinder during an isothermal expansion or compression.
7. Explain and calculate the work done in a cylinder during an adiabatic expansion or compression.
8. Explain and calculate the work done in a cylinder during a polytropic expansion or compression.

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Topic 5 Chemistry Fundamentals

Learning Outcome

Explain the fundamental principles in the structure, formation and interaction of chemical compounds and the importance of chemistry in industrial operations.

Learning Objectives

1. Define each term and explain the relationship between atoms, ions, elements, molecules, compounds, and mixtures.
2. Using the Periodic Table of the Elements, determine the atomic numbers and the atomic masses of elements.
3. Explain electronegativity and the bonding of ions.
4. Explain the formation of chemical compounds, explain typical reactions and apply fundamental principles to the balancing of simple chemical reactions.
5. Calculate the amount of reactants required or products produced in a chemical reaction.
6. Define acids, bases, and salts and explain their properties.
7. Define organic chemistry and explain, in general terms, the structure and applications of hydrocarbons and hydrocarbon derivatives.
8. Explain typical applications of chemistry in industry, including water treatment and testing, corrosion, combustion, hydrocarbon processing, petrochemical and pulp and paper processes.

Topic 6 Metallurgy and Materials

Learning Outcome

Explain the production, properties and applications of metallic and non-metallic materials.

Learning Objectives

1. Define and explain the importance and application of mechanical properties of materials, including brittleness, hardness, ductility, malleability, plasticity, elasticity, and toughness.
2. Describe material testing, including tension test, Brinell and Rockwell hardness tests, Charpy and Izod impact tests.
3. Describe the blast furnace and cupola furnace methods for iron production and compare the characteristics of gray, white, malleable, and ductile cast iron.
4. Define steel and explain the compositions and characteristics of low carbon, medium carbon and high carbon steels.
5. Define alloy steels, and explain the benefits of alloying elements, including nickel, chromium, molybdenum, vanadium, copper, lead, manganese and tungsten.
6. Explain the purposes of hot working, cold working and heat treating of metals.
7. Describe the production of carbon and alloy steel, using the open hearth, basic oxygen and electric-arc furnace processes.
8. Describe the properties and applications of non-ferrous metals and alloys.
9. Explain the basic structure, properties and applications of polymers, ceramics and composites.

Topic 7 Corrosion Principles

Learning Outcome

Explain the mechanisms that cause corrosion and the methods used to monitor and control corrosion.

Learning Objectives

1. Define corrosion terms and explain the causes and characteristics of corrosion types, including galvanic, atmospheric, stray current, biological, stress cracking, hydrogen induced, sulphide stress cracking and chloride stress cracking.
2. Explain specifically the nature and sources of corrosion on the water side of boilers, including caustic corrosion, hydrogen damage, and pitting.
3. Explain the environmental factors that affect corrosion.
4. Explain the principles of corrosion inhibitor mechanisms, including adsorbed films, passivation, cathodic precipitates, and neutralization.
5. Describe the principles and applications of cathodic protection devices or systems, including sacrificial anodes, galvanic anodes, impressed current, and groundbeds.
6. Describe the principles and applications of corrosion monitoring devices, including coupons, electrical resistance probes, galvanic probes, and hydrogen probes.
7. Describe corrosion inspection procedures, including ultrasonics and radiography.

Major Topic: Boiler Codes, Electrical and Instrumentation Theory

Topic 1 Legislation and Codes for Power Engineers

Learning Outcome

Explain the purpose of, general content of, and interaction with the legislation and codes that pertain to the design and operation of boilers and related equipment.

Learning Objectives

1. Explain Codes and Standards.
2. Explain the purpose and scope of the National Board of Boiler Inspectors (NBBI).
3. Explain the scope of the ASME and state the purpose and general content of the following sections of the the ASME Codes: Section I, II, IV, V, VI, VII, VIII, IX.

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Topic 2 Fuels, Combustion, and Flue Gas Analysis

Learning Outcome

Explain the properties and combustion of common fuels and the analysis of combustion flue gas.

Learning Objectives

1. Explain/define complete combustion, incomplete combustion, combustion products, and write balanced combustion equations.
2. Explain the purpose and benefits of excess air and calculate the theoretical and excess air required for the complete combustion of a given fuel.
3. Explain proximate analysis, ultimate analysis, and heating value of a fuel and describe the use of calorimetry to determine heating value. Explain higher and lower heating values.
4. Given the ultimate analysis of a fuel, use Dulong's Formula to calculate the heating value of the fuel.
5. Describe the properties, classifications and combustion characteristics of coal.
6. Describe the properties, classifications and combustion characteristics of fuel oil.
7. Describe the properties and combustion characteristics of natural gas.
8. Explain the use and combustion characteristics of alternatives to traditional fossil fuels, including biomass, coke and oil emulsions.
9. Explain the analysis of flue gas for the measurement of O_2, CO, and CO_2 in relation to combustion efficiency. Describe typical, automatic flue gas analyzers.
10. Explain the formation, monitoring and control of nitrogen oxides (NO_X), sulfur dioxide, and particulates.

Topic 3 Piping Design, Connections, Support

Learning Outcome

Discuss the codes, designs, specifications, and connections for ferrous, non-ferrous and non-metallic piping and explain expansion and support devices common to piping systems.

Learning Objectives

1. Identify and explain the general scope of the ASME, ANSI, ASTM codes and standards with respect to piping and pipe fittings. Differentiate between power piping (Code B31.1) and pressure piping (Code B31.3).
2. Explain methods of pipe manufacture; size specifications and service ratings, and the material specifications and applications for ferrous pipe.
3. Using pipe specifications and the ASME code Sections I and II you will be able to identify the size of pipe required for a particular installation, process or operating condition.
4. Explain the materials, code specifications and applications of common, non-ferrous metal piping and cast iron.
5. Describe screwed, welded, and flanged methods of pipe connection and identify the fittings used for each method.
6. Describe the construction, designs, and materials of flange gaskets and explain the confined, semi-confined, and unconfined flange styles.
7. Explain the materials, construction and approved applications of common, non-metallic pipe.
8. Explain the effects of temperature on piping; explain the mechanisms and the dangers of expansion in piping systems, including attached equipment.
9. State the purpose and explain the designs, locations and applications of simple and offset U-bend expansion bends.
10. Describe designs, locations, care and maintenance of slip, corrugated, bellows, hinged, universal, pressure-balanced, and externally pressurized expansion joints.
11. Describe design, location, operation of pipe support components, including hangers, roller stands, variable spring hangers, constant load hangers, anchors, and guides.

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Topic 4 Steam Traps, Water Hammer, Insulation

Learning Outcome

Explain the designs and operation of steam trap systems, the causes and prevention of water hammer, and the designs and applications of pipe insulation.

Learning Objectives

1. Explain the dynamics, design, and components of steam/condensate return systems for steam lines and condensing vessels. Explain roles and locations of separators and traps.
2. Describe the design, operation and application of ball float, inverted bucket, thermostatic, bi-metallic, impulse, controlled disc, and liquid expansion steam traps.
3. Explain the selection, sizing and capacity of steam traps and explain the factors that determine efficient trap operation.
4. Explain the procedures for commissioning, testing, and maintenance of steam traps.
5. Explain and compare condensate-induced and flow-induced water hammer in steam and condensate lines. Explain the typical velocities, pressures and damage that can be created in steam/condensate lines due to water hammer.
6. Describe specific trap and condensate return arrangements that are designed to prevent water hammer in steam and condensate lines.
7. State precautions that must be observed to prevent water hammer and describe a typical steam system start-up procedure that will prevent water hammer.
8. State the purposes of insulation and explain the properties required for a good insulating material. Explain thermal conductivity, K-Factor and R-Value.
9. Identify the most common industrial insulating materials, describe the composition and characteristics of each, and explain in what service each would be used.
10. Describe common methods for applying insulation to piping and equipment, including wrap and clad, blanket, insulated covers and boxes. Explain the care of insulation and cladding and the importance of maintaining good condition.

Topic 5 Valves and Actuators

Learning Outcome

Describe the designs, configurations and operation of the common valve designs that are used in power and process piping.

Learning Objectives

1. Explain the factors that determine the suitability and applications of the major valve styles; gate, globe, ball, plug, butterfly and needle.
2. Explain the factors that determine the selection of valve materials, and describe examples of typical valve body and trim materials. How are common control valves identified?
3. Describe the configurations and applications for gate valves, including gate designs (solid, split, flexible, sliding), stem configurations (rising, non-rising, outside screw-and-yoke, inside screw), and bonnet designs (flanged, screwed, welded).
4. Describe the designs and applications of globe valves, including conventional disc, composition disc, plug-type disc, and angle valves. Describe high-pressure plug-type control valves.
5. Describe the designs, application and operation of single-seated and double-seated balance valves. Explain caged trim for balanced control valves.
6. Describe the designs and applications of typical plug valves, including tapered and cylindrical plug, four-way, eccentric, and jacketed.
7. Describe the designs and configurations for mixing and diverter valves.
8. Describe the designs and operation of diaphragm valves.
9. Describe designs and operation of butterfly valves, including vertical, horizontal, swing-through, lined, and high-performance.
10. Describe the design, application, and operation of gear, motor, air-diaphragm, and air-piston actuators for valves.

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Topic 6 AC Theory and Machines

Learning Outcome

Explain formation and characteristics of AC power, and describe the design, construction and operating principles of AC generators, motors and transformers.

Learning Objectives

1. Explain the creation of single phase and three-phase alternating power; define cycle, frequency and phase relationships (voltage/current) for AC sine waves.
2. Define the following terms and explain their relationships in an ac circuit: capacitance, inductance, reactance, impedance, power factor, alternator ratings (kVA and kW).
3. Describe the stator and rotor designs, operation, and applications for salient pole and cylindrical rotor alternators
4. Describe water, air and hydrogen cooling systems for large generators.
5. Explain parallel operation of alternators and state the requirements for synchronization. Describe manual and automatic synchronization.
6. Describe the design, applications and operating principles for large three-phase squirrel cage and wound rotor induction motors.
7. Describe the design and operating principle of synchronous motors.
8. Explain variable speed control, variable speed starting, and step starting for large induction motors.
9. Explain the principles and applications of power transformation. Perform transformer calculations.
10. Describe the designs and components of typical core and shell type transformers, including cooling components.

Topic 7 AC Systems, Switchgear, Safety

Learning Outcome

Identify the components of typical AC systems and switchgear and discuss safety around electrical systems and equipment.

Learning Objectives

1. Using a one-line electrical drawing, identify the layout of a typical industrial AC power system with multiple generators, and explain the interaction of the major components.
2. Explain the function of the typical gages, meters, and switches on an AC generator panel.
3. Explain the purpose and function of the circuit protective and switching equipment associated with an AC generator: fuses, safety switches, circuit breakers, circuit protection relays, automatic bus switchover, grounding and lightning arrestors.
4. Explain the components and operation of a typical Uninterruptible Power Supply (UPS) system.
5. Explain safety procedures and precautions that must be exercised when working around and operating electrical system components. Explain grounding.

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Topic 8 Electrical Calculations

Learning Outcome

Define terms and perform simple calculations involving DC and AC power circuits.

Learning Objectives

1. Use Ohm's Law and Kirchhoff's Laws to calculate current, resistance or voltage drop in series or parallel multi-resistor circuits.
2. Calculate unknown resistances using a Wheatstone Bridge circuit.
3. Explain and perform calculations involving electrical power, work and energy.
4. Calculate the frequency, period and phase angle for an AC sine wave.
5. Define terms and calculate the peak-to-peak, root mean square, and maximum values for AC voltage and current.
6. Given required parameters, calculate the inductive reactance, capacitive reactance, total reactance, and impedance for an AC circuit, plus circuit frequency and current flow.
7. Calculate real power, imaginary power and power factor for an AC circuit.
8. Given the load, voltage and power factor of a 3-phase generator, calculate the kVA and kW ratings of the generator.

Topic 9 Control Loops and Strategies

Learning Outcome

Explain the operation and components of pneumatic, electronic and digital control loops, and discuss control modes and strategies.

Learning Objectives

1. Describe the operation, components and terminologies for a typical control loop.
2. Describe the operation and components of a purely pneumatic control loop. Explain the function of each component.
3. Describe the operation and components of an analog/electronic control loop. Explain the function of each component.
4. Describe the operation and components of a digital control loop. Explain the function of each component.
5. Explain the purpose, operation, and give examples of on-off, proportional, proportional-plus-reset, and proportional-plus-reset-plus-derivative control. Define proportional band and gain.
6. Describe and give typical examples of feed forward, feed back, cascade, ratio, split-range, and select control.
7. Explain, with examples, the purpose and incorporation of alarms and shutdowns into a control loop/ system.
8. Explain the interactions that occur and the interfaces that exist between an operator and the various components of a control loop/system, including the components of a controller interface

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Topic 10 Instrument and Control Devices

Learning Outcome

Explain the operating principles of various instrument devices that are used to measure and control process conditions.

Learning Objectives

1. Describe the design, operation and applications for the following temperature devices: bimetallic thermometer, filled thermal element, thermocouple, RTD, thermistor, radiation and optical pyrometers
2. Describe the design, operation and applications for the following pressure devices: bourdon tubes, bellows, capsules, diaphragms, and absolute pressure gage.
3. Describe the design, operation and applications for the following flow devices: orifice plate, venturi tube, flow nozzle, square root extractor, pitot tube, elbow taps, target meter, variable area, nutating disc, rotary meter and magnetic flowmeter.
4. Describe the design, operation and applications for the following level devices: atmospheric and pressure bubblers, diaphragm box, differential pressure transmitter, capacitance probe, conductance probes, radiation and ultrasonic detectors and load cells.

Major Topic: Pumps and Boilers

Topic 1 Watertube Boiler Designs

Learning Outcome

Describe common designs, configurations and circulation patterns for modern bent-tube watertube boilers and steam generators and explain how boilers are rated.

Learning Objectives

1. Explain the difference between packaged, shop assembled, and field-erected watertube boilers. Explain how boilers are rated.
2. Explain the process of water circulation in a watertube boiler and the factors that influence circulation.
3. Identify examples of and describe the A, O, and D design configurations and explain the water and gas circulation patterns for each. Define integral furnace.
4. Define a steam-generating unit, identify oil and gas-fired units, and explain the components, heating surfaces, and flow patterns through a typical unit. State typical temperatures throughout the unit.
5. Differentiate between critical and super-critical boilers.
6. Explain the purpose and advantage of forced circulation and describe the flow through a typical controlled circulation boiler.
7. Explain the purpose and design of a once-through boiler.

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Topic 2 Special Boiler Designs

Learning Outcome

Describe the designs, components, firing methods, and operating considerations for some special boilers used in industry.

Learning Objectives

1. Describe typical designs, components and operating strategies for once-through, steam flood boilers.
2. Describe typical designs, components and operating strategies for Fluidized Bed boilers.
3. Describe typical designs, components and operating strategies for Heat Recovery Steam Generators.
4. Describe typical designs, components and operating strategies for Black Liquor Recovery boilers used in pulp mills.
5. Describe typical designs, components and operating strategies for Refuse boilers used in waste disposal.
6. Describe typical designs, components and operating strategies for waste heat, biomass boilers.

Topic 3 Boiler Construction

Learning Outcome

Explain Code requirements, in general terms, and describe construction and assembly methods for the major components of a large boiler.

Learning Objectives

1. Explain top and bottom support and describe the support techniques for various components of a large boiler, including lateral supports for furnace walls. Explain allowances for expansion.
2. Explain the purpose, design, locations and installation methods for boiler casing insulation, refractory, and cladding.
3. Describe the methods used to fabricate boiler tubes.
4. Describe the preparation, fabrication, and testing of boiler drums.
5. Describe methods of attaching tubes to drums and headers, including expanding and welding, and explain where each method would be used.
6. Explain code requirements/sizes for, and describe the designs and installation of, manholes and handholes, including welded handholes. Explain procedures for removing and installing covers.
7. Describe the field assembly of a large boiler or steam generating unit.

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Topic 4 Boiler Heat Transfer Components

Learning Outcome

Explain the purpose, location, design and operating conditions for the major heat transfer components of a large watertube boiler or steam generator.

Learning Objectives

1. Describe baffle designs and locations and explain their significance to boiler heat transfer.
2. Describe the designs of integral furnace sidewall and header arrangements, including tube-and-tile, tangent tube, and membrane.
3. Define primary, secondary, convection, radiation, platen, and pendant as they apply to superheaters. Describe the locations of superheaters within a steam generator and state the operating characteristics of convection and radiant superheaters.
4. Explain the purpose and design of a separately-fired superheater.
5. Explain the purpose and describe the locations of reheaters. Explain the position of and flow through the reheater in relation to the superheaters.
6. Describe designs and locations for integral and separate economizers.
7. Describe the designs, operation, and location of plate, tubular, and rotary regenerative air heaters.
8. Explain operating care and considerations that must be given to the various heat transfer sections of the boiler.
9. Explain a typical water and gas temperature profile through a large steam generating unit.

Topic 5 High Pressure Boiler Fittings

Learning Outcome

Describe the design and operation of common external and internal fittings attached to the pressure side of a high-pressure boiler.

Learning Objectives

1. Describe the design, installation, operation, and setting of a high-pressure pressure relief valve. Explain the Code requirements for size, capacity and locations of the pressure relief valves on a boiler.
2. Describe the code requirements for boiler pressure gages, including attachment and locations.
3. Describe common designs, connections and components of high-pressure water columns and flat gage glasses, including illumination and quick shut-off devices and bulls-eye glasses. Explain testing and maintenance of a high-pressure gage glass.
4. Describe the float and probe designs for low-water fuel cutoffs and explain how these are tested.
5. Describe boiler steam outlet arrangements and fittings including gate, angle, and globe stop valves and globe, Y, angle, and spring-cushioned non-return valves.
6. Describe manual blowoff piping arrangements. Describe the design and operation of sliding disc, seatless sliding plunger, seat and disc, and combination valves. Explain manual blowoff procedures. Describe the requirements for a blowoff tank.
7. Explain the components of the steam drum internals of a watertube boiler. Describe the design and operation of various steam separation devices, including baffles, primary and secondary separators, and scrubbers.

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Topic 6 Burner Designs Supply System

Learning Outcome

Describe the typical components of fuel supply systems and describe common burner/furnace designs for gas, oil, and coal-fired boilers.

Learning Objectives

1. Describe a complete fuel gas supply system from fuel gas header to burner and explain the function of each component, including control and shut-off valves, auto-vents, and instruments. State the typical operating pressures.
2. Describe the design and operation of spud and ring burners, and explain high-efficiency, low NOx designs.
3. Describe a complete fuel oil supply system from storage tanks to burners and explain the function of each system component.
4. Describe the design and operation of air, steam, and mechanical atomizing burners.
5. Describe a coal supply system from stockpiles to burners for a typical pulverized coal furnace.
6. Describe the design and operation of a pulverized coal burner and explain turbulent vertical, tangential, and cyclone furnaces.
7. Describe the design and operation of ball, impact, ball-race, and bowl mill pulverizers.
8. Describe the designs and operation of underfeed, overfeed, and crossfeed stokers for furnaces burning solid fuels.

Topic 7 Boiler Draf t and Flue Gas Equipment

Learning Outcome

Explain boiler draft systems and fans and describe the equipment used to remove ash from flue gas.

Learning Objectives

1. Define and explain the applications and designs of natural, forced, induced and balanced draft.
2. Explain how draft is measured, monitored, and controlled in a large, balanced draft boiler. Explain the position of control dampers.
3. Describe typical draft fan designs, single and double inlet arrangements, and explain methods used to control fan output.
4. Explain the start-up and running checks that must be made on draft fans.
5. Describe typical windbox and air louver arrangements and distinguish between primary and secondary air.
6. Describe the design and operation of flue gas particulate clean-up equipment, including mechanical and electrostatic precipitators and baghouse filters.
7. Describe the design and operation of ash handling systems, including hydro and air systems, bottom ash systems, and scraper conveyor systems.
8. Describe the designs and operation of SO_2 recovery systems, including lime and wet gas scrubbing.

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Topic 8 Boiler Control Systems

Learning Outcome

Explain the components and operation of automatic control systems for boiler water level, combustion, steam temperature, and start-up.

Learning Objectives

1. Describe on-off and single element control of boiler feedwater.
2. Explain swell and shrinkage in a boiler. Describe the components and operation of a two-element feedwater control system, explaining the interaction of the controllers.
3. Describe the components and operation of a three-element feedwater control system.
4. Describe the components and operation of a direct combustion control system.
5. Describe the components and operation of a 'steam flow – airflow' combustion control system.
6. Describe the components and operation of a 'fuel flow – airflow' combustion control system.
7. Describe the components and operation of an 'airflow – fuel flow' combustion control system.
8. Describe the components and operation of a multi-element combustion control system.
9. Describe steam temperature control methods and equipment, including attemperation (desuperheating), gas recirculation, gas bypass, and tilting burners.
10. Describe the automatic, programmed start-up sequence for a gas-fired boiler.

Topic 9 Boiler Procedures

Learning Outcome

Describe common procedures in the operation and maintenance of high pressure boilers.

Learning Objectives

1. Explain the steps involved in the commissioning of a new boiler or before starting a boiler after major repairs, including:
   a) hydrostatic test
   b) external and internal inspections
   c) drying out refractory
   d) boiling out
   e) testing shutdowns and safety devices
2. Describe the wet and dry methods when laying up a boiler for an extended time, including nitrogen blanketing.
3. Describe the proper shut down and preparation of a boiler for internal inspection.
4. Describe a thorough inspection of the water and furnace sides of a boiler.
5. Describe typical equipment and procedures for cleaning the water side of a boiler:
   a) mechanically
   b) chemically
6. Explain routine tasks and visual monitoring that the operator must perform on a large operating boiler.
7. Explain the procedures and precautions that an operator must exercise to avoid furnace and pressure-side explosions.
8. Describe sootblowing systems and describe the procedures for operating sootblowers.

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Topic 10 Internal Water Treatment for Boilers

Learning Outcome

Discuss internal water treatment methods and systems for the control of scale, corrosion, and carryover and explain testing and monitoring strategies.

Learning Objectives

1. Explain the causes and effects of boiler scale; explain the most common internal methods of scale control, including phosphate treatment, chelate treatment, sludge conditioning and dispersion.
2. Explain the causes and effects of boiler and condensate return line corrosion; explain treatment methods for acidic, caustic, oxygen, and carbon dioxide corrosion, including sulphite, hydrazine, and amine treatment.
3. Explain the mechanical and chemical causes, effects and types of carryover; explain methods of carryover control, including the use of antifoam and blowdown.
4. Describe the design and explain the operation of simple blowdown, heat recovery, and automatic blowdown systems.
5. Explain, in general terms, the sampling and testing strategies for boiler internal conditions; describe typical sampling and automatic monitoring equipment.
6. Describe typical chemical feed systems, including pot feeders, continuous feed with day tanks, and continuous feed with pump tanks.

Topic 11 Boiler Water Pretreatment

Learning Outcome

Explain the purpose, principles, equipment, and monitoring of boiler water pretreatment processes.

Learning Objectives

1. Describe the design and explain the terms, purpose and operation of a clarifier, using coagulation, flocculation, and subsidence.
2. Describe the design and explain the terms, purpose and operation of gravity and pressure filters.
3. Describe the design and explain the terms, purpose and operation, including chemical reactions for a cold lime softener.
4. Describe the design and explain the terms, purpose and operation of a hot lime softener.
5. Explain the principles of ion exchange softening in general, identifying the common anions and cations in untreated water.
6. Describe the design, components, and operation of a sodium zeolite softening system including chemical reactions.
7. Describe the design, components, and operation of a hydrogen zeolite softening system including chemical reactions.
8. Describe the design, components, and operation of a dealkalization system including chemical reactions.
9. Describe the design, components, and operation of a demineralizer system, including mixed bed and degasification.
10. Explain the principle and operation of a reverse osmosis system.
11. Describe the design, principle, and operation controls of a typical deaerator.

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Topic 12 Pump Designs and Operation

Learning Outcome

Describe the designs, principles, components and operating procedures for common industrial pumps.

Learning Objectives

1. Explain the principle of operation and describe the components of typical plunger, piston and diaphragm reciprocating pumps.
2. Explain the designs and operating principles of the external gear, internal gear, sliding vane, lobe, and screw type rotary pumps.
3. Explain the designs and operating principles of volute and diffuser centrifugal pumps, including impeller designs.
4. Describe centrifugal pump arrangements, including vertical, horizontal, single and double suction, opposed impellers, multi-staging, split and barrel casings.
5. Describe the design and applications of axial and mixed flow pumps.
6. Describe the design and components of a multistage centrifugal pump, clearly stating the purpose and general design of: wear rings, shaft sleeves, seals, bearings and lubrication components, vents and drains.
7. Explain design features that eliminate thrust in large centrifugal pumps.
8. Describe systems used to maintain minimum flow through a centrifugal pump.
9. Explain priming, start-up, capacity control and operating cautions for centrifugal pumps.

Topic 13 Pressure Vessels

Learning Outcome

Explain pressure vessel design, stresses, and operating considerations.

Learning Objectives

1. Define “pressure vessel” and explain, in general terms, how pressure vessels are regulated in design, construction and repair (including purpose of Section VIII, ASME).
2. Explain the stamping/nameplate requirements for pressure vessels and identify terms and specifications on a typical nameplate.
3. Describe the weld locations on a typical pressure vessel and identify head designs, including ellipsoidal, torispherical, hemispherical, conical, and toriconical.
4. Describe acceptable nozzle attachment methods, including reinforcements; describe inspection openings.
5. Explain the loads that contribute to stresses in pressure vessels, including pressure, thermal, attachments, static, wind, seismic, and cyclic loads.
6. Explain the components and fittings of a typical pressure vessel.
7. Explain operating and maintenance considerations for the safe operation of pressure vessels, including the appropriate use of hydrostatic and pneumatic testing.

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Major Topic: Prime Movers and Refrigeration Topic 1

Steam Turbine Principles and Design Learning Outcome

Describe designs, operating principles and major components of steam turbines.

Learning Objectives

1. Explain impulse turbine operating principles. Describe convergent and divergent nozzles, and the pressure-velocity profiles through an impulse section.
2. Explain reaction turbine operating principles and describe the pressure-velocity profiles through reaction blading.
3. Explain pressure, velocity, and pressure-velocity compounding of impulse turbines. Describe the pressure-velocity profiles and the purpose and applications of each.
4. Explain the purpose, general operating principles and arrangement for each of the following turbine types: condensing, condensing-bleeder, backpressure, extraction, topping, mixed-pressure, cross-compounded, tandem compounded, double flow and reheat.
5. Describe the designs of typical turbine casings and state the purpose and location of casing fittings, including drains and sentinel valves. Describe the designs and principles of casing/shaft seals.
6. Describe the designs and applications of disc and drum rotors. Describe methods of rotor and casing blade attachment and explain blade-sealing arrangements.
7. Explain thrust in a large turbine and describe methods to offset thrust, including thrust bearings, dummy piston, and thrust-adjusting gear.
8. Identify typical designs and components for small and large industrial turbines. Explain typical size/ capacity rating specifications and explain typical applications.
9. Explain the use and design of reducing gears attached to steam turbines.

Topic 2 Steam Turbine Auxiliaries and Operation

Learning Outcome

Describe auxiliary support and control systems for steam turbines and explain start-up and shutdown procedures.

Learning Objectives

1. Describe typical lube oil systems for small and large steam turbines.
2. Explain the purpose and describe the design and operation of barring gear and jacking oil systems on a large turbine.
3. Describe a condensing turbine circuit and explain typical operating parameters.
4. Explain and state the applications, where applicable, of the following governor types: speed-sensitive, pressure-sensitive, nozzle, throttle, and bypass. Explain governor droop and isochronous control.
5. Explain the operation and the major components of the three main speed-sensitive governor systems: mechanical, mechanical-hydraulic, and electronic-hydraulic.
6. Explain the operation and describe the components of typical mechanical and electronic overspeed trip systems.
7. Explain the sequence followed for the cold start-up and the shutdown of a non-condensing steam turbine.
8. Explain the sequence followed for the cold start-up and the shutdown of a condensing and extracting steam turbine.

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Topic 3 Turbine Condenser Systems

Learning Outcome

Explain typical designs, components and operating principles of steam turbine condensers.

Learning Objectives

1. Explain the purposes of a turbine condenser in a steam plant cycle and describe a typical condensing circuit, with operating temperatures and pressures.
2. Explain the design, operation and applications of the jet condenser, including the ejector type.
3. Explain the design, operation and applications of the surface condenser, including air cooled and water-cooled, down flow and central flow.
4. Describe construction details for surface condensers, including shells, tube attachment, supports, and allowances for expansion.
5. Explain the effects of air in a condenser and describe the design and operation of single and two-stage air ejectors. Explain the detection of condenser air leaks. Explain vacuum pumps.
6. Explain the devices and operating considerations used to protect a condenser against high backpressure, high condensate level, and cooling water contamination. Describe a cooling water leak test.
7. Describe the operating conditions and corresponding design considerations for condensate extraction pumps and cooling water pumps.
8. Describe a feed water heater system in conjunction with a steam condenser and explain the designs of low-pressure and high-pressure feed water heaters.

Topic 4 Gas Turbine Principles and Designs

Learning Outcome

Explain common designs, major components, operating principles, and arrangements for industrial gas turbines.

Learning Objectives

1. Explain gas turbine advantages and disadvantages, background and industrial applications. Identify the types of gas turbines, their major components and describe the operating principles of a simple gas turbine.
2. Explain single and dual shaft arrangements for gas turbines. Describe open cycle and closed cycle operation.
3. Describe a typical open cycle gas turbine installation, including buildings or enclosures, intake and exhaust systems, auxiliary systems, and reducing gear.
4. Explain the efficiency and rating of gas turbines and describe the purpose and applications of gas turbine cycle improvements, including intercooling, regenerating, reheating and combined cycle.
5. Describe various aspects of compressor design and centrifugal and axial types of compressors.
6. Describe the types, operation, components and arrangements of combustors.
7. Describe turbine section design and operation especially with respect to blading and materials.
8. Explain the types and functions of the control systems and instrumentation needed for gas turbine operation.
9. Explain the typical operating parameters of a gas turbine; describe the effects of compressor inlet temperature, compressor discharge pressure, and turbine inlet temperature on gas turbine performance.

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Topic 5 Gas Turbine Auxiliaries and Operation

Learning Outcome

Describe the support auxiliaries for a gas turbine and explain common operational, control and maintenance procedures.

Learning Objectives

1. Describe the types of bearings used in a gas turbine and explain the components, operation, protective devices and routine maintenance of a typical lube oil system.
2. Describe and explain the operation and routine maintenance of a typical fuel gas supply system for a gas turbine.
3. Describe and explain the operation and routine maintenance of a typical fuel oil supply system for a gas turbine.
4. Explain the control of NO_X from a gas turbine and describe the purpose and operation of water/steam injection and dry low NO_X systems.
5. Explain the purpose, location and operation of the gas turbine starting motor and turning gear.
6. Describe the compressor intake and the turbine exhaust components.
7. Describe the preparation and complete start-up sequence for a gas turbine.
8. Describe the shutdown sequence and procedure for a gas turbine.
9. Explain the purpose and describe typical on-line and off-line waterwash procedures for gas turbine blades.

Topic 6 Cogeneration Systems and Operation

Learning Outcome

Explain cogeneration and describe common configurations, components and applications.

Learning Objectives

1. Define cogeneration and explain its purpose, advantages, and applications.
2. Explain the components and operation of simple-cycle cogeneration systems.
3. Explain the components and operation of combined-cycle, gas/steam turbine cogeneration systems.
4. Explain the components and operation of a fully fired, combined-cycle cogeneration system.
5. Explain single-shaft and dual-shaft combined-cycle power plants.
6. Explain the general control strategies and components, for both power and steam production, including diverter and duct burner operation.
7. Describe the various designs of heat recovery steam generators (HRSGs) and explain their industrial applications.
8. Explain the environmental considerations and techniques in the operation of a cogeneration system.
9. Describe typical cogeneration systems that use internal combustion engines (gas or diesel) and heat recovery water heaters (HRWHs).
10. Explain a typical start-up procedure for a combined cycle cogeneration system.

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Topic 7 Compressor Theory and Designs

Learning Outcome

Explain the classification, designs, and operating principles of industrial air and gas compressors.

Learning Objectives

1. Explain compressor terminologies, including compression ratio, capacity, staging, intercooling and aftercooling. Explain the effects of moisture in compressed gases. Explain the effects of altitude on the compression process.
2. Describe the operation and common arrangements of reciprocating compressors, including single-acting, double-acting, and tandem arrangements.
3. Identify the components of a reciprocating compressor and describe the operation of plate and channel valves.
4. Describe internal and external lubrication systems for reciprocating compressors.
5. Describe the design and explain the operating principles of rotary compressors, including sliding vane, rotary lobe, and rotary screw.
6. Identify the components and controls for a packaged industrial screw compressor.
7. Describe designs and principles of centrifugal compressors/blowers, including single and multi-stage designs.
8. Describe designs and principles of axial compressors/blowers.

Topic 8 Compressor Auxiliaries and Operation

Learning Outcome

Explain the controls and system auxiliaries for a typical instrument air system and explain startup procedures for air compressors.

Learning Objectives

1. Describe the control devices and strategies for air compressors, including start-and-stop, variable speed, constant speed; describe pilot and unloader devices.
2. Explain the design and operation of an anti-surge system for a dynamic compressor.
3. Describe the designs of water and air-cooled aftercoolers and intercoolers, with separators.
4. Describe the components, arrangement, and parameters of a typical, complete instrument air system, including wet and dry receivers, dryers.
5. Describe the components and operating principles and sequences of instrument air dryers. Explain dewpoint monitoring of air systems.
6. Describe the design, fittings, and operating consideration for air receivers.
7. Explain the start-up procedure for a positive displacement compressor.
8. Explain the start-up procedure for a dynamic compressor/blower.

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Topic 9 Heat Exchangers and Cooling Towers

Learning Outcome

Describe the design, operation, and applications of various types of industrial heat exchangers.

Learning Objectives

1. Describe double pipe heat exchangers, including jacketed pipe, U-tube, and concentric pipe designs.
2. Describe shell-and-tube heat exchangers including fixed straight tube and U-tube designs. Describe common front and rear head designs, shell flow configurations, and explain the purpose of baffles.
3. Explain the operation and the typical fittings/equipment on the steam/condensate side of a reboiler and a feed water heater.
4. Describe the design and operation of a plate-and-frame exchanger.
5. Describe the design and components of overhead, aerial coolers, including fan and cooler arrangements. Explain cooler control
6. Describe the design and components, including controls, of an overhead, aerial condenser. Explain condenser operation, control and precautions when used to condense excess steam.
7. Describe the design and explain the operation of natural draft cooling towers, including atmospheric and hyperbolic styles
8. Describe the design and operation of mechanical draft cooling towers, including forced draft, induced draft counterflow, and induced draft crossflow.

Topic 10 Wastewater Treatment

Learning Outcome

Explain the purpose, designs, processes and control of industrial wastewater treatment.

Learning Objectives

1. State the purpose of wastewater treatment, list typical waste liquids, and explain the legislation and permitting, including parameters, for the disposal of wastewater.
2. Sketch an industrial wastewater treatment system and describe the processes that occur at each stage of treatment.
3. Describe the equipment and process involved in the removal of suspended solids from wastewater, including screening, flotation, and sedimentation.
4. Describe the equipment and process involved in the removal of colloidal solids from wastewater, including chemical coagulation, flocculation, and clarification.
5. Describe the equipment and process involved in the biological removal of solids from wastewater, including activated sludge, rotating biological contactors, and trickling filters.
6. Describe the control strategy for a wastewater treatment system. Define and explain the control of and sampling points for the main control parameters, including nutrients, BOD, COD, pH, and settle ability.

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Topic 11 Plant Maintenance and Administration

Learning Outcome

Explain typical components of maintenance and administration programs for utilities and process facilities.

Learning Objectives

1. Explain typical communication and accountability structures within a large facility, including the responsibilities for external communication.
2. Describe the typical components and responsibilities of scheduled and preventive maintenance management programs.
3. Explain the importance and extent of record keeping and describe the quality and content requirements for operating logbooks and records.
4. Using a complete boiler turnaround and inspection as an example, describe project management using two methods, Gantt Chart and critical path.
5. Explain the importance of procedures in the operation of a facility and describe the application of well- written procedures to personnel training and daily operation.
6. Explain typical environmental monitoring and management programs for operating facilities.

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Reference Curriculum for Facility Operator Single Topic Examination

Introduction

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Recommended Study Program:

It is recommended that, before undertaking this examination, the candidate completes Power Engineering Course of study, offered through a recognized and approved technical institute or training provider which addresses the Syllabus - Curriculum Outline.

Preparatory Math Topics for Power Engineering

Topic 1 Numerical Unit Systems

Learning Outcome

Perform simple calculations involving SI units.

Learning Objectives

1. Describe basic SI and USCS units, matching associated symbols for unit prefixes.
2. Perform conversions both within and between SI and USCS units.

Topic 2 Basic Arithmetic Operations

Learning Outcome

Perform basic arithmetic operations without the use of a calculator.

Learning Objectives

1. Add and subtract integers.
2. Multiply and divide whole and decimal numbers.
3. Perform arithmetic operations involving combinations of addition, subtraction, multiplication, division, and powers in the proper order of operation.

Topic 3 Fractions, Decimals, and Percentages

Learning Outcome

Perform basic arithmetic operations involving fractions, decimals, and percentages.

Learning Objectives

1. Identify proper and improper fractions and mixed numbers.
2. Add, subtract, and multiply fractions, and reduce them to lowest terms.
3. Convert fractions to decimal numbers and decimal numbers to fractions.
4. Analyze percentage problems.

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Topic 4 Ratio and Proportion

Learning Outcome

Describe the concepts of ratio and proportion.

Learning Objectives

1. Convert ratios of one quantity to another quantity.
2. Solve word problems involving ratios and proportions.

Topic 5 Equations and Transposition

Learning Outcome

Transpose equations in order to find values for different variables in a formula.

Learning Objectives

1. Solve equations and word problems.

Topic 6 Length, Lines, and Simple Plane Figures

Learning Outcome

Describe measurement of length, types of lines and angles, and calculate perimeters and areas of simple plane figures.

Learning Objectives

1. Describe linear measurement systems and convert measurement units from one system to another.
2. Define parallel and perpendicular lines and types of angles.
3. Describe types of simple plane figures, including triangles and quadrilaterals.
4. Describe the components of a circle, circumference, area, and diameter.

Topic 7 Length, Lines, and Simple Plane Figures

Learning Outcome

Calculate the volumes of rectangular objects, cylinders, and spheres and the surface areas of cylinders and spheres.

Learning Objectives

1. Convert between commonly used volume units.
2. Calculate the volume of a rectangular prism.
3. Calculate the surface area and volume of a cylinder.
4. Calculate the surface area and volume of a sphere.

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Elementary Physical, Chemical, and Thermodynamic Principles

Topic 1 Introduction to Matter and Chemistry

Learning Outcome

Identify basic types of matter, their properties, and the associated chemical principles.

Learning Objectives

1. Differentiate among the physical states of matter.
2. Differentiate between chemical and physical changes in matter.
3. Classify matter as either a type of mixture or a pure substance.
4. Describe the purpose and uses of the periodic table using the parts of an atom.
5. Describe the three main ways atoms bond together: covalent, ionic, and metallic bonding.
6. Discuss chemical equations and their purpose.
7. Perform simple stoichiometric calculations.
8. Demonstrate how unstable compounds are combined to make stable compounds.

Topic 2 Introduction to Thermodynamics

Learning Outcome

Explain the principles and laws of thermodynamics.

Learning Objectives

1. Define the first two laws of thermodynamics.
2. Define heat and specific heat, and perform sensible heat calculations.
3. Describe the expansion of solids and liquids.

Topic 3 Introduction to Heat Transfer and Heat Exchangers

Learning Outcome

Explain the modes of heat transfer and the theory of heat exchanger operation.

Learning Objectives

1. Describe the three modes of heat transfer with reference to heat exchangers.
2. Discuss the general design and construction of typical heat exchangers.
3. Describe heat transfer fluids and how they affect the operation of a heat exchanger, including fouling, leakage, and vapor locking.
4. Describe heat exchanger inspection, maintenance, and operation, including placing them in service and removing them from service.

Topic 4 Thermodynamics of Steam

Learning Outcome

Apply the thermodynamics principles through practical applications using the steam tables and the temperature-enthalpy chart.

Learning Objectives

1. Describe heat as it relates to steam, water, and ice.
2. Explain the various columns of the steam tables.
3. Explain the thermodynamic principles of steam, using the steam tables.

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Introduction to Power Engineering and its Governance

Topic 1 Introduction to Power Engineering

Learning Outcome

Describe the Power Engineer profession.

Learning Objectives

1. Describe steam, its uses and the basic steam cycle.
2. Describe the role and duties of a Power Engineer.
3. Describe how shift work affects sleep patterns, diet, and overall health.

Topic 2 Jurisdictional Legislation for Power Engineers

Learning Outcome

Describe the application of Jurisdictional Acts and Regulations with respect to boilers and pressure vessels.

Learning Objectives

1. Describe how the Power Engineering profession is regulated in Canada.
2. Explain the purpose and scope of your Jurisdictional Act and Regulations pertaining to Power Engineering and Pressure Equipment.
3. Explain the purpose and intent of the Regulations governing Power Engineers and Pressure Welders.

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Topic 3 Codes and Standards for Power Engineers and Pressure Vessels

Learning Outcome

Describe the purpose of boiler and pressure vessel Codes and Standards.

Learning Objectives

1. Discuss the history of how codes and standards became necessary in the pressure equipment field.
2. Explain the content and use of the CSA B51 Boiler, Pressure Vessel, and Pressure Piping Code.
3. Explain the content and use of the CSA B52 Mechanical Refrigeration Code.
4. Explain the content and use of ASME Boiler and Pressure Vessel Code (ASME BPVC) Section I Power Boilers.
5. Explain the content and use of ASME BPVC Section VII - Recommended Guidelines for the Care of Power Boilers.
6. Explain the content and use of ASME BPVC Section IV - Rules for Construction of Heating Boilers.
7. Explain the content and use of ASME BPVC Section VI - Recommended Rules for Care and Operation of Heating Boilers.
8. Explain the purpose, intent, and limitation of ASME CSD-1 (Controls and Safety Devices) Standard.

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Introduction to Plant and Fire Safety

Topic 1 Introduction to Plant Safety

Learning Outcome

Describe general plant safety as it related to Power Engineers.

Learning Objectives

1. Discuss the cost and effects of workplace accidents.
2. Describe the basic hazards that may be in an energy plant, and the basic Personal Protective Equipment that may be required.
3. Define, give examples of, and describe common power house hazards.
4. Describe Industrial health and safety management system.
5. Describe Hazard Assessment and Control programs.

Topic 2 Plant Safety Programs

Learning Outcome

Describe common safety programs generally applied in plants.

Learning Objectives

1. Describe common occupational health and safety (OH&S) programs found in most plants.
2. Describe industrial safety programs in which Power Engineers may require additional training.
3. Discuss safe work permits.
4. Describe methods of equipment isolation and lock out.

Topic 3 Handling of Dangerous Materials

Learning Outcome

Describe the policies and procedures for safe storage and handling of dangerous materials.

Learning Objectives

1. Discuss the WHMIS system.
2. Discuss the essential components required in the WHMIS systems.
3. Describe the safe handling and use of gas cylinders in an energy plant (power plant).
4. Discuss the safe handling of Hydrocarbons.

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Topic 4 Plant Fire Safety

Learning Outcome

Explain fire safety in an industrial plant.

Learning Objectives

1. Discuss the theory, terminology, and the life safety issues associated with fires.
2. Explain the five classes of fires, and describe the types of fire extinguishing media and how they act on these fires.
3. Explain fire prevention.
4. Discuss fire prevention methods for the five types of fires.

Topic 5 Fire Extinguishing Methods and Equipment

Learning Outcome

Describe typical fire extinguishing equipment and its operation in plant environments.

Learning Objectives

1. Describe the construction and operation of various types of portable fire extinguishers.
2. Discuss the inspection and maintenance requirements of portable fire extinguishers.
3. Describe the types, layout, and operation of standpipe and sprinkler systems.
4. Discuss the maintenance requirements of standpipe and sprinkler system components.
5. Describe the purpose, operation, and maintenance of fire pumps.

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Reference Curriculum for Facility Operator Single Topic Examination

Introduction

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Introduction to Plant Operations and the Environment

Topic 1 Introduction to the Environment

Learning Outcome

Identify environmental considerations and how they relate to an operating plant.

Learning Objectives

1. Describe four important Biogeochemical Cycles that operate within the environment.
2. Describe typical interdependencies seen among elements within an “ecosystem.”
3. List the types of impacts that operating facilities can have on the environment.
4. Describe the alert processes related to environmental problems of plants.
5. Explain the importance of “attitude” in limiting environmental impacts of plants.
6. Describe the long-term environmental impacts after the decommissioning and abandonment of plants.

Topic 2 Gas and Noise Emissions

Learning Outcome

Explain how gas and noise emissions affect plant operations.

Learning Objectives

1. Identify the sources and effects of common gases and vapours that have an adverse environmental impact.
2. Identify the common greenhouse and acid rain causing gases and describe their effects.
3. Describe the common methods for monitoring and reducing gaseous pollutants.
4. Describe the effects of noise pollution and methods of identifying, measuring, and controlling it.

Topic 3 Liquid and Solid Emissions

Learning Outcome

Explain how liquid and solid emissions affect plant operation.

Learning Objectives

1. Describe the sources and effects of solid pollutants from energy plants.
2. Describe the theory of operation of separators/collectors and monitoring of flue gas particulates.
3. Describe the disposal methods of solid waste from energy plants.
4. List sources and effects of liquid and thermal pollution.
5. Describe the preventive measures that can be taken to prevent liquid and thermal pollution.
6. Describe methods of liquid waste disposal.

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Elements of Material Science and Welding Technology

Topic 1 Energy Plant Construction and Operation Materials

Learning Outcome

Describe the mechanical properties of engineering materials used in engineering.

Learning Objectives

1. Describe the mechanical properties of materials.
2. Describe the various types of ferrous materials.
3. Describe the various types of non-ferrous materials.

Topic 2 Introduction to Welding

Learning Outcome

Describe welding processes relevant to the plant and Power Engineering.

Learning Objectives

1. Describe non-fusion welding process, equipment used, and methods.
2. Describe forge and oxy-fuel fusion welding processes and cutting processes.
3. Describe metal arc welding processes.
4. Describe heat treatment of welds.
5. Describe the types of weld joints used in pressure vessel construction.
6. Describe the additional construction components required for pressure vessels to ensure structural integrity and “access”.

Topic 3 Boiler and Pressure Vessel Inspection

Learning Outcome

Describe inspection processes and testing methods for welds and materials.

Learning Objectives

1. Describe common weld defects.
2. Describe the process of Visual Testing of welds.
3. Describe the process of Penetrant Testing for detecting weld or material defects.
4. Describe the process of radiographic weld testing.
5. Describe the process of ultrasonic weld testing.

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Introductory Fluid Handling Technology

Topic 1 Introduction to Energy Plant Piping Systems

Learning Outcome

Discuss the basic types of piping, piping connections, supports, and drainage devices used in industry.

Learning Objectives

1. State the applications for the most common materials and identify the sizes of commercial pipe.
2. Describe methods of connection for screwed, flanged, and welded pipe; identify fittings and their markings.
3. Describe methods and devices used to allow for pipe expansion and support.
4. Explain the methods used to promote good drainage of steam pipes, including the installation and maintenance of steam traps, to reduce the effects of water hammer.
5. Explain the requirements, materials, and methods for insulating pipe.

Topic 2 Introduction to Energy Plant Valves

Learning Outcome

Discuss the design and uses of the valve designs most commonly used in industry and on boilers.

Learning Objectives

1. Describe standard valve designs.
2. Describe design and operation of specialized boiler valves.
3. Describe a typical steam pressure reducing station, and the design and operation of steam system pressure-reducing valves.
4. Discuss valve details, including materials of construction and identification markings.
5. Describe typical valve maintenance requirements.

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Basic Concepts in Electrotechnology

Topic 1 Basic Electricity

Learning Outcome

Apply the concepts of basic electricity while performing simple calculations using voltage, current, resistance, and power.

Learning Objectives

1. Describe the atomic structure of matter and its relationship to electricity.
2. Describe basic electrical circuits.
3. State Ohm's Law and apply it to single-resistor circuits.
4. Apply Ohm's Law to series resistance circuits.
5. Apply Ohm's Law to parallel resistance circuits.
6. Explain electrical conductors and insulators using examples.
7. Explain the factors that affect resistance mathematically.
8. Calculate the power developed in an electrical circuit.

Topic 2 Magnetism and Electromagnetism

Learning Outcome

Describe the basic principles of magnetism.

Learning Objectives

1. Describe magnetism and the relationship between magnetism and electricity.
2. Describe the relationship between electricity and magnetism in an electrical generator.
3. Describe the relationship between electricity and magnetism in an electric motor.

Topic 3 Electrical Metering Devices

Learning Outcome

Describe the design and application of electrical metering devices.

Learning Objectives

1. Describe electrical meters and their uses.
2. Describe how voltage, current, and resistance are measured in an electric circuit.
3. Describe the construction and operation of a kilowatt hour meter.

Topic 4 Motors and Generators

Learning Outcome

Describe the operating principles of the various types of AC and DC motors and generators.

Learning Objectives

1. Describe the construction and operation of DC generators and motors.
2. Describe the construction and operation of AC generators (alternators) and motors.
3. Interpret the information on a motor nameplate.
4. Perform basic calculations relating to power factor and power factor correction.

Topic 5 Transformers

Learning Outcome

Describe the operating principles of electrical transformers.

Learning Objectives

1. Describe the principle of operation of transformers.
2. Perform basic transformer calculations as they relate to the construction and operation of single-phase transformers.
3. Describe the construction and operation of three-phase transformers.
4. Discuss special transformer types and their applications.
5. Discuss transformer cooling, safety, and maintenance.

Topic 6 Electrical Distribution Circuits

Learning Outcome

Describe an electrical distribution system.

Learning Objectives

1. List and describe the standard types of electrical voltage systems.
2. Interpret electrical single-line diagrams and circuit symbols.
3. Describe the major components of an electrical distribution system.
4. Describe the function and operation of fuses and circuit breakers.
5. Describe the function and operation of alternate power supply system equipment.

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Energy Plant Instrumentation and Controls

Topic 1 Introduction to Energy Plant Controls and Instrumentation

Learning Outcome

Describe the overall purpose and function of plant instrumentation systems.

Learning Objectives

1. Describe the concept and basic components of a control loop.
2. Describe the various means by which control signals are transmitted, and the function of transducers.
3. List and describe the types of instruments that are not control loop components.

Topic 2 Introduction to Process Measurement

Learning Outcome

Describe the construction and operation of common devices used to measure pressure, level, flow, temperature, humidity, and composition.

Learning Objectives

1. Describe the types of pressure sensing and measuring devices.
2. Describe the types of level sensing and measuring devices.
3. Describe the types of flow sensing and measuring devices.
4. Describe the types of temperature sensing and measuring devices.
5. Describe the types of humidity sensing and measuring devices.
6. Describe the types of gas sensing and measuring devices.

Topic 3 Basic Control and Instrumentation Components

Learning Outcome

Describe the basic types and functions of transmitters, recorders, controllers, and control actuators.

Learning Objectives

1. Describe the construction and operational principles of instrumentation transmitters.
2. Describe the construction and operational principles of instrumentation indicators and recorders.
3. Describe the construction and operational principles of instrumentation controllers.
4. Describe the construction and operational principles of final control elements.

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Topic 4 Introduction to Programmable Controllers

Learning Outcome

Describe the operation of programming controls for boilers, including applicable testing and maintenance procedures.

Learning Objectives

1. Discuss how programmable controllers work and how they act as sequencers for equipment.
2. Describe applications of programmable controllers.
3. Explain the HMI (human machine interface) and purpose of touchscreen displays, functions, and alarm handling.

Topic 5 Electronic Control Systems and Computer Applications

Learning Outcome

Describe the design and operation of electronic control systems.

Learning Objectives

1. Discuss electronic process control systems.
2. Describe computers and how they operate within control systems.
3. Describe the applications of computerized control systems and plant computers.

Topic 6 Electrical Control Systems

Learning Outcome

Describe the design and operation of electrical control systems.

Learning Objectives

1. Describe the basic construction and operation of various electric control system components.
2. Describe the function of control devices in electric control systems.
3. Explain the operating sequence of basic electric control circuits.

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Fundamental Industrial Communication Skills

Topic 1 Energy Plant Sketching

Learning Outcome

Create engineering equipment sketches.

Learning Objectives

1. Create sketches using center lines and dimensioning.
2. Recognize standard views of an object.
3. Recognize cross-hatching methods in sectional drawings.
4. Identify common symbols and lines used in plant system trace drawings.
5. Complete a plant line tracing.

Topic 2 Plant Diagrams and Drawings

Learning Outcome

Identify common types of diagrams used in plants.

Learning Objectives

1. Explain the layout of plant diagrams.
2. Explain the use of process flow diagrams (PFDs).
3. Explain the use of piping and instrumentation diagrams (P&IDs).
4. Explain the use of general arrangement, block plans and equipment diagrams.

Topic 3 Plant Communications

Learning Outcome

Describe the types and proper usage of plant communication systems.

Learning Objectives

1. Discuss effective written and verbal communication skills, including the use of two-way radios.
2. Describe the legal documentation requirements for Power Engineers, including log books and log sheets.
3. Discuss the elements of Maintenance Management Systems, including work requests, and work orders.
4. Discuss the purpose, revision, and control of Standard Operating Procedures.
5. Discuss updating procedures for piping and instrumentation diagrams.

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Introduction to Boiler Designs

Topic 1 Introduction to Boilers

Learning Outcome

Describe the historical development of boilers, boiler design, components, and configuration.

Learning Objectives

1. Describe the history of boiler applications, boiler design, and modern boiler improvements.
2. Describe packaged boilers.
3. Describe the construction of shop-assembled and field-erected boilers.
4. Describe components and design aspects common to all boiler vessels.

Topic 2 Firetube Boilers

Learning Outcome

Describe the design, components, and characteristics of firetube boilers.

Learning Objectives

1. Differentiate the Scotch Boiler from the other firetube boilers, and describe its development history.
2. Describe circulation patterns in firetube boilers.
3. Discuss construction details of firetube boilers.

Topic 3 Watertube Boilers

Learning Outcome

Describe the design, components, and characteristics of watertube boilers.

Learning Objectives

1. Describe the design and operating principles of watertube boilers.
2. Describe watertube boiler components.
3. Explain the design and application of packaged watertube boilers.
4. Describe the design, construction, and components of large-scale steam generating units.

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Topic 4 Electric Boilers

Learning Outcome

Explain the general design and application of electric boilers.

Learning Objectives

1. Discuss the advantages and disadvantages of electric boilers.
2. Describe the construction and operating principle of electric boilers.

Topic 5 Special Boiler Designs for Heating Plants

Learning Outcome

Describe the special design considerations of boilers used in heating plants.

Learning Objectives

1. Describe the design of watertube and coil tube heating boilers.
2. Describe cast iron boilers and vertical firetube boilers.
3. Describe the construction and application of firetube heating boiler designs.

Topic 6 Differences between Power and Heating Boilers

Learning Outcome

Differentiate between ASME Section I and ASME Section IV boilers.

Learning Objectives

1. Discuss the differences between power boiler and heating boiler design and installation.
2. Discuss the differences between power boiler and heating boiler operation.

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Elements of Boiler Systems

Topic 1 Combustion

Learning Outcome

Discuss the basic theory of combustion, and the equipment used to provide proper combustion conditions within a boiler.

Learning Objectives

1. Discuss combustion, combustion equations, and the relationship between theoretical and excess air.
2. Discuss the characteristics of solid, liquid, and gaseous fuels.
3. Explain the effects of fuels and combustion on refractory materials.

Topic 2 Fuel Delivery and Firing Systems

Learning Outcome

Describe common fuel systems found in boiler systems.

Learning Objectives

1. Describe solid fuel delivery systems.
2. Describe the main types of solid fuel firing systems.
3. Describe gaseous fuel delivery systems.
4. Describe the main types of gaseous fuel firing systems.
5. Describe liquid fuel delivery systems.
6. Describe the main types liquid fuel firing systems.
7. Describe flue gas analysis and how it relates to boiler efficiency.

Topic 3 Draft

Learning Outcome

Describe basic concepts and equipment used to supply combustion air to boiler furnaces.

Learning Objectives

1. Describe the various air streams that deliver combustion air to a furnace.
2. Relate differential pressure to the creation of draft.
3. Describe forced, induced, and balanced mechanical draft.
4. Discuss common methods of controlling combustion airflow.
5. Discuss common methods of measuring furnace pressures.

Topic 4 Feedwater Systems

Learning Outcome

Describe feedwater systems used with boilers.

Learning Objectives

1. Describe the overall layout of feedwater, condensate, and make-up water systems.
2. Describe the valves used in feedwater systems.
3. Describe the control strategies for single-element, two-element, and three-element boiler feedwater systems.
4. Describe methods of supplying feedwater to steam heating boilers.
5. Explain the operation of condensate receiver make-up water controls.
6. Describe the return of condensate, and the supply of feedwater to high-pressure boilers.

Topic 5 Blowoff and Blowdown Systems

Learning Outcome

Describe the equipment, operation, and purpose of boiler blowoff and blowdown systems.

Learning Objectives

1. Describe blowoff, blowoff equipment and blowoff procedures.
2. Describe continuous blowdown, blowdown equipment, and blowdown procedures.
3. Describe the maintenance and repair of blowoff systems.

Topic 6 Boiler Fireside Cleaning Systems

Learning Outcome

Describe types of boiler fireside cleaning equipment, their purpose, and their operation.

Learning Objectives

1. Describe common options for in-service fireside cleaning.
2. Describe the construction and operation of retractable soot blowers.
3. Describe the construction and operation of stationary soot blowers.
4. Describe falling shot cleaning methods.

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Lubrication and Bearings

Topic 1 Lubrication Principles

Learning Outcome

Describe the importance of lubrication and the principles concerned with lubrication.

Learning Objectives

1. Discuss the concept of lubrication and list the purposes of a lubricant.
2. List the various classes and types of lubricants and describe their respective properties and application.
3. List the properties of lubricating oils, the additives used, and their selection criteria.

Topic 2 Types of Bearings and Lubrication

Learning Outcome

Describe bearing types, methods for care and maintenance of bearings, and bearing lubrication systems.

Learning Objectives

1. Define boundary and full fluid film lubrication.
2. Describe shell (sleeve) bearings.
3. Describe the construction and operation of antifriction and thrust bearings.
4. Describe how to clean and replace roller and ball type bearings.
5. Explain the causes of bearing failure.

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Pumps and Compressors

Topic 1 Types of Pumps

Learning Outcome

Describe the construction and operating principles of various types of pumps used in plants.

Learning Objectives

1. List common pump applications.
2. Define the terms associated with pump performance.
3. Describe the common pumps found in plants.

Topic 2 Pump Operation and Maintenance

Learning Outcome

Describe the major considerations and procedures for pump operation and maintenance.

Learning Objectives

1. Discuss the components of a driver and pump assembly.
2. Discuss pump shaft sealing, compression packing, and the replacement of compression packing.
3. Describe the standard types of mechanical seals.
4. Describe pump bearings, shaft alignment procedures, and the equipment used to align shafts.
5. Describe centrifugal pump startup and priming procedures.
6. Describe positive displacement pump operating characteristics, priming, startup, and routine checks.

Topic 3 Introduction to Compressors

Learning Outcome

Describe the operating principles of the different types of compressors.

Learning Objectives

1. Describe the main classifications and types of compressors.
2. Describe gaseous compression systems.

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Topic 4 Compressor Operation and Maintenance

Learning Outcome

Describe the major considerations and general procedures for compressor operation and maintenance.

Learning Objectives

1. Describe compressor parts and auxiliary equipment.
2. Describe the construction and operation of seals for compressors.
3. Describe the capacity control of compressors.
4. Describe preventative maintenance and routine procedures for compressors.

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Boiler Safety Devices

<u>Topic 1 Pressure Relief Valves</u>

Learning Outcome

Explain the code requirements, design, and operation of pressure relief valves for power boilers, heating boilers, and pressure vessels.

Learning Objectives

1. Discuss the code requirements, construction, and operation of ASME Section I Pressure Relief Valves and Devices.
2. Discuss the code requirements, construction, and operation of ASME Section IV Pressure Relief Valves and Devices.
3. Describe the testing and repair of pressure relief valves.
4. Describe the construction and operation of temperature and pressure relief valves.

<u>Topic 2 Combustion Safety</u>

Learning Outcome

Explain the design and operation of combustion safety controls on burners and boilers.

Learning Objectives

1. Describe the operation of control and safety devices found on boiler fuel supplies.
2. Describe the construction and operation of flame detectors.
3. Describe the combustion safety controls for boilers and burner systems.
4. Describe burner management systems.
5. Interpret burner operating sequence charts, and provide a typical sequence of startup and shutdown events.

<u>Topic 3 Water Level Safety Controls</u>

Learning Outcome

Describe feedwater devices, and control methods used on boilers.

Learning Objectives

1. Describe the construction and operation of boiler low water level fuel cut-off equipment.
2. List the CSA and ASME code requirements regarding low water fuel cut-off devices.
3. Describe direct and indirect type boiler water level indicators.

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Topic 4 Boiler Fittings

Learning Outcome

Relate the code, operation, and required fittings to the operating principles of fittings found on boilers.

Learning Objectives

1. Explain the code references for boiler fittings.
2. Describe the code requirements for pressure gauges on steam boilers.
3. Describe the code requirements for the boiler connections and valves on steam boilers.
4. Describe the code requirements for fittings on hot water heating boilers.
5. Describe the non-code fittings used on boilers.

Topic 5 Firing Rate Controls

Learning Outcome

Describe the operating and safety controls found on boilers.

Learning Objectives

1. Describe basic boiler firing rate controls.
2. Discuss various operating controls for steam and hot water boilers.

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Boiler Plant Operation and Management

Topic 1 Boiler Plant Startup

Learning Outcome

Describe the operational procedures related to starting up auxiliary equipment in a boiler plant.

Learning Objectives

1. Describe the basic auxiliaries that need to be checked, prepared, or placed in service before starting a boiler plant.
2. Describe the general procedures for starting a plant for the first time, or restarting after an outage or turnaround.
3. Discuss basic operating practices for starting pumps and fans.
4. Describe the general preparation for a hot water boiler startup.
5. Describe the general preparation for a steam boiler startup.
6. Describe the safety and housekeeping preparation requirements for boiler plant startup.

Topic 2 Boiler Startup

Learning Outcome

Describe procedures for safely starting boiler systems.

Learning Objectives

1. Describe operating considerations when warming a cold boiler.
2. Describe how to start and cut-in a hot water boiler.
3. Describe how to start a single boiler steam plant.
4. Describe how to cut-in a steam boiler in a multiple boiler plant.
5. Describe semi-automatic burner ignition systems.
6. Discuss the post startup inspection for boilers returning to service after a major outage.

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Topic 3 Boiler Operation

Learning Outcome

Describe operational procedures related to operating boilers.

Learning Objectives

1. Describe the operation of a hot water heating boiler under routine conditions.
2. Describe routine steam boiler operating duties.
3. Describe emergency conditions in boiler plants and the required responses.
4. Describe basic boiler troubleshooting activities.

Topic 4 Operational Checks

Learning Outcome

Describe operational checks for operating boiler plants.

Learning Objectives

1. Describe the shift based operator responsibilities for boiler plants.
2. Describe the safety device operational checks carried out on boilers.
3. Describe routine maintenance activities for boiler plant operation.
4. Describe the use of Standard Operating Procedures (SOPs).
5. Describe the need for boiler operating and maintenance logs, and the type of information that should be recorded.

Topic 5 Shutdown Procedures

Learning Outcome

Describe generic shutdown and layup procedures for different boiler types.

Learning Objectives

1. Describe hot water boiler shutdown procedures.
2. Describe steam boiler shutdown and lockout procedures.
3. Describe extended period layup requirements for steam boilers.

Topic 6 Boiler Plant Monitoring and Reporting

Learning Outcome

Describe the points and readings that need to be monitored and recorded in a plant.

Learning Objectives

1. Discuss recording requirements for operating and performance conditions.
2. Discuss the various systems required to conduct equipment repairs, and to manage the related maintenance records.
3. Describe the operational causes, consequences, and prevention of water hammer.
4. Describe the consequences and actions required for various equipment failures.
5. Describe the consequences, and actions required, in the event of boiler accidents.

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Energy Plant Maintenance

Topic 1 Energy Plant Maintenance I

Learning Outcome

Describe the safe use of common hand tools in the powerhouse.

Learning Objectives

1. Describe the types and proper use of hacksaws, files, chisels, hammers, screwdrivers, and wrenches.
2. Describe the types and proper use of hand threading tools.
3. Describe the types and proper use of measuring tools.
4. Describe the proper layout of work and the use of layout tools.
5. Describe the types and proper use of portable and fixed grinders, hand drills, drill presses, and the care of drill bits.

Topic 2 Energy Plant Maintenance II

Learning Outcome

Discuss and describe the safe and proper setup of equipment for hoisting and working above ground.

Learning Objectives

1. Describe the requirements for setting up work platforms in general and ladders and scaffolding in particular.
2. Describe the general safety precautions and calculations used when rigging equipment.
3. Describe the general safety precautions used when hoisting equipment.
4. Discuss the correct use and limitations of wire cable and rope, including cable attachments and rope knots.
5. List and describe common types of metal fasteners, such as screws, bolts, studs, nuts, and washers.

Topic 3 Boiler Maintenance

Learning Outcome

Describe the service and maintenance required for boilers.

Learning Objectives

1. Describe the general maintenance and service of packaged firetube and cast iron sectional boilers.
2. Identify the operational procedures for wet and dry boiler layups.
3. Describe ways of detecting firetube and tubesheet leaks.
4. Describe the general procedure for the removal and replacement of defective firetubes.

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Topic 4 Boiler Cleaning

Learning Outcome

Discuss the procedure for preparing a boiler for inspection and cleaning, and describe mechanical and chemical boiler cleaning methods.

Learning Objectives

1. List the steps and precautions to prepare a boiler for inspection.
2. Describe the internal inspection of a boiler.
3. Describe the methods and tools used to mechanically clean boilers.
4. Describe two methods used to chemically clean boilers.

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Water Treatment

Topic 1 External Boiler Water Treatment

Learning Outcome

Describe the general principle, methods, and equipment used in preparing raw feedwater for steam production.

Learning Objectives

1. Describe typical impurities and their effects on plant and boiler water pre-treatment systems, and their treatment process.
2. Describe the equipment requirements for pre-treatment of plant water systems.
3. Describe water filtration and the removal of suspended solids.
4. Describe the purpose, processes, and equipment used in water softening.
5. Describe the theory, process, and equipment used in deaeration.

Topic 2 Internal Boiler Water Treatment

Learning Outcome

Describe the general principles, methods, and equipment used for internal boiler water treatment.

Learning Objectives

1. Describe the types of problems, and associated treatments, related to internal boiler water contamination.
2. Describe internal boiler feedwater chemical feed systems.
3. Describe standard boiler water testing.

Topic 3 Condensate Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condensate.

Learning Objectives

1. Describe condensate treatment and the effects of non-treatment.
2. Describe the tests conducted on condensate.

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Topic 4 Cooling Tower and Condenser Water Treatment

Learning Outcome

Discuss the general principles, methods, and equipment used for the treatment of condenser water, and their effects on the cooling tower.

Learning Objectives

1. Describe the effects of water on condensers and cooling tower materials.
2. Describe condenser and cooling tower water treatment.
3. Describe cooling tower and condenser water tests for common treatment methods.

Topic 5 Recirculating System Water Treatment

Learning Outcome

Describe recirculating water systems, their effects, treatment, and tests.

Learning Objectives

1. Describe recirculating water system corrosion and deposition.
2. Describe the use of sacrificial anodes, and measurement techniques to determine corrosion.
3. Describe glycol system testing requirements.
4. Discuss the monitoring tools, procedures, and tests used in recirculating water systems.

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Types of Prime Movers and Heat Engines

Topic 1 Heat Engines and Prime Movers

Learning Outcome

Discuss the historical conversion of heat energy into mechanical energy.

Learning Objectives

1. Differentiate between the terms “heat engine” and “prime mover.”
2. Discuss the history of the steam engine and the expansive power of steam.

Topic 2 Steam Turbines

Learning Outcome

Describe the construction and operation of steam turbines.

Learning Objectives

1. Describe the principle of operation and major components of a steam turbine.
2. Describe the lubrication and sealing of steam turbine shafts.
3. Describe how the rotational speed of a steam turbine is governed and controlled.
4. List the steps to follow in a typical steam turbine start-up and shut-down.

Topic 3 Condensers and Cooling Towers

Learning Outcome

Describe the operation and maintenance of condensers and cooling towers.

Learning Objectives

1. Explain the construction and operation of condensers, and how they relate to the operation of cooling towers.
2. Explain the principle of operation, the purpose, and the major components of cooling towers.
3. Describe the construction and operation of natural draft cooling towers.
4. Describe the construction and operation of mechanical draft cooling towers.
5. Discuss cold climate operation for cooling towers.
6. Explain typical problems and resolutions required within the operation of cooling towers.

Topic 4 Gas Turbines

Learning Outcome

Describe the application, startup, operation, and maintenance required for gas turbines.

Learning Objectives

1. Describe the principle of construction and operation of gas turbines.
2. Identify the operational characteristics of gas turbines.
3. Describe regeneration and combined steam-gas turbine operating cycles.
4. Describe the key elements of gas turbine startup, operation, and auxiliaries.

Topic 5 Internal Combustion Engines

Learning Outcome

Describe the application, construction, and operation of internal combustion engines.

Learning Objectives

1. Discuss the fuels used in internal combustion engines.
2. Describe the working cycles of the 4-stroke and 2-stroke spark ignition engines.
3. Describe the working cycle of the 4-stroke compression ignition (diesel) cycle.
4. Describe the construction of basic spark and compression engines.
5. Explain the basic operating considerations for diesel engines.

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Plant Auxiliary Systems

Topic 1 Lighting Systems

Learning Outcome

Explain the various lighting systems and some of the basic design considerations for lighting a space.

Learning Objectives

1. Describe the common types of lighting equipment and systems.
2. Discuss the different types of artificial light sources.
3. Explain the various methods of lighting control.
4. Describe the general requirements and criteria for emergency lighting in buildings.
5. Discuss the interrelationship between lighting, air conditioning, and energy conservation in buildings.

Topic 2 Building Water Systems

Learning Outcome

Explain the various water supply systems used in buildings.

Learning Objectives

1. Describe the cold water distribution system in a building.
2. Describe the hot water distribution system in a building.
3. Describe the construction and operation of building system hot water heaters, including temperature regulation.
4. List and describe the construction and operation of water system protective devices in buildings.
5. Explain what is meant by “backflow prevention” and describe the common methods used.
6. Describe the maintenance requirements for the components in a building water distribution system.

Topic 3 Drainage Systems

Learning Outcome

Describe the design and components of various drainage systems used in facilities.

Learning Objectives

1. Describe the overall layout of building drainage systems.
2. Describe storm water drainage systems for buildings.
3. Describe how surface runoff is managed in order to minimize environmental impact.

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Basic Concepts of Compression and Absorption Refrigeration

Topic 1 Refrigeration Basics

Learning Outcome

Explain the basic concept of refrigeration and refrigerants.

Learning Objectives

1. Explain the fundamentals of refrigeration.
2. Describe the cycle of operations in a vapor compression refrigeration system.
3. Explain how the operating temperatures and pressures are selected and related for a vapor compression refrigeration system.
4. State how the capacity of a refrigeration system is described and how refrigeration tables are used to calculate system performance.
5. Describe how refrigerants are classified.
6. Describe the thermodynamic properties of refrigerants.
7. Describe the properties of refrigerants relating to miscibility, leakage tendency, odor, moisture reaction, toxicity, and flammability.

Topic 2 Compression Refrigeration Systems

Learning Outcome

Describe the operating principles of compression refrigeration systems.

Learning Objectives

1. Describe the basic layout of compression refrigeration systems.
2. Distinguish between direct and indirect refrigeration systems.
3. Describe the layout of packaged refrigeration systems and the role of a refrigeration economizer.
4. Describe the special types of refrigeration compressors, and how they are similar to and different from air compressors.
5. Describe the special designs of refrigeration system evaporators and condensers.

Topic 3 Refrigeration System Control and Operation

Learning Outcome

Describe the purposes and operating principles of refrigeration system operational and safety controls.

Learning Objectives

1. Describe refrigeration system controls.
2. List the safety shutdown devices specific to centrifugal compressor water chillers.
3. Describe typical refrigeration system safety shutdown devices.
4. Describe the construction and operation of refrigerant metering devices.
5. Describe the different methods used to control evaporator capacity.
6. Describe the different methods used to control the capacity of refrigeration compressors.

Topic 4 Refrigeration System Operation and Maintenance

Learning Outcome

Describe the operating principles and maintenance of refrigeration systems.

Learning Objectives

1. Discuss refrigeration auxiliaries.
2. Describe refrigeration system leak test procedures.
3. Describe how a refrigeration system is dried and charged prior to start-up.
4. List the steps for adding oil to an in-service refrigeration compressor.
5. Describe the start-up and shut-down procedure for a compression refrigeration system.
6. Describe operational log sheets and preventative maintenance procedures for refrigeration systems.
7. Describe how a refrigeration system is purged of noncondensable gases.
8. Discuss refrigeration condenser operation and maintenance requirements.
9. Explain typical problems and resolutions related to refrigeration systems.

Topic 5 Absorption Refrigeration Systems

Learning Outcome

Describe the operating principle, maintenance, and operation of absorption refrigeration systems.

Learning Objectives

1. Describe the basic absorption system, comparing the differences to the compression system.
2. Describe the theory and operation of an ammonia absorption refrigeration system.
3. Describe the theory and operation of a lithium bromide absorption refrigeration system.
4. Explain the operation of absorption refrigeration systems with respect to crystallization and dilution.
5. Describe the major parts and systems of an absorption system, including: heat exchanger bypass system, p ump motor lubrication and cooling system, and purging system.
6. Describe the startup and shutdown procedures for an absorption refrigeration system.
7. Describe the preventive maintenance that should be performed on an absorption refrigeration system.
8. Explain typical problems and resolutions related to an absorption refrigeration system.

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Topic 6 Refrigeration Plant Safety

Learning Outcome

Outline the potential hazards inherent to refrigeration plants, the CSA requirements intended to mitigate hazards, and typical responses taken in the case of a significant leak.

Learning Objectives

1. Identify and provide a basic explanation of the CSA B52 Code requirements for refrigeration plant machinery rooms.
2. Identify safe practices for refrigeration plant operation and maintenance.
3. Describe the appropriate emergency response to a significant refrigerant leak.
4. Describe the Canadian Environmental Emergency Regulations and how they relate to refrigeration plants.

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HVAC Fundamentals for Facility Operators

Topic 1 Conditioning the Air

Learning Outcome

Explain the methods and techniques for conditioning air in plants and buildings.

Learning Objectives

1. Discuss the process to condition air for human comfort and health.
2. List the categories and functions of HVAC systems.
3. Describe the operation of air-handling units.
4. Define the terms humidity, relative humidity, and dewpoint.
5. Define the terms dry-bulb temperature, wet-bulb temperature, wet-bulb depression, and how they relate to relative humidity.

Topic 2 Humidification

Learning Outcome

Explain the equipment and principles of humidification.

Learning Objectives

1. Describe the general purpose and principles of humidification.
2. Describe residential and warm air types of humidifiers.
3. Describe industrial and commercial types of humidifiers.

Topic 3 Fans for Air Distribution Systems

Learning Outcome

Describe the airflow behavior and movement of air through distribution systems.

Learning Objectives

1. Discuss the theory of airflow and pressure conversions.
2. Describe the major types of air handling fans, their construction, and operation.
3. Interpret fan performance curves.
4. Describe fan motors, drives, and belt guards.
5. Describe fan volume controls.

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Topic 4 Ventilation and Air Filters

Learning Outcome

Describe the various ventilation systems, including various types of air filters used in these systems.

Learning Objectives

1. Explain the difference between natural and mechanical ventilation.
2. Describe the various contaminants found in air.
3. Describe the types of air cleaning devices used in industrial/commercial buildings.

Topic 5 HVAC Duct Systems

Learning Outcome

Describe the designs and components of duct systems used in HVAC applications.

Learning Objectives

1. Explain how air duct systems are classified.
2. Describe air duct materials, system layout, fabrication, and installation.
3. Describe air duct leakage.
4. List and describe the types of liners, dampers, and louvres used in air duct systems.
5. Discuss terminal air distribution devices, and the principles of diffusion, induction, entrainment, and aspiration.

Topic 6 Types of Coils and Operation

Learning Outcome

Describe the various types and operation of coils used in HVAC systems.

Learning Objectives

1. Explain how steam, hot water, and glycol coils are sized, configured, and operated to reduce the chance of freezing.
2. Describe the installation recommendations for coils, piping, steam traps, control valves, air vents, and vacuum relief devices.

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Building Environmental Systems and Control

Topic 1 Steam Heating

Learning Outcome

Describe the components, operating principles, and maintenance procedures of steam heating systems.

Learning Objectives

1. Describe the construction and operation of steam heating system devices used to transfer heat from the steam to a heated space.
2. Describe the auxiliary equipment used in a steam heating system, including air vents, radiator valves and traps, and condensate return equipment.
3. Describe standard types of piping and equipment layout for steam heating systems.
4. Describe the general operation and maintenance of steam heating systems.
5. Apply a steam heating system troubleshooting guide.

Topic 2 Hot Water Heating

Learning Outcome

Describe the various designs, equipment, and operation of hot water heating systems.

Learning Objectives

1. Describe the standard piping and circulation layouts of hot water heating systems.
2. Compare the advantages and disadvantages of hot water and steam heating systems.
3. Describe various types of special hot water heating systems.
4. Describe the purpose and function of standard hot water heating system accessories.
5. Explain how the location of the hot water circulating pump and the expansion tank are determined.
6. Describe the routine operation of hot water heating systems, including cleaning, filling, starting, and use of glycol/antifreeze.
7. Apply a hot water heating troubleshooting guide.

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Topic 3 Other Heating Systems

Learning Outcome

Describe common heating systems encountered by Power Engineers.

Learning Objectives

1. Describe natural gas fueled warm air heating systems.
2. Describe the recommended maintenance procedures for warm air heating and ventilating systems.
3. Discuss the concept and application of infrared heating.
4. Describe the different methods of electric heating, and their advantages and disadvantages as compared to other types of systems.

Topic 4 Cooling Systems and Combination Systems

Learning Outcome

Describe central, unitary and combined HVAC systems.

Learning Objectives

1. Describe the general layout and operation of unitary air conditioning systems.
2. Describe the general layout and operation of central air conditioning systems.
3. Describe the general layout and operation of combined air conditioning systems.
4. Discuss how HVAC systems should be operated under different situations.

Topic 5 Heat Gains and Losses, and Heat Recovery Methods

Learning Outcome

Describe heat gains and losses, and common methods for energy recovery.

Learning Objectives

1. Define heat transmission terminology.
2. Describe heat gain and heat loss analysis in a building or plant.
3. Describe the general principles of HVAC heat recovery.

Topic 6 HVAC Control Strategy

Learning Outcome

Describe the control systems strategies used in HVAC systems.

Learning Objectives

1. Describe a basic ventilation control strategy for HVAC systems.
2. Describe heating control strategies for HVAC systems.
3. Describe humidification, dehumidification, and cooling control strategies for HVAC systems.
4. Describe volume control with static pressure regulation for HVAC systems.

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Typical Industrial Plant Configurations

Topic 1 Common Plant Configurations in Hydrocarbon Centric Industries

Learning Outcome

Identify steam-related processes employed in common types of plants.

Learning Objectives

1. Identify standard thermal system pathways and segments commonly used in plants.
2. Identify equipment and processes in heat transfer fluid (HTF) heating systems.
3. Identify the main thermal processes used in oil refining industries.
4. Describe the main processes used in steam assisted gravity drainage (SAGD) and cyclic steam stimulation (CSS).
5. Identify thermal processes used in gas separation and compression plants.

Topic 2 Common Plant Configurations in Energy Intensive Industries

Learning Outcome

Identify steam related processes employed in common types of plants.

Learning Objectives

1. Identify the main steam/boiler processes used in wood and biomass processing plants.
2. Identify the important thermal processes used in food production and preservation.
3. Identify the common processes and equipment used in metallurgical processing plants.

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Elementary Mechanics and Dynamics

Topic 1 Introduction to Basic Mechanics

Learning Outcome

Apply basic terms and calculations used in the study of mechanics.

Learning Objectives

1. Define mass, force, acceleration, velocity, and weight.
2. Perform simple calculations involving force, pressure, work, power, and energy.

Topic 2 Forces and Moments

Learning Outcome

Perform calculations involving forces and moments, and determine when a system of forces is in equilibrium.

Learning Objectives

1. Define the moment of a force and its units.
2. Determine the direction and calculate the magnitude of the moment of a force.

Topic 3 Simple Machines

Learning Outcome

Perform calculations relating to mechanical advantage, velocity ratio and efficiency.

Learning Objectives

1. Define the term simple machine and apply to calculations of mechanical advantage, velocity ratio and efficiency of simple machines.

Topic 4 Scalars and Vectors

Learning Outcome

Define and identify scalar and vector quantities and solve simple vector problems graphically.

Learning Objectives

1. Define scalar and vector quantities as they apply to drawing vector diagrams.

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Topic 5 Linear Velocity and Acceleration

Learning Outcome

Solve simple problems involving linear velocity, time, and distance.

Learning Objectives

1. Solve distance, displacement, speed, and velocity problems.
2. Draw graphs of velocity as a function of time.
3. Define acceleration, state its units, and solve simple acceleration problems.
4. Apply mathematical formulae relating acceleration, velocity, distance and time to solve problems.

Topic 6 Force, Work, Pressure, Power, and Energy

Learning Outcome

Perform calculations involving force, work, pressure, power, and energy.

Learning Objectives

1. Perform calculations involving force and work.
2. Perform calculations involving gauge, atmospheric, and absolute pressure.
3. Perform calculations involving power and different forms of mechanical energy.

Topic 7 Friction

Learning Outcome

Solve problems involving friction.

Learning Objectives

1. Apply the laws governing the types of friction.
2. Apply the coefficient of friction to problems involving forces on a horizontal plane.

Topic 8 Stress and Strain

Learning Outcome

Explain physical properties of materials and how their behavior is affected when external forces are applied.

Learning Objectives

1. Describe the mechanical properties of materials, including elasticity, stiffness, plasticity, ductility, toughness, brittleness, and hardness.
2. Calculate stress including tensile, compressive, and shear stresses within rigid bodies due to external loads.
3. Calculate the strain of members under load.

Topic 9 Power Transmission

Learning Outcome

Perform calculations pertaining to common power transmission systems.

Learning Objectives

1. Calculate pulley speeds, transmitted power, and efficiency of belt drive systems.
2. Calculate gear speeds for gear and chain drive systems.