FOSSIL CONSULTING SERVICES, INC
6325 WOODSIDE COURT, SUITE 350, COLUMBIA, MD 21046
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ST220 – STEAM TURBINE GENERATOR OPERATIONS

Operator Awareness and Response

This 4½-day course has been developed to improve the effectiveness of steam turbine generator operators. Participation will provide the attendee with the knowledge and skills to identify and evaluate steam turbine generator abnormal operating conditions, and to determine the most appropriate response to that condition.

Do you fully understand the Starting and Loading Instructions for your unit? Not just what to do, but why it is done that way.

Do you know the correct response to emergency situations? Not just what to do, but why it is done that way.

The course should be attended by all power plant personnel involved in operating steam turbine generators. Control room and auxiliary operators, plant management, supervisors, engineers, and work leaders, will benefit from attendance in this course.

OBJECTIVES

Upon successful completion of this course the participant should be able to:

- Explain the two step process by which the turbine converts heat energy in steam into mechanical energy
- Describe the problems that can occur that are related to turbine nozzles and how they occur
- Explain the differences between impulse and reaction turbines.
- Describe how turbine stage pressures are affected by turbine load
- Describe how turbines used in power plants can be classified.
- Describe the steam flow path through a typical reheat turbine
- Describe the arrangement and, where appropriate operational characteristics, of turbine centerline components (Shells/casings, standards/pedestals, rotors/spindles, etc.)
- Explain why there are two sets of main steam valves in series between the boiler and turbine at the HP and IP turbines
- Describe how main steam valves are sealed and how sticking of valves can occur
- Describe the arrangement of main steam HP turbine inlet and Reheat valves and need for and importance of valve testing.
- Describe the main features of main steam valve actuators
- Describe the function and arrangement of auxiliary steam valves
- Describe the function, arrangement, operation, and testing of extraction non-return valves
- Describe the function, arrangement, operation, and testing of the Turbine Lube Oil System
- Describe the function, arrangement, operation, and testing of the Turbine Steam/Gland Seal Systems
- Describe the function, arrangement, operation, and testing of the Turbine Separate EHC hydraulic Systems
- Describe the function, arrangement, and operation of the Turbine Exhaust Hood Cooling System
- Describe how the integrity of two lines of defense is preserved in the turbine controls
- Explain the terms regulation and droop for the turbine governor
- Explain why governor droop is useful in sharing load among units in an electrical transmission system
- Describe how the emergency overspeed governor trips non-controlling valves
- Describe other overspeed protection features commonly provided.
- Describe features of common EHC control systems
- Explain why acceleration control and load control with load rate control are desirable
- Explain the function and use of the load limit
- Explain the function and use of the Main Steam/Throttle Pressure Limiter
- Explain how a load control loop can be implemented in an EHC system

- Explain how a pressure control loop can be implemented in an EHC system
- Explain how coordinated control system and automatic dispatch systems interface with the turbine controls
- Describe the principal features of TSI equipment hardware
- Describe how TSI vibration instrumentation is arranged
- Describe the possible causes and symptoms of excessive turbine vibration
- Explain what eccentricity is and how it is measured in the TSI system
- Explain how the condition of the thrust bearing is monitored in the TSI system
- Explain what differential expansion is, what causes excessive differential expansion, and how to respond to excessive differential expansion
- Describe how differential expansion is monitored by the TSI
- Describe the significance of shell expansion and how it is monitored in the TSI system
- Describe the bearing temperatures that are monitored
- Describe turbine metal temperatures that are monitored, including steam chest and water induction thermocouple temperatures
- Explain the term thermal stress and give three means available to operators to control thermal stress
- Explain the term cyclic life expenditure and describe how it can be controlled.
- Explain the term Fracture Appearance Transition Temperature and give its value
- Describe the principal features of the GE and Westinghouse Starting and Loading Instructions including:
    - The criteria for prewarming
    - The criteria for cold, warm and hot starts
    - Typical requirements for cold, warm and hot starts
    - How first stage steam/impulse chamber temperature is determined and why it is important
    - Recommendations for turbine drain operation
- Describe GE and Westinghouse general operational recommendations regarding
    - Eccentricity
    - Shell, rotor and differential expansion
    - Bearing vibration
    - Lube oil system operation
    - Steam/Gland seal system operation
    - Turning gear operation
    - Actual overspeed tests
- Describe typical GE and Westinghouse Operational limitations
    - Overspeed
    - Low vacuum
    - Thrust bearing wear
    - Low lube oil & hydraulic pressure
    - High exhaust hood temperature
    - External trips
    - Main & reheat steam pressure and temperature limitations
    - Main Stop Valve/Steam Chest Temperature Differential
    - Downward temperature ramps
    - Thrust bearing temperature
    - Operation with high backpressure
    - Operation with feedwater heaters out of service
    - Under-frequency operation
    - Low speed operation
    - Operation at critical speeds
    - Breaking vacuum
- Describe the issues associated with synchronizing HP and LP rotors on turning gear for cross compound units
- Understand how to prevent water induction
- Describe how to identify and respond to water induction
- Describe the operator appropriate response to tripping of generator protective relays.
- Explain the function of instrument transformers (PTs and CTs)

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- Briefly describe the function of each of the following protective relays with emphasis on whether the tripping of the relay indicates a generator failure/fault or an operational problem:
    - Instantaneous Overcurrent (50) Relay
    - Time Delay Overcurrent (51) Relay
    - Ground Overcurrent (50N, 51N)
    - Zone Protection Relays
    - Distance Relay (21)
    - Differential Relay (87)
    - Overvoltage Relays (59, 24)
    - Undervoltage Relay (27)
    - Frequency Related Devices
    - Frequency Relay (81)
    - Volts/Hertz Relay (24)
    - Reverse Power Protection (32)
    - Loss of Field Relay (40)
    - Out-of-Step Relay (78)
    - Negative Phase Sequence Current Relay (46)
    - Field Ground Fault (64)
    - Sync Check Relay (25)
    - Sudden Pressure Relay (63)
- Explain how the Lockout Relay (86) differs from other protective relays
- Describe briefly the interconnection of generating plants to the electrical power system and the impact of electrical system operation on generating unit and steam turbine operation.
- Describe reactive power including:
    - Explain why generating units need to generate or absorb reactive power
    - The different terms used to describe reactive power flow from and into a generating unit
    - Describe how to control the generation of reactive power.
- Describe operation of common generator voltage controls
- Describe how to properly synchronize a generator to the power system, including the function/use of the synchroscope.
- Describe the significance and use of the generator reactive capability curves.
- Describe operation of cross-compound generators including
    - Synchronization on turning gear
    - Precautions/limitations that must be considered
- Describe operational limits common to most generators including
    - Minimum operating temperature
    - Maximum operating temperatures
    - Cold gas temperature balance
    - Operation with a hydrogen cooler out of service
- Describe abnormal generator operations including:
    - Operation with unbalanced phase currents
    - Loss of field
    - Off-frequency operation
    - Operation of hydrogen cooled units with air

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This course is offered for "on-site" presentation in three versions:

1. Generic Version – This course is presented using our standard, generic Steam Turbine Generator Operations text at your facility.
2. Custom Version 1 (Partial Customization) - This course is presented using our standard generic Steam Turbine Generator Operations text; but the presentation is customized using site and unit specific materials. FCS will provide the client with a detailed list of required reference materials. FCS will use these materials to provide a plant and unit specific student handout. The unit specific handout is used during the presentation.
3. Custom Version 2 (Fully Customized Training Manual) – Prior to the course presentation, FCS personnel will visit the site to gather reference materials, photograph key plant equipment, and discuss plant procedures and operating concerns with plant personnel. FCS will develop a unit specific training manual that covers the same topics included in the outline. This customize training manual will be used during the course presentation and will be provided in an editable electronic form so that additional copies can be printed and the materials can be further customized should changes at your plant warrant.

Contact Mike McClintock at (717) 337-0874 or mmcclintock@fossilconsulting.com for information regarding technical content and pricing

CONTINUING EDUCATION UNITS

FCS is authorized to provide Continuing Education Units for successful completion of its training courses and seminars. 2.9 CEU'S will be awarded for successful completion of this course

INSTRUCTORS

Mike McClintock has 40+ years of experience in the power generation industry, which includes gas and steam turbine manufacturers and development of plant operations and maintenance training programs and short courses. He has done erection, startup and maintenance of steam and gas turbines in a variety of plants. He has managed, developed and presented training for plant operations and maintenance personnel on steam and gas turbine operations and maintenance. His experience covers GE, Westinghouse, Allis Chalmers/Siemens, Pratt & Whitney, ABB, Dresser-Rand, Hitachi, Toshiba, and Mitsubishi equipment. He has successfully developed and presented courses on plant heat rate improvement for operators and engineering personnel. Mike is a licensed Professional Engineer in Maryland.

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COURSE OUTLINE

I. Introduction (1 hr)
- A. Introduction of Instructors
- B. Review Course Outline
- C. Discuss Course Text
- D. Class Participation
- E. Class Structure
- F. Course Objectives

II. Tb Fundamentals (2 hrs)
- A. The T/G in the Cycle
- B. Basic Turbine Theory
  1. Conversion in Nozzles
  2. Conversion in Blades
- C. Basic Turbine Types
  1. Impulse Turbines
  2. Reaction Turbines
  3. Impulse vs. Reaction
- D. Turbine Classification

III. Tb Construction (4 hrs)
- A. Turbine Arrangement Overview
- B. Stationary Components
  a. Shell/Cylinder
  b. In. Shell/Blade Ring
  c. Nozzles/Diaphragm
  d. Turbine Seals
  e. Bearings
  f. Standards/Pedestals
  g. Turning Gear
  h. Blowout Diaphragm
- C. Rotating Components
  a. Rotors/Spindles
  b. Buckets/Blades

IV. Main Steam Valves (2 hr)
- A. Function and Overview
- B. Steam Chests
- C. Main Stop/Throttle Valves
- D. Control/Governor Valves
- E. Reheat Valves
- F. Auxiliary Valves

V. Tb Support Systems (5 hrs)
- A. Lube Oil System
- B. Steam/Gland Seal System
- C. LP Hood Cooling System
- D. Hydraulic Oil System

VI. Turbine Controls (5 hrs)
- A. Turbine Control System Fundamentals
  a. Transducers
  b. Summers
  c. Differentiators
  d. Integrators
  e. Amplifiers
  f. Overriding Devices (Gates)
  g. Function Generator
- B. Flyball Governor System
- C. Regulation
- D. Mechanical Hydraulic Amplifiers
- E. Impeller Governor System
- F. Non-Controlling Valves
- G. Overspeed Protection
- H. O/S Related Features
- I. EHC Control Systems
- J. Load Limit
- K. Pressure Limiters
- L. Load Control
- M. Pressure Control
- N. Coordinated Control Systems

VII. Turbine Supervisory Instruments (2 hrs)
- A. Bentley Nevada Supplied Equipment
- B. Vibration
- C. Eccentricity
- D. Thrust Bearing Wear
- E. Differential Expansion
- F. Shell Expansion
- G. Bearing Temperatures
- H. Turbine Metal Temperatures

VIII. Turbine Operations (4 hrs)
- A. Thermal Stress
- B. Fatigue and Cyclic Life Expenditure
- C. Fracture Appearance Transition Temperature
- D. GE Starting & Loading Instructions
  a. GE SALI Charts
  b. Operational Recommendations
  c. GE Operational Limitations
  d. Synchronization of HP LP Shafts on Turning Gear
- E. Westinghouse Starting and Loading Instructions
  a. Westinghouse Starting & Loading Charts
  b. Operational Recommendations
  c. Operational Limitations
- F. Water Induction Recommendations

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IX. Generator (2 hrs)
- A. Electrical Theory Review
  1. Magnetism
  2. AC Generators
  3. Power
  4. Three Phase Power
  5. Terminal Con.
- B. Generator Construction
  1. Stator & Windings
     i. Frame
     ii. Core
     iii. Stator Bars
     iv. Wedges
     v. End Support
  2. End Shield
  3. Bearings
  4. Generator Rotor
     i. Forging/Winding
     ii. Retaining Ring
     iii. Fans/Blowers
     iv. Collector Rings
  5. Generator Cooling

X. Gen Support Systems (2 hrs)
- A. Gas Control System
- B. Seal Oil System
- C. Stator Winding Cooling

XI. Generator Voltage Regulators (2 hrs)
- A. Automatic Voltage Regulators
- B. Regulator Protective Features

XII. Protective Relays (1 hr)
- A. Operator Response to Protective Relays
- B. Introduction
- C. Types of Relays
- D. Relay Descriptions

XIII. Synchronizing and Operating Generators (2 hrs)
- A. Electrical Power Systems
- B. Reactive Power
- C. Generator Voltage Controls
- D. Synchronizing the Generator
- E. Generator Capability
- F. Operational Limits
- G. Abnormal Operations
  1. Unbalanced Phase Currents
  2. Loss of Field
  3. Off Frequency Operation
  4. Operation in Air

XIV. Course Conclusion (1 hr)
- A. Questions/Answers
- B. Review/Exam
- C. Course Critique