FOSSIL CONSULTING SERVICES, INC
6325 WOODSIDE COURT, SUITE 350, COLUMBIA, MD 21046
(410) 312-6240 fcs@fossilconsulting.com

G100 – GENERATOR OPERATIONS & MAINTENANCE

This 3-day course has been developed to improve the effectiveness of generator operations and maintenance activities. Participation will provide the attendee with the knowledge and skills:

- Startup and operate generators safely and effectively
- Identify and evaluate generator abnormal operating conditions, and to determine the most appropriate response to that condition
- Develop and implement an effective generator preventive maintenance program
- Understand why inspections are performed not just how to perform the inspection

The course should be attended by all plant personnel involved in operating and maintaining generators, whether they are driven by steam turbines, combustion turbines, hydro turbines, or reciprocating engines. Control room and auxiliary operators, maintenance technicians, 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:

- Describe the conversion of mechanical energy to electrical energy in AC generators.
- Describe the function of the components in AC generators.
- Describe the different types of generator cooling systems.
- Trace the flowpath for generator auxiliary systems.
- Describe the major components in generator auxiliary systems.
- Describe the appropriate operator response to tripping of generator protective relays.
- Explain the function of instrument transformers (PTs and CTs)
- 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.

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- Describe reactive power including:
  - Why generating units need to generate or absorb reactive power
  - Different terms used to describe reactive power flow from and into a generating unit
  - 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
- Define the items that must be considered when performing generator maintenance.
- Describe the types of defects that are found in generator components during inspections.
- Identify causes for the defect.
- List the possible corrective actions concerning the defect.
- Describe the criteria used to determine the best corrective action.
- Describe the items that must be addressed during maintenance planning.
- Describe the methods used to determine generator internal component condition prior to disassembly.
- Describe the checks and inspections performed during generator disassembly and reassembly.
- Describe the proper method for cleaning generator components.
- Describe the proper method of inspecting the various generator components.
- Describe the electrical tests performed on generators.

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

1. Generic Version – This course is presented using our standard, generic Introduction to Combined Cycle Power Plant text at your facility.
2. Custom Version 1 (Partial Customization) - This course is presented using our standard generic Introduction to Combined Cycle Power Plant 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 Harold (HP) Grace, in Jacksonville, FL at (904) 272-9537 or hgrace@fossilconsulting.com for information regarding technical content and pricing.

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CONTINUING EDUCATION UNITS

FCS is authorized to provide Continuing Education Units for successful completion of its training courses and seminars. 1.9 CEU'S will be awarded for successful completion of this course.

INSTRUCTORS

Harold Grace brings 30+ years experience to Fossil Consulting Services. He has provided Combined Cycle Power Plant training to over 500 individuals over the past several years. Prior to FCS, Mr. Grace was Vice President of HPC Technologies in Bradenton Florida. Prior to that he was Manager - Turbine Generator Services, for General Physics, where he was responsible for turbine generator training, engineering and consulting services. Mr. Grace was also employed by GE for 18 years in a number of capacities including Field Engineer, Senior Project Manager, Service Supervisor, Service Manager, and Manager of Power Generator Jacksonville Service Shop. He is a licensed Chief Engineer with the National Institute for the Uniform Licensing of Power Engineers, Inc (NIULPE), Ohio State Association of Power Engineers, Inc., a NIULPE Technical Instructor, Licensed Examiner, and is Chairman/President - NIULPE of Florida. Mr. Grace is a member of and Vice Chairman for the ASME Combined Cycle Power Plant Committee.

Mike McClintock has 30+ years of experience in the power generation industry, which includes 11 years with gas and steam turbine manufacturers and 19 years in 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.

Vic Madison is a Senior Project Manager at FCS. He has over 20 years of power plant related experience. This includes Navy Nuclear Power, Commercial Nuclear Power and Conventional Power Plant operations experience as well as training experience. Mr. Madison has been a training consultant for 20 years. His training experience includes the design and development of paper-based materials, Computer-Based Training (CBT), and Web-Based Training (WBT) for a wide variety of business sectors. As a classroom instructor, Mr. Madison has presented a great number of courses for operators, maintenance and supervisors. These include both generic and plant specific courses, presented in the US and Internationally.

Scott Hommel is a Senior Project Manager at FCS. He has over 20 years of power plant and electrical transmission & distribution related experience and over 15 years of training experience. This includes over 10 years in the Navy Nuclear Power Program as both an operator and a trainer, and over 10 years as a training consultant in the electrical power generation, transmission and distribution field. Mr. Hommel complements these experiences with a Bachelors Degree in Electronics and several years as a training consultant in the fiber optic telecommunications field. Mr. Hommel has experience in all facets of training curriculum design, development, and implementation for all types of training topics in various formats, including paper-based materials and Computer-Based Training (CBT). As a classroom instructor, Mr. Hommel has presented a great number of courses for operations, maintenance and supervision, totally over 10,000 hours of classroom presentation time.

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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. **Electrical Theory Review** (2 hrs)
- A. Magnetism
- B. AC Generators
- C. Power
- D. Three Phase Power

II. **Generator Construction** (2 hrs)
- A. Stator & Windings
  - 1 Frame
  - 2 Core
  - 3 Stator Bars
  - 4 Wedges
  - 5 End Support
- B. End Shield
- C. Bearings
- D. Generator Rotor
  - 1 Forging/Winding
  - 2 Retaining Ring
  - 3 Fans/Blowers00
  - 4 Collector Rings
- E. Generator Cooling

III. **Gen Support Systems** (1 hr)
- A. Gas Control System
- B. Seal Oil System
- C. Stator Winding Cooling

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

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

VI. **Synchronizing and Operating Generators** (4 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
- H. Operation in Air

VII. **Job Planning & Scheduling** (2 hrs)
- A. Pre-outage Preparation
  1. Safety
  2. Parts Identification
  3. Tooling
  4. Lifting Devices
  5. Site Planning
  6. Technical Info.
  7. Replacement Parts
  8. Schedules
- B. Outage Management
- C. Pre-Outage Inspections

XIV. **Generator Maintenance** (4 hrs)
- A. Disassembly
- B. Cleaning & Inspection
- C. Electrical Testing
- D. Reassembly

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