Balance of Plant

Balance of Plant

This five-day overview course describes the portion of the sub-systems that support the plant gas turbine operation. This is a technician-level course for both operating and maintenance personnel, providing the knowledge base necessary to begin working on equipment.

I. Review of Combined Cycle Operation

II. Balance of Plant Overview

- Auxiliary Steam System
- HRSG Blowdown System
- Circulating Water System
- Closed Cycle Cooling Water System
- Compressed Air System
- Compressed Gases System
- Condensate System
- Demineralized Water System
- Feed Water System
- Fire Protection System
- Plant Drains System
- Potable Water System
- Service Water System
- HP, HRH, CRH, and LP Steam Systems
- Condenser Air Removal System

Combined-Cycle Plant Maintenance and Operations

Combined-Cycle Plant Maintenance and Operations

This five-day course begins with a review of gas turbine theory. Next, the main turbine systems are described, including air inlet and filtration, compressor, combustion system, turbine section, bearings, support systems, protection systems, HRSG, duct burner, and SCR system. Water chemistry as it relates to turbine operations is discussed. Plant operations and turbine control processes are also described. The final portion of the course describes combined-cycle plant maintenance and inspections.

I. Gas Turbine Theory

- Basic Gas Turbine Cycle
- Gas Path
- Gas Turbine Design
- Major Components

II. Air Inlet and Filtration Systems

- Air Inlet System
- Inlet Compartment
- Air Filtration System
- Power Augmentation

III. Compressor Section

- Compressor
- Compressor Cleaning

IV. Combustion System

- Emissions
- Components

V. Turbine Section

- Turbine Rotor
- Cooling
- Nozzles
- Diaphragm
- Shrouds
- Exhaust Frame

VI. Bearings

- Tilting Pad Journal Bearings
- Thrust Bearing
- Lubrication
- Lubricant Sealing

VII. Support Systems

- Ignition System
- Lube Oil System
- Gas Fuel Control System
- Generator
- Starting System
- Control System

VIII. Protection Systems

- Over Speed Protection
- Over Temperature Protection
- Flame Detection and Protection System
- Vibration Protection
- Combustion Monitoring

IX. Heat Recovery Steam Generator

- HRSG Design Basics
- HRSG System Description
- HRSG Components
- HRSG Systems

X. Duct Burner System

- System Description
- Burner System
- Operation

XI. Selective Catalytic Reduction System

- System Description
- System Components
- System Operation
- SCR System Control

XII. Water Chemistry

- Water Treatment
- Water Treatment Problems
- Blowdown

XIII. Plant Operations and Controls

- Control Panels and Definitions
- Motor Control Center
- Supervisory Remote Equipment
- Annunciator System
- Gas Turbine Operator Commands
- Governor Commands

XIV. HSRG Operation

- Startup
- Combined Cycle Plant Startup
- Removing HRSG From Service
- Cyclic Operations of HRSG
- Shutdown - Combustion Turbine Trip
- Flexible Operation of Combined Cycle Gas Turbine

XV.Combined Cycle Plant Maintenance and Inspections

- Maintenance
- Maintenance System
- Turbine Routine Maintenance
- HRSG Routine Maintenance
- Inspection Technology for HRSGs
- Inspection Types

Combustion Fundamentals

Combustion Fundamentals

This three-day course is designed to provide participants with a working knowledge of the combustion process used in modern power plant applications. Different fuels, the equipment used to burn these fuels, and the monitoring of the emissions is covered in detail. Emission monitoring and the requirements of the Clean Air Act are also discussed in detail.

I. Fuels

- Fuel Characteristics
- Solid Fuels
- Gaseous Fuels
- Safety
- Liquid Fuels

II. Combustions

- Coal Oil and Gas
- Combustion Process

III. Basic and Ideal combustion

- Basic Combustion
- Ideal Combustion
- Combustion Control

IV. Components of a Burner Port

- Diffuser
- Air Register
- Burner Throat
- Ignitor
- Flame Detectors

V. Factors Affecting Proper Combustion

- Flame Characteristics
- Oil Flame
- Gas Flame
- Smoke

VI. Performance Monitoring

- Checking Combustion Efficiency
- Performance Monitoring
- Corrosion, Deposits, and Emissions Control
- Boiler Efficiency Related Factors
- Combustion Related Factors
- Stack Gas Waste Heat Losses
- Combustible Losses
- Radiation Losses
- Waterside Losses
- Steam Heat Loss Factors
- Boiler Maintenance Practices
- Blower Factors
- Air Heaters
- Boiler Auxiliaries

VII. Furnace Safeguards Supervisory System (FSSS)

- Overview
- FSSS Role in Steam Generating Process

VIII. Unintentional Fires External to the Furnace

IX. Plant Emissions and the Clean Air Act

- Emissions
- Particulate

- Sulfur Oxide
- Nitrogen Oxide
- Thermal NOX
- Fuel NOX
- NOX Reduction Processes
- Fly Ash
- Optical Properties of Fly Ash

X. Overview of Continuous Emission Monitoring (CEM)

- SO2 Monitoring
- NOX Monitoring
- Volumetric Flow
- Opacity
- Diluent Gas (O2 or CO2)
- Records

GE EHC MK I Turbine Controls

GE EHC MK I Turbine Controls

This seven-day course provides a component-level study of the system's control circuits with demonstrations of control system response using a MK I EHC table-top simulator. This simulator uses meters to display the processing of input signals by the control system, and makes available to the student the controls and indications normally available to an operator, including turbine load set, pressure set, bypass valve jack load limiter, turbine warming controls, and valve response.

I. EHC System Overview

- EHC System Block Diagram
- Control Panel
- Test Panel
- Control Line-up

II. Turbine Control Hydraulics

- Pumps
- Nitrogen Charged Accumulators
- Filters and Strainers
- Pressure Switches and Setpoints
- Fullers Earth System
- Fluid Actuation System
- Stop Valve Actuators
- Control Valve Actuators
- Combined Reheat Valves (CIV)
- Cyclic Maintenance and Troubleshooting

III. Emergency Trip System

- Mechanical Trip System
- Electrical Trip Solenoids
- Electrical Trip Lockout Valve
- Backup Overspeed Trip
- Relay Dump Valve
- Thrust Bearing Wear Detector

IV. Bearing Oil System

- Main Shaft Oil Pump
- Oil Driven Suction Pump
- Turning Gear Pump
- Emergency DC Pump
- Lift Pumps

V. Speed Control

- Speed Control Block Diagram
- Speed Sensors
- Frequency-to-Voltage Converters
- Primary and Secondary Low Value Gates
- Speed Control References and Logic
- Speed Matcher
- Calibration and Testing Speed Control Circuitry

VI. Load Control

- Control Valve Amplifier/Stop Valve Amplifier
- Intercept Valve Amplifier
- Load Set Circuit
- Load Limit and Load Set Runback Circuit
- Load/Pressure Limit Logic
- Loading Rate and Load Set Limits Circuit

- Loading Rates and Load Set Limit Logic
- Load Control Unit Logic
- Stage Pressure Sensor/Feedback
- Throttle Pressure Compensator/Limiter
- Chest/Rotor Shell Warming
- Testing and Calibration of Load Control

Circuits VII. Flow Control

- Main Stop Valve Position Control
- Intercept Valve Position Control
- Control Valve Position Control
- Stop Valve Position Driver
- SADI Cards
- Diode Function Generators
- Control Valve Position Driver
- Valve Logic

VIII. Miscellaneous Control Circuits

- Alarm and Trip Circuitry
- Monitor Circuit and First Hit Detection
- Standby Control System
- Power/Load Unbalance Circuit
- Early Valve Actuation Circuit
- Total Control Valve Signal

IV. Common Circuit Cards

- 1 KHz and 3 KHz Oscillators
- DC OP Amp.
- OP Amp/ DFG Driving Amp
- Voltage Comparator
- Meter Amplifier
- Calibration and Testing

X. Valve Testing

- Control Valve Testing
- IV and RSV Testing
- Stop Valve Testing

GE EHC MK II Turbine Controls

GE EHC MK II Turbine Controls

This seven-day course provides a component-level study of the system's control circuits with demonstrations of control system response using a MK II EHC table-top simulator. This simulator uses meters to display the processing of input signals by the control system, and makes available to the student the controls and indications normally available to an operator, including turbine load set, pressure set, bypass valve jack load limiter, turbine warming controls, and valve response.

I. EHC System Overview

- EHC System Block Diagram
- Control Panel
- Operating Panel
- Test Panel

II. Turbine Control Hydraulics

- Main Turbine Control Oil System
- Emergency Governor
- Backup Overspeed Trip
- Thrust Bearing Wear Detector
- Fluid Actuation System and Fluid Jet System
- Main Stop Valves
- Control Valves
- Combined Reheat Valves

III. Trip and Monitoring

- Fundamental Trip Circuits
- 24 Volt Trip Bus
- 125 Volt Trip Bus
- Trip Test Circuits
- First Hit Detection
- Electrical Malfunction Indication

IV. Speed Control

- Speed Control Unit Description
- Speed Sensors
- Frequency to Voltage converters
- Low Value Gate
- Speed Control References
- Speed Control Logic
- Speed Matcher
- Auxiliary Speed Unit

V. Load Control

- Load Control Description
- Stage Pressure Sensor
- Main Steam Pressure with Limiter
- Load Set Circuit
- Load Limit and Load Set Runback Circuit
- Loading Rate and Load Set Limits Circuit
- Control Valve Amplifier
- Main Stop Valve Amplifier
- Intercept Valve Amplifier
- Motor Position Indicator
- Load Control Unit Logic
- Basic Operation
- Stage Pressure Feedback
- Chest/Rotor Shell Warming
- Loading Rates and Load Set Limit Logic
- Load Limit Positioning Circuit
- Load/Pressure Limit Logic
- Load Set Positioning Circuit with Load Limit Runback
- Motor Drive Circuit
- Control Valve Test Bias Circuit

VI. Flow Control

- Operation
- Control Valve Position Units
- Electronic Circuitry
- Main Stop Valve Position Unit
- Intercept Valve Position Units
- Reheat Stop Valves
- Valve Logic
- Circuitry
- Testing Procedures

VII. Miscellaneous Circuits

- Standby Control System
- Power/Load Unbalance Circuit
- Early Valve Actuation Circuit

GE Speedtronic MK V Steam Turbine

GE Speedtronic MK V Steam Turbine

This three-day course begins with a system overview; a "big picture" of the GE Speedtronic. Next, the hydraulic controls and components are explained. Other major topics include the system software, master trip circuit, control configuration, and miscellaneous circuits.

I. System Overview

- System Block Diagram
- Operator Interface
- Backup Interface
- Diagnostics

II. Turbine Control Hydraulics

- Main Turbine Control Oil System
- Emergency Governor
- Backup Overspeed Trip
- Thrust Bearing Wear Detector
- Fluid Actuation System and Fluid Jet System
- Main Stop Valves
- Control Valves
- Combined Reheat Valves

III. Software

- Application Software
- Software Voting
- Diagnostics

IV. Master Trip Circuit

- Fundamental Trip Circuits
- 24 Volt protective Bus
- 125 Volt Trip Bus
- Primary Trip Relays
- Emergency Trip Relays
- Logging Functions

V. Control Configuration

- Speed Control Description
- Load Control Description
- Flow Control Description

VI. Miscellaneous Circuits

- Turbine Supervisory Instrumentation
- Power/Load Unbalance Module
- Logging Functions
- Protection Module
- Flame Detection
- Power Supply Card

GE MK VI Speedtronics

GE MK VI Speedtronics

This four-day course describes the GE MK VI Speedtronics control system that supports the plant turbine operation. This is a technician-level course for both operating and maintenance personnel, providing the knowledge base necessary to begin working on equipment.

I. System Overview

- Functional Description
- Control Panel Features and Controls
- Control Panels and Definitions
- Generator Control Panel
- Motor Control Center
- Supervisory Remote Equipment
- Annunciator System

II. Tools

- ToolBox
- CIMPLICITY HMI
- Controller

III. Gas Turbine Operator Commands

- Operating Mode Commands
- Cooldown Cycle Commands
- Gas Turbine Unit Commands
- Gas Turbine Load Commands
- Fuel Commands

IV. Control System and Operation

- Control System Operation
- Control System Overview

V. Fuel Control System

- System Operation
- Liquid Fuel System

VI. Turbine Protection Systems

- Trip Oil
- Overspeed Protection
- Overtemperature Protection
- Flame Detection and Protection System
- Vibration Protection
- Combustion Monitoring

VII. Operator Screens and Operating Procedures

- Operator Screens
- Operating Procedures

GE EX2000 Digital Exciter

GE EX2000 Digital Exciter

This five-day course begins with a review of the fundamentals of AC power followed by a review of semiconductor fundamentals. AC generator types and operations are also discussed. Major generator components are explained, followed by a description of the governor control system. In the final portion, the EX2000 digital exciter is explained, including exciter operation, software and hardware structures, how to operate the programmer, keyboard functions, operating modes, and running diagnostic tests.

I. Fundamentals of AC Power

- Magnetic Fields
- AC Waveforms
- Phase Relationships
- Resistance in AC Circuits
- Inductance in AC Circuits
- Capacitance in AC Circuits
- Power in AC Circuits

II. Semiconductor Fundamentals

- Atomic Review
- Extrinsic Semiconductors
- Diodes
- Transistors
- Silicon Controlled Rectifiers
- Thyrite

III. AC Generators

- AC Generator Theory
- Types of AC Generators
- AC Generator Operating Characteristics
- Detailed Operation
- Concepts of Voltage Control
- Three-Phase Systems

IV. Major Generator Components

- AC Generators
- Types of AC Machines
- AC Generator Components
- Three-Phase Generation

V. Governor Control System

- System Functions
- Governor Components
- Governor Operation
- Parallel Operation

VI. EX2000 Exciter

- System Overview
- Installation
- Exciter OperationIX.

GE EX2100 Digital Exciter

GE EX2100 Digital Exciter

This five-day course begins with an overview of the EX2100 digital exciter. Next, both the analog and digital exciter operation is described, including the software and hardware structures. The final portion of the course describes how to operate the programmer, including keyboard functions, operating modes, and running diagnostic tests.

I. Overview

- Definition and Scope
- EX2100 System Overview
- Communications Interfaces

II. Operating Description

- Exciter Operation
- Excitation Software Structure
- Diagnostics
- Exciter Hardware Structure
- Communication
- Backup Options
- Multi-Bridge Configuration

III. Operating the Programmer

- Keypad
- Display
- Operating Modes

Heat Recovery Steam Generator

Heat Recovery Steam Generator

This three-day course describes the function and operation of heat recovery steam generators, including their components, function, operation, and maintenance.

I. Heat Recovery Steam Generator Overview

- Purpose
- Function/Description
- HRSG Thermodynamics
- Steam Generation Principles

II. Major Components

- HRSG Structure
- HRSG Low Pressure Circuit
- HP/IP Feedwater Pumps
- HRSG Intermediate Pressure Circuit
- HRSG Reheat Steam Circuit
- HRSG High Pressure Circuit

III. Pre-Operational Checks

- Precautions And Limitations
- Valve Lineup Checklist
- Power Supply Lineup Checklist
- System Startup Prerequisites

IV. Operating Procedures

- Startup Procedure
- Normal Operation
- Shutdown Procedure

V. Routine Maintenance

- Daily
- Weekly
- Monthly
- Quarterly
- Six Months
- Annually

VI. Alarm Response

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Steam Plant Fundamentals

Steam Plant Fundamentals

This ten-day course begins by reviewing a simple wind power plant and the basic energy processes and equipment, such as equipment for converting chemical energy to heat energy,equipment for transferring heat energy to steam energy, and equipment for converting steam energy to mechanical energy, and converting mechanical energy into electrical energy. Along the way, we describe the boiler feedwater cycle as it applies to a steam power plant. The combustion process is fully described followed by the steam-water cycle in boilers, how turbines are classified, constructed, and operate, and the steam-water cycle in turbines; followed by a description of the condenser steam cycle, and the function and components of the condensate and boiler feed system. The next topic describes the water treatment process, including sources of water, reasons for purification of water, and the methods of water treatment. We also review the mechanical equipment and processes associated with a steam generating plant, and describe the oils and lubrication requirements for plant equipment. The next section describes valves, traps, and associated system piping, and explains the pumps and air compressors used in a steam plant. Instrumentation and control systems that comprise the steam plant operating systems and a description of steam plant operating procedures using checklists and typical operating procedures are provided. The final section describes the job of the plant operator.

I. Basic Power Plant Theory

- Simple Power Plants
- Basic Energy Processes and Equipment
- Boiler Feedwater Cycle
- Pressure and Flow
- Temperature and Heat
- Properties of Water

II. The Combustion Process

- Combustion
- Fuel Handling and Preparation
- Handling Combustion Air and Gas
- Heat Flow
- Ash Removal
- Furnace Explosions

III. Steam Cycles (Boilers and Turbines)

- Steam-Water Cycle (Boilers)
- Steam-Water Cycle (Turbine)
- Condenser Steam Cycle
- Condensate and Boiler Feed System

IV. Water Treatment and Circulating Water System

- Water Treatment Process
- Circulating Water System

V. Steam Plant Mechanical Equipment

- Oils and Lubrication
- Valves, Traps, and Piping
- Pumps and Compressors

VI. Steam Plant Instrumentation and Controls

- Instrumentation
- Main Control Systems

VII. Steam Power Plant Operation

- Plant Operating Procedures
- Station Performance
- Job of the Operator

Westinghouse AEH

Westinghouse AEH

This five-day course covers the operation of the Westinghouse AEH turbine control system. The main focus of this course is to present the principles of each part of the AEH system. The electronic system is covered down to the circuit card level. This approach provides participants with an understanding of the turbine control system, enhancing maintenance and troubleshooting.

I. Electro-Hydraulic Control System

- Electronic Controller
- Operator Panel
- Steam Valve Actuators
- High-Pressure Fluid Control System
- Lube Oil & Associated Emergency Trip System

II. Turbine Control Systems

- System Arrangement/Simplified Drawing
- EHC System Signal Paths
- E-H Fluid System Flow Paths
- E-H System Components

III. Instrumentation and Control

- Principles of Operation
- EHC System Operator Panels
- Turbine Pressure Instrumentation
- Megawatt Transducer
- Speed Channels
- Turbine Supervisory Instruments

IV. Trip Systems

- Overspeed Protection Controller (OPC)
- Partial Loss of Load (CIV)
- Load Drop Anticipator (LDA)
- Emergency Trip System
- Relay Logic
- Trip Cabinet
- Emergency Trip Test Panel

V. EHC Electronics and Common Circuits

- High Treshold Logic (HTL)
- Analog Switch (AS)
- Operational Amplifiers
- Open Loop Characteristics
- Closed Loop Characteristics

VI. Speed Control

- Flow Diagrams
- Manual Speed Control (GVMA, TM)
- Automatic Speed Control (GVAA, GV)
- Tracking (GI,GD)
- Reference Counter and D/A Converter (RDAC)
- Setter Counter and D/A Converter
- Servo-LVDT Valve Positioner
- Flow Diagrams and Detailed Schematics
- Troubleshooting and Maintenance

VII. Pseudo Manual

- J Flip Flop
- K Flip Flop
- CL Flip Flop

VIII. Load Control and Impulse Pressure Control

- Simplified Flow Diagram
- Impulse Pressure Control (IPI, IPO)
- Load Limit
- Initial Loading
- Detailed Schematics
- Troubleshooting and Maintenance

IX. Miscellaneous Circuits

- Power Supplies
- Turbine Control System Connections with Other Systems
- Systems Required to Support the Turbine Control System

Westinghouse Digital EHC System

Westinghouse Digital EHC System

This five-day course gives students a working knowledge of Digital Electro-Hydraulic Control Systems. The course allows students to become comfortable with its operation by analyzing the system on both a block diagram and circuit card level. The course emphasizes a "nuts and bolts" approach to the DEH system that will greatly enhance the abilities of maintenance and supervisory personnel to perform their jobs.

I. Introduction to DEH

- Overall System Operation
- DEH Application Programs
- Manual Backup Control System

II. Fluid System

- E-H Fluid System
- Lubricating Oil and Auto-Stop Oil System
- Control Function and Interlocks

III. Analog System

- Manual DEH Control
- 7300 Series Relay (NRC) Card
- 7300 Series Digital Input Converter (NDI)
- 7300 Series Programmable Driver (NPD) Card
- 7300 Series Input (NCI) Card
- 7300 Series Servo Driver (NSD) Card
- 7300 Series Analog Comparator (NAC) Card
- 7300 Series Analog Mixing Amplifier (NMA) Card
- 7300 Series Quad-Loop Power Supply (NQP) Card
- 7300 Series Elco Adapter (NEA) Card
- 7300 Series Contact Output (NCO) Card
- 7300 Series Annunciator Interface (NAI) Card
- Throttle Valve Control
- Governor Valve Control
- Throttle Pressure Control
- Throttle Valve Servo Amplifiers
- Throttle Valve Additive Position
- Position Characterizer
- Governor Valve Servo Amplifiers
- Governor Valve Additive Position
- Overspeed Protection Control (OPC)
- Load Drop Anticipation (LDA)

IV. Computer Basics

- Introduction to Logic
- Memories
- Basic Computer

V. Automatic Control

- Central Processor Unit
- Process I/O System
- External Interrupt Subsystem
- Contact-Closure Input (CCI) Subsystem
- Analog Input (AI) Subsystem
- Digital Speed Channel Subsystem
- Analog Output Subsystem
- Contact-Closure Output Subsystem
- Data Link Subsystem
- Breaker Open Interrupt Program

- Valve Pushbutton Interrupt Program
- Remote Attention Interrupt Program
- Auxiliary Synchronizer Task
- Stop Initialize Subroutine
- System Error Task
- Contact Input Scan Task
- DEH Control Analog Input Scan Task
- Analog Input Conversion Task
- Operator's Panel "B" Task
- Valve Pushbutton Task
- Visual Display Task
- Logic Task
- Control Task
- Valve Management (VM) Program
- Tracking Subroutine
- Preset Subroutine
- Control Output Task
- Data Link Programs
- ATC Programs
- ATC Message Writer Task
- CRT Programs
- Logout Task

VI. Digital System Equipment

- External Interrupt Subsystem
- Input and Output Subsystems
- Q Line Centralized I/O Subsystem
- External Interrupt/Service Request (EE) Card
- Isolated Interrupt Filter (XIF) Card
- Sequencer of Event Interrupt (XIS) Card
- 16 Bit DC Input (SCI) Card
- Single-Point Analog-to-Digital Converter (SPA)
- Isolated Digital/Analog Hybrid (XHC) Card
- 7300 Series Speed Channel (NSP) Card
- Contact Output (XCO) Card
- Resettable Contact Output (XCZ) Card
- Direct Digital Output (DDO) Card
- Digital/Analog Controller (DAC) Card
- Process Output Driver (IPO) Card
- Analog Input Point (QAV) Card
- Analog High Level Input Point (QAW) Card
- RT Input Amplifier (QRT) Card
- Universal Input/Output Bus (UIOB)
- Bus Extender (QBE) Card
- Crate Paddle (QPD) Card
- Time Base (QTB) Card
- W2500 Input/Output (W10) Card
- Asynchronous Half Duplex Series Interface (WHD) Card
- Paper Tape Reader (PTR) Card
- Teletype Beehive Board (TTB and TTY)

VII. W2500 Computer

- Function
- Basic Operation
- Interconnections