500 Tallevast Road • Suite 101
Sarasota, FL 34243 USA
Tel: 941-747-7733 • Fax: 941-746-5374
www.hpcnet.com

Course Information Letter ---- TG415

Design and Major Repair of Steam Turbines

TG415

This course is designed for power generation engineers, operations superintendents and maintenance superintendents familiar with steam turbine components and the most basic steam turbine design theory. The course is extremely helpful for those engineers who want to become familiar with turbine design and also desire to "take charge" of steam path upgrades, modifications and/or major maintenance and to learn those penetrating questions and evaluate the contractors answers, all based on "knowledge gained". The course is scheduled for 4.5 days of classroom work; each topic is covered in sufficient detail in class. The attendee is also directed toward independent study using several textbooks, detailed course notes and a list of references included with the course. Depending on the number of attendees, there may be some opportunity to discuss case studies with which the instructor has experience or problems attendees may have and which are of interest to all attendees.

Upon completion of this course the participant will be sufficiently familiar with the design of large utility steam turbines to participate in or lead major maintenance projects, steam path upgrades and/or modifications which commonly required as part of service life extension programs for fossil fired or nuclear power plants. The participant will be better equipped to discuss design details with the original equipment manufacturer or the supplier of the steam path upgrade or modification.

Topical Outline includes: Historical perspective of steam turbines, steam power cycles, steam path, blade/bucket profiles, blade vane stress, blades roots and fasteners, root stresses, cover bands, rotors, fixed blades / diaphragms, blade vibration, casings / cylinders, material selection, state of the art steam path features, discussion of ultra-supercritical steam turbines.

OBJECTIVES:

Upon completion of the course the participant will be able to:

1. Describe the evolution of these complex machines and basic design criteria used by manufacturers.
2. Describe the ideal and actual thermodynamic cycles, as well as heat balance.
3. Demonstrate knowledge regarding the range of expected efficiency for steam turbines designed with the latest technology.
4. Will demonstrate a general understanding of basic design criteria such as velocity ratio, constant pressure ratio and variable pressure ratio stages and the efficiency loss mechanisms including moisture effect and seal leakages.
5. Describe the design basis for 2d and 3d airfoil (blade and vane) profiles, on and off design effects, profile losses.
6. Demonstrate a basic understanding of steady and dynamic loading including centrifugal and vibratory and steam bending loads and the stresses these loads produce in the blade vane.
7. Demonstrate knowledge of blade fastener types and how operational loads are transferred to the turbine disc or wheel.
8. Describe how blades are installed and what types of design features are incorporated to secure these blades in the turbine disc.
9. Demonstrate knowledge regarding the function of cover bands (shrouding) and tie wires, and why the manufacturer uses one or more of these in the large utility steam turbine.
10. Describe the types of rotors available including monobloc, built-up and welded,
11. Describe the types of analyses performed by the manufacturer to assure reliable long term reliability of turbine rotors.
12. Describe the types of loads imposed on stationary diaphragms and blade rings including distortion producing creep.
13. Demonstrate knowledge regarding repair options of stationary blading, and the effect of repair tolerance on overall reliability and efficiency.
14. Demonstrate knowledge regarding blade vibration producing effects and how these translate to blade stress.
15. Demonstrate a basic understanding of casing design including single and double shells, effect of pressure and temperature and torque loading, relative movement between components.
16. State the type of repairs necessary to correct shell/casing defects resulting for thermal stresses and high temperature creep.
17. Demonstrate knowledge regarding the types of materials used in large utility steam turbines and the reasons for specific alloying elements and processes used to produce these high quality materials.

COURSE SYNOPSIS

1. HISTORICAL PERSPECTIVE and PRINCIPLES FOR DESIGNING A NEW LARGE UTILITY STEAM TURBINE (4 hours): 100 years of design evolution including DeLaval, Curtis, Rateau, Parsons impulse and reaction designs. A summary type discussion of the steps necessary to design a new steam turbine including rules of thumb for sizing important features such as inlet and exhaust areas, rotor size, number or shells/cylinders, type of valve control.
2. STEAM POWER CYCLES (2-hours) The Carnot Cycle, The Rankine Cycle, The Steam Reheat Cycle, Regenerative Feedwater Heating, The Power Cycle - Mollier Diagram, Cycle and Unit Efficiency, Power Cycle Heat Balance.
3. STEAM PATH (4 hours): Fluid flow thru nozzles, Fluid flow thru steam turbines, Losses in the Steam Path, Steam Path Deterioration, Stage Velocity Ratio, Partial Arc (Throttle Control), Full Arc (Nozzle Control), Effects of Internal Moisture Separation, Removal of Feedwater Heaters from Service. Includes a detailed presentation of losses (profile loss, labyrinth seals etc).
4. BLADE/BUCKET PROFILES (1 hour): Blades with Constant Profile, Straight Generated Profiles, Vortex or Twisted Profiles
5. STRESSES IN BLADE VANE (4 hours): Centrifugal Stress, Lacing or Tie Wire, Leading Edge Erosion Shield, Vane Bending Stresses, Steam Bending Effects, Centrifugal Bending Effects, Blade Vibratory Stresses – detailed review of loads on steam turbine blades, empirical relationships for calculation of stresses with recommendations for use of finite element analysis techniques.
6. BLADE ROOTS AND FASTENERS (2 to 4 hours): Functions of the Root, Root Forms, Blade Root Platforms, Root Load Bearing Surface Curvature, Pinning of Radial Entry Roots, Root Side Grips of Tangential Entry Blades, Unequal Load Sharing within Blade Roots, Blade Root Operational Problems, Fatigue Failure in the Root
7. BLADE ROOT STRESSES (1 hour): Radial, Tangential and Axial Entry Forms, Closing Blades and Windows, Considerations of the Blade Root Transfer Surface
8. COVER BANDS (SHROUDING) AND TIE-WIRES (2 hours): Functions of the Cover Band and Tie Wires, Types, Tenons and their Attachment by Riveting, Shaping of Shroud Band Ends, Riveting/Peening
9. TURBINE ROTORS (3 hours): Function of the Rotor, Construction, Heat Treatment, Inspection of Bores, Inspection of Forging, Rotor Dynamics/Critical Speed, Rotor Thermal Stability, Stresses, Temperature Control
10. TURBINE FIXED BLADES AND DIAPHRAGMS (2 hours): Function, Diaphragm and Blade Ring Construction and Manufacture, Built up Fixed Blade Rows, Diaphragm Stresses
11. BLADE VIBRATION (2 hours): Prediction of Blade Frequencies, Sources of Vibration Stimulus, General Equation for Blade Frequencies, Torsional Vibration, Correction Factors for Natural Frequency, The Campbell Diagram, Nozzle Impulse Effects, Partial Admission, Steam Force Diagram, Nozzle Passing Effect
12. STEAM TURBINE CASINGS/CYLINDERS (2 hours): Multiple Shells/Cylinders, Thermal Gradient and Shell Design, Estimating Low Cycle Fatigue Life, Shell Manufacture, Steam Inlet Connection Points of the Casings, Steam Nozzle Boxes
13. MATERIALS for STEAM PATH and other TURBINE COMPONENTS (2 hours): Alloying Elements, Tensile Strength, Yield Strength, Ductility, Hardness, Impact Strength, FATT, Modulus of Elasticity, Modulus of Rigidity, Fatigue Strength, Creep Rupture, Poisson's Ratio, Resistance to Corrosion, Coefficient of Thermal Expansion, Diffusivity, Thermal Conductivity, Rotor Forging Material, Turbine Disc or Wheel Material, Blading Materials, Titanium Alloy for Blades, High Pressure and Temperature Casing
14. STEAM TURBINE DAMAGE AND REPAIR (4 hours): Evaluating damage to steam turbine components including blades/buckets, nozzles/diaphragms, rotors, shells/cylinders/valve bodies and make pass/fail decisions including decisions to repair and/or replace
15. INTERPRETRATION OF TEST DATA (2 hours): Review several case histories as presented in K. C. Cotton's "Evaluating and Improving Steam Turbine Performance" and use his methodology for determining the most likely cause of performance degradation prior to taking corrective action
16. STEAM PATH AUDIT (1 hour): A brief review of the steps necessary for conducting a steam path audit including identifying the potential energy "parasitic" losses.

FREQUENTLY ASKED QUESTIONS

- Will HPC Technical Services bring this course to our location for our personnel only? YES, call or email Stephen Parker, stparker@hpcnet.com for a price quotation.
- Will HPC Technical Services customize the presentation at our site to suit our particular needs? Yes. Please contact Stephen Parker.
- Is HPC Technical Services' textbook available for purchase as a reference document? No.
- What is the cost for HPC Technical Service to deliver this course at our location? Well, of course that can vary and it needs to be priced on an individual need basis. You gain from the customization and price. Again, please contact Stephen Parker.
- Are HPC Technical Services' consultants available for "technical consulting regarding an operational or maintenance problem? Yes. Call Harold Parker, hparker@hpcnet.com for discussion and/or a rate sheet.

COURSE DATES/LOCATION/FEE

For current dates / locations / prices, please see HPC's website, www.hpcnet.com.

WHAT YOU WILL RECEIVE:

1. 1 copy (CD) of HPC's instructor power point presentation for note taking (approximately 500 slides)
2. 1 copy of Ken Cotton's book, Evaluating and Improving Steam Turbine Performance
3. 1 copy of Bill Sanders (Volumes 1 and 2), Turbine Steam Path Maintenance and Repair
4. A "Certificate of Completion" with 2.9 CEUs, authorized for issue by the International Associate of Continuing Education/Training.

STEAM TURBINE MAINTENANCE CERTIFICATION:

1) Field Engineer

Those who attend this course are automatically qualified to take HPC Technical Services' Certification Examination. This examination is offered at no additional expense to the participant. An 80% passing grade is required. The examination length will not exceed 2-hours. Those who complete this examination will receive a revised "certificate of completion" that recognizes this accomplishment along with two-copies of a "To Whom It May Concern" letter that states their accomplishment. (Two copies are provided, one for the participants' employer and one for the participants' personal file.)

Consult HPC's website, www.hpcnet.com, for detail on this certification program.

INSTRUCTOR:

Herb Sirois. Mr. Sirois is founder of a technical consultation company serving the electric utility and process industries and major insurance companies for over 14 years. He has managed an integrated turbomachinery design and manufacturing company and was manager of Sales and Marketing for engineered aftermarket products and services to the utility and process industries for a major turbomachinery manufacturer. Herb is a Mechanical Engineer with extensive contributions to the design and application of turbomachinery including steam and gas turbines, blowers, fans and pumps and has conducted technical development programs for turbine product lines, failure analysis and engineering for a major mechanical drive steam turbine manufacturer. Mr. Sirois instructs HPC's higher-level steam turbine design and performance courses.

HPC TECHNICAL SERVICES
500 Tallevast Road, Suite 101, Sarasota, FL 34243
Telephone: 941-747-7733 .... FAX: 941-746-5374
Website: www.hpcnet.com

REGISTRATION FORM

Company: _____

Plant: _____

Address: _____

City/State/Zip: _____

Telephone: _____ FAX: _____

Course Number/Title: _____

Course Dates: _____/_____/_____ Thru _____/_____/_____

Course Location: _____ Course Fee: _____

Please enroll the following individual(s) listed below:

Student #1: _____

Student #2: _____

☐ **Taking advantage of HPC's 3-4-2 Policy: Send 3, Pay for 2 when paying in advance.**

Student #3: _____

Enrolled by: _____ Date: _____

METHOD OF PAYMENT

- ☐ Check to Follow
- ☐ Check Enclosed #: _____
- ☐ MC/Visa/AMEX #: _____
  Expiration Date: _____ CV Code: _____
- ☐ Purchase Order #: _____

HOW DID YOU LEARN OF THIS COURSE?

- ☐ Familiar with HPC courses
- ☐ Recommended by others
- ☐ Received a fax
- ☐ Received an email
- ☐ Internet search
- ☐ Other: _____