

Fundamentals of calculation and selection of centrifugal pumps

Scope

Centrifugal pumps like all rotating equipment, are the most sensitive equipment in a plant. Proper selection and sizing are of paramount importance as they play a vital role in the performance and reliability of the plant.

Fundamentals of calculation and selection of centrifugal pumps course is designed to provide you with a complete understanding of the construction details and the functioning of centrifugal pumps.

Course Objectives

Upon completion of the course, participants will be able to:

- Identify different types of pumps, including centrifugal and positive displacement pumps;
- Recognize the advantages and the limitations of each type of pump;
- Construct system curves;
- Perform NPSH calculations;
- Provide guidelines and best practices for operation, maintenance and troubleshooting of pumps.

Training Methodology

The duration of the seminar is five days. In the first four days, the theory will be covered with lectures, instructor led discussions exercises and videos. There will be also demonstrations

of actual pump parts, such as impellers, bearings mechanical seals and shafts.

Who Should Attend:

This course is primarily designed for:

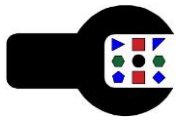
- Petroleum, Chemical, Process Mechanical and project Engineers;
- Operation, technical service and maintenance professionals;
- Technical professionals responsible for piping system inspection.

Duration: Five days

Course instructor: Mr. George Loizou

George is a Mechanical Engineer with more than 37 years of experience mainly in the Oil and Gas Industry. George holds an M.S. Degree from The Pennsylvania State University. He is a member of SMRP, a Certified Maintenance and Reliability Professional (CMRP), member of the Cyprus Scientific and Technical Chamber and of the Institution of Mechanical Engineers of UK. He is also certified trainer by Human Resources Development Authority (HRDA) of Cyprus.

George worked as Head of Mechanical Maintenance at the Cyprus Petroleum Refinery Ltd, Engineering Manager and Terminal Manager at Cyprus Petroleum Storage Company Ltd.



Course outline

➤ Day 1

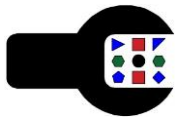
- Course Overview
- Quiz
- **Module 1. Introduction**
 - Historical Perspective
 - Pump Types
 - Centrifugal pump standards
 - Classification of centrifugal pumps
- **Module 2 Basic Pumping terms**
 - Pipes and pipe fittings
 - Fluid properties
 - Pumping terms
- **Module 3 Basic Fluid mechanics**
 - Reynolds number
 - Velocity head
 - Static head
 - Head loss
 - The energy equations
 - System curves
 - Hazen & Williams formula for pressure drop
 - Net Positive Suction Head
 - Cavitation
- **Module 4. Centrifugal Pump Operation**
 - Centrifugal performance pump curves
 - Total head
 - Power
 - NPSHr
 - Efficiency
 - Pump selection
 - Pump efficiency check
 - Centrifugal pumps operating in series
 - Centrifugal pumps operating in parallel
 - Control of centrifugal pumps
 - Throttling of the discharge valve;

- Installing a recirculation line;
- Increasing/decreasing the speed of the pump
- Performance curve shapes

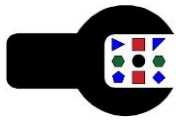
– Quiz

➤ Day 2

- **Module 5. Centrifugal Pumps components**
 - Casings
 - Impellers
 - Impeller types
 - Wear rings/ open impeller adjustment
 - Axial thrust
 - Radial thrust
 - Specific speed
 - Affinity laws
 - Impeller trimming
 - Suction specific speed
 - Pump operating window
 - Heat generation
 - Flow within the impeller
 - Velocity triangles
 - Shaft diameter
 - Impeller design
 - Stepanoff chart
 - Inlet and outlet angles
 - Blade width
 - Number of vanes
 - Wrap angle
 - Blade shape – Multiple arc method
 - Underfiling of impeller blades
 - Drooping curves
 - Cutwater/tongue clearance
 - Volute casing/design
 - Shaft
 - Bearings
 - Bearing bracket
 - Oil level in bearing bracket
 - Bearing seals

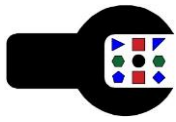


- Constant level oiler
 - Stuffing box
 - Shaft sleeves
 - Couplings
 - Coupling rating
 - Types of couplings
 - Auxiliary fittings
- **Day 3**
- **Module 6. Bearings**
 - Sliding and Rolling element bearings
 - Friction
 - Lubrication
 - Plain bearings
 - Hydrodynamic bearings
 - Plain bearing calculations
 - Plain Bearing characteristic number
 - Oil flow
 - Temperature rise
 - Hydrodynamic bearing clearances
 - Plain bearing materials
 - Hydrostatic bearings
 - Rolling element bearings
 - Types
 - Bearing arrangements
 - Thrust bearings
 - Bearing life
 - Dynamic Equivalent load
 - Static Equivalent load
 - Recommended shaft and housing fits for radial bearings
 - Bearing internal clearance
 - Bearing temperature during operation
 - Bearing designations
 - Bearing materials
 - Bearing installation
 - Bearing removal
 - Ceramic hybrid bearings
 - **Module 7. Lubricants**
 - Lubrication and lubricants
 - Oil additives
 - Predicting Oil Life
 - Greases
 - Predicting Grease Life
 - Calculating regrease frequency and quantity
 - Oil mist lubrication
 - Oil analysis
 - **Module 8. Shaft sealing**
 - The stuffing box
 - Gland packing
 - Packing installation and removal
 - Guidelines for stuffing box dimensions
 - Mechanical seals
 - Balanced/Unbalanced seals
 - Terms and definitions (Buffer fluid, barrier fluid, flush fluid, etc.)
 - Non contacting gas lubricated seals
 - Mechanical seal per API STD 682 (4th edition 2014)
 - Seal categories
 - Seal types
 - Seal configurations
 - Arrangements
 - Materials
 - Temperature limits
 - Stuffing box pressure
 - Piping plans per API 682
 - Sealless pumps
 - Canned pumps
 - Magnetic drive pumps
- **Day 4**
- **Module 9. Pump Installation**
 - Pump Foundations
 - Anchor bolts



➤ Day 5

- Pump Setting and Levelling
- Grouting
- **Module 10. Shaft alignment**
 - What is Alignment?
 - Types of misalignments
 - Sources and effects of misalignments
 - Alignment methods
 - Misalignment tolerances
 - Tools required for alignment
 - Dial gauges and Total indicator reading (TIR)
 - Soft foot
 - Sag
 - Temperature corrections
 - Reverse dial method
 - Laser alignment
- **Module 11. Pump Piping**
 - General requirements
 - Typical suction and discharge arrangements
 - Dos and don'ts
- **Module 12. Pump Operation & Maintenance**
 - Commissioning
 - Pre start-up checks
 - Startup and operation
 - Pump maintenance
 - Single-stage pump dismantling and repair
 - Shop measurements
- **Module 13. Vibration analysis**
 - Defects that can be detected
 - Measurement locations
 - Acceptable vibration limits
 - Unbalance
 - Misalignment
 - Mechanical looseness
 - Bent shaft
 - Rotor rub
 - Bearing defects
 - Bearing frequencies
 - Cavitation
 - Vane passing frequency
- **Module 14. Positive displacement pumps**
 - Positive displacement pump characteristics
 - Classification of positive displacement pumps
 - Rotary pumps
 - Internal gear pumps
 - External gear pumps
 - Lobe pumps
 - Screw pumps
 - Rotary pump selection
 - Operation of rotary pumps
 - Reciprocation pumps
 - Valves
 - Piston pumps
 - Pulsation dampeners
 - Inlet stabilizers
 - Plunger pumps
 - Diaphragm pumps
 - Metering pumps
 - Metering pump stroke
 - Metering pump calibration
 - Air operated double diaphragm pumps
- **Module 15. Other types of dynamic pumps**
 - Single stage double suction
 - Multistage pumps
 - Single stage vertical pumps
 - Regenerative turbine pumps
 - Vertical mixed flow pumps
 - Axial flow pumps
- **Module 16. Drivers**
 - Area classification
 - Electric motors
 - Number of poles and revolutions
 - Slip
 - Enclosure types
 - Temperature class
 - Motor service factor
 - Power factor



- Insulation class
- Variable speed motors
- Steam Turbines
 - Classification of steam turbines
 - Blade types
 - The governor
 - Overspeed trip
- Diesel engines
 - Foundations
 - Torsional vibrations
- Quiz
- Course Evaluation
- Presentation of certificates