NUCLEAR TRAINING CENTRE

COURSE PI 30.1

5605N313

NUCLEAR TRAINING COURSE

COURSE PI 30.1

MECHANICAL EQUIPMENT

INDEX

430.10-0 Identification and Coding of Mechanical Equipment

The trainee will:

1. State how equipment is identified:

   (a) in field (by three (3) things)

   (b) on flow sheets (by two (2) things).

2. State colour codes for
   - Compressed Air
   - D_2O
   - H_2O
   - Steam
   - Oil

3. Draw symbols for
   - Centrifugal Pump
   - Recip. Pump
   - Heat Exchanger
   - Gate Valve
   - Safety Valve and Relief Valve
   - Compressors
   - Non-Return Valve
   - Globe Valve

430.10-1 Centrifugal Pumps

The trainee will:

1. Define:

   (a) suction lift
   (b) suction head
   (c) total (system head)

2. Label a simple schematic of a centrifugal pump, showing correct direction of impeller rotation, suction, discharge and fluids collector, (ie, *volute, or diffuser bowl*).

3. State six (6) basic features by which centrifugal pumps are classified and state options for each, ie, mount - vertical, horizontal, etc.

4. Be able to identify from a schematic or drawing:

   (a) type of mount
   (b) type of casing (ie, volute, diffuser bowl)
   (c) type of impeller
   (d) # stages
   (e) type of flow through the impeller
   (f) casing split

5. Compare efficiency, flow rate and, pressure at discharge for three (3) centrifugal pump impeller types.

6. Discuss causes, effects and symptoms of four (4) operational problems in centrifugal pumps; cavitation, air-locking, vapour-locking and loss of prime (lack of prime).

330.10-1 Centrifugal Pumps

The trainee will:

1. List those special design(s) which compensate for axial forces in centrifugal pumps.

2. List those special designs which compensate for radial forces in centrifugal pumps.

3. Explain briefly the operation of:

   (a) balance holes and wear rings
   (b) opposed impellers
   (c) balancing drum
   (d) balancing disc

   to compensate for axial forces in centrifugal pumps

4. Explain why a double suction impeller helps eliminate/alleviate cavitation.

430.10-2 Positive Displacement Pumps

The Trainee will:

1. Be able to name all eight (8) types of positive displacement pumps discussed in the text and know which ones are reciprocating or rotary.

2. State what is meant by:

   (a) double acting
   (b) single acting
   (c) duplex
   (d) triplex

3. Discuss causes, effects and symptoms of two (2) operational problems of positive displacement pumps.

   (a) cavitation
   (b) operation against blocked discharge (and necessity for pressure relief valve at discharge).

4. Compare centrifugal and positive displacement pumps with respect to:

   (a) principle of operation
   (b) how change in total head changes capacity
   (c) operation against a closed discharge and need for pressure relief valve
   (d) pressures and flow rates generated (capacities)
   (e) handled liquids
   (f) priming

5. Name one (1) type of pump which would offer "leak free" operation.

430.10-3 Compressors - Dynamic and Positive Displacement

The trainee will:

1. Name two (2) basic classes of compressors and compare their capacity, pressure and efficiency.

2. State that dynamic compressors are divided into two (2) types and name them.

3. Define "surge" and state in which type of compressors it occurs, ie, dynamic and/or positive displacement.

4. State characteristics (advantages; disadvantages) of reciprocating piston, diaphragm and screw compressors.

430.10-4 Air Systems

The trainee will:

1. For each of four (4) air systems in the NGD, state special requirements and kind(s) of compressor(s) used.

2. Draw and label a schematic of a typical air system.

3. Explain what compressor "unloading" is. State explicitly:

   (a) Is motor running during unloading?
   (b) Is air (gas) being compressed?
   (c) Is motor load reduced?
   (d) When is it used?

4. State why compressor "unloading" is used.

5. State the methods of compressor unloading used in NGD.

6. Explain what is meant by "automatic dual control" of compressors in the NGD. Name the two (2) modes of operation that are necessary.

230.11-1 Compressors

The trainee will:

1. Define:

   (a) capacity
   (b) volumetric efficiency
   (c) compression efficiency
   (d) compressor (shaft) efficiency

2. (a) Draw "Adiabatic" and "Isothermal" compression processes on a P-V diagram, both starting at some arbitrary point (V_o,P_o) and both terminating on the same isobaric line but at different points.

   (b) State that the compression work done in each case is represented by the area under the process curve.

3. For a two-stage reciprocating compressor, indicate on a P-V diagram that work savings due to:

   (a) water jacketing of LP cylinder
   (b) intercooler
   (c) water jacketing of HP cylinder

4. State some advantages of cooling, other than for work savings.

5. List three (3) or more "circumstances" or "sets of conditions" which would lead to explosions in a compressed air system.

430.10-5 Fans

The trainee will:

1. Name the two (2) basic types of fans and state the basic differences between them.

2. State which type of fan is used for air conditioning and ventilation systems with extensive ducting grids in large stations.

430.10-6 Vacuum Pumps

The trainee will:

1. State the two (2) basic classifications of vacuum pumps.

2. State the principle of operation of vapour vacuum pumps.

330.11-1 Heat Exchanges

The trainee will:

1. Be able to describe a typical shell and tube heat exchanger according to the following:

   (a) number of passes that tube fluid makes
   (b) type of tube bundle - straight; U shaped: coil

2. Briefly describe three (3) different "patterns of shell/tube flow" and two different "types of flow" possible in heat exchangers. State which combination is most efficient.

3. State which type of tube bundle is susceptible to contraction/expansion problems and state how they can be solved.

4. State two (2) functions of baffles in a heat exchanger.

430.12-1 Piping, Tubing and Joints

The trainee will:

1. State how to specify the size of a pipe and tube. State what N.S. and schedule # are and state how O.D., I.D. and wall thickness are given/found.

2. Compare pipes and tubes with respect to their distinguishing features:

   (a) variety of size available
   (b) tolerances
   (c) surface qualities
   (d) workability/bendability
   (e) cost

3. Name the various types of pipe joints and give the advantages and/or limitations specified in course notes:

   (a) permanent - welded
   (b) dismountable - flanged (welding neck); grayloc; victaulic

4. Name the dismountable pipe joint which is most commonly used in NGD for high pressures, and high temperatures. State why the victaulic joint is restricted to low temperatures.

5. Name the various types of dismountable tube joints and specify which one is most commonly preferred for use in NGD.

6. Name one (1) "zero leakage" (dismountable) pipe joint and one (1) "zero leakage" (dismountable) tube joint.

430.13-1 Valves

The trainee will:

1. State the (4) basic functions that valves perform in systems:

   (a) isolation
   (b) regulation
   (c) backflow prevention
   (d) pressure relief

   Give an example of a kind of valve used for each.

2. Name different types of stem seals. State the main advantage of a "bellows seal" in a valve.

3. State what functions a lantern ring serves in the stuffing box packing of a valve.

4. State what is meant by "zero leakage valve" and name two (2) types of "zero leakage" valves.

5. Compare gate valves and globe valves in respect to:

   (a) basic function (application)
   (b) pressure drop across valve when fully open
   (c) directionality (direction of fluid flow for various fluids)
   (d) flow pattern (changes in flow direction through the valve)

6. Be able to explain the reason for "double port" design in globe valves and "parallel slide disc" design in gate valves and state an application for each.

7. Compare "swing check" and "lift (piston) check" valves with respect to:

   (a) pressure drop across open valve
   (b) leakage in "backflow prevent mode"
   (c) use restrictions (horizontal, vertical)

8. Compare safety and relief valves with respect to:

   (a) type of fluid handled
   (b) valve action
   (c) amount of discharge
   (d) relative magnitude of opening and closing pressure

9. State, for the four (4) special valves listed below, which are used for isolation, control, or both isolation and control:

   (a) butterfly
   (b) ball
   (c) diaphragm
   (d) plug

10. State advantages of butterfly and ball valves over globe type valves.

430.14-1 Lubrication

The trainee will:

1. State the three (3) types (methods) of lubrication and indicate which one(s) have metal-to-metal contact; have an oil wedge.

2. Define each of the four (4) major properties of liquid lubricants:

   (a) viscosity
   (b) flashpoint
   (c) temperature stability
   (d) oiliness

3. Explain how viscosity varies with temperature, (ie, state the effect of temperature on viscosity).

430.14-2 Lubrication and Bearings - Unit I Bearings

The trainee will:

1. State the four (4) roles of bearings.

2. Be able to draw a classification tree of the major types and sub-types of bearings, and state whether each particular bearing is used for axial or radial support.

430.14-2 Lubrication and Bearings - Unit II Bearings

The trainee will:

1. State at least three (3) characteristics, for each of the three (3) methods of lubrication, ie, hydrodynamic, hydrostatic, boundary.

2. Be able to explain the concept of oil wedge lubrication as applied in radial and axial plain bearings.

3. State the types (methods) of lubrication in each of the two main types of bearings - plain and rolling element.

430.14-2 Lubrication and Bearings - Unit III Bearing Design

The trainee will:

1. With the aid of sketches, describe the construction of a tilting pad type bearing and explain briefly how lubrication is achieved at running speed. Name this type of lubrication.

2. State that tilting pad type bearings can be signed to compensate for radial loads or axial loads.

3. In Kingsbury (Mitchell) tilting pad axial thrust bearings, state whether the:

   (a) thrust collar
   (b) set (or sets) of tilting pads

   are

   (i) stationary (ie, fixed to housing or casing), or
   (ii) rotate with the shaft.

4. State that in Kingsbury (Mitchell) tilting pad axial thrust bearings, a rotating thrust collar may be in contact with a single set of tilting pads or it may be "sandwiched" between two sets of tilting pads.

230.12-1 Lubrication

The trainee will:

1. State the direction of viscosity increase from S.A.E. 20 to S.A.E. 50 (crankcase oils).

2. Define viscosity index (V.I.) of oils and state whether an oil with $V.I._{100}$ is more or less temperature stable than an oil with $V.I._{50}$.

3. State three (3) advantages of a continuous circulating lubricating oil system over a "once through" lubrication system.

430.15-1 Sealing Devices

The trainee will:

1. State the qualities desired in gasketing materials.

2. State the types of gasket materials which might be used for high temperature and high pressure; which structure and material would form a gasket for high temperature AND high pressure use.

3. Explain the effects of having I.D. of gasketing:

   (a) too small
   (b) too large

4. Explain the purpose of a lantern ring in a pump stuffing box.

5. Explain the operation of a mechanical seal with the aid of a simple sketch.

330.14-1 Axial Mechanical Seals

The trainee will:

1. State advantages and disadvantages of mechanical seals as compared to packings with respect to the following:

   (a) long or short downtime to replace
   (b) cost
   (c) ease of installation
   (d) degree of failure (partial or total)
   (e) care required during handling and installation
   (f) lifetime
   (g) leakage control
   (h) friction (comparative magnitude)
   (i) shaft wear

330.13-1 Shaft Couplings

The trainee will:

1. Sketch or describe the types of shaft misalignments:

   (a) angular offset
   (b) parallel offset

2. Briefly explain each of the items in the simple motor/pump alignment procedure given below:

   (a) align motor to fixed pump (not vice-versa)
   (b) check shaft and coupling "run-out"
   (c) eliminate end-float
   (d) rough initial alignment
   (e) measurement of "parallel offset" and "angular offset" by taking "face" and "periphery" readings, 90° apart
   (f) correction in vertical plane and horizontal plane
   (g) check

3. State what functions the following perform in a motor/pump alignment procedure:

   (a) dial indicator
   (b) spreader mechanism

4. Name the two (2) basic types of couplings and know what degree of misalignment each can absorb.

5. List characteristics of rigid and also of flexible couplings with reference to:

   (a) torques transferred (large, medium, small)
   (b) necessity of lubrication of this drive component
   (c) speed limitation (high, medium, low)
   (d) driver/driven shaft (axis) orientation
   (e) positive drive or slip
   (f) R.P.M. change possible driver/driven or not

230.13-2 Belt Drives

The trainee will:

1. List characteristics of V-belt drives with reference to:

   (a) torques transferred (large, medium, small)
   (b) necessity of lubrication of this drive component
   (c) speed limitation (high, medium, low)
   (d) driver/driven shaft (axis) orientation
   (e) positive drive or slip
   (f) R.P.M. change possible driver/driven or not

2. List the items that should be checked during a routine inspection of a multiple V-belt drive of a compressor.

230.13-3 Chain Drives

The trainee will:

1. List characteristics of this type of drive with respect to:

   (a) torques transferred (large, medium, small)
   (b) necessity of lubrication of this drive component
   (c) speed limitation (high, medium, low)
   (d) driver/driven shaft (axis) orientation
   (e) positive drive or slip
   (f) R.P.M. change possible driver/driven or not

230.13-4 Gears and Gearing

The trainee will:

1. List the characteristics of this type of drive with reference to:

   (a) torques transferred (large, medium, small)
   (b) necessity of lubrication of this drive component
   (c) speed limitation (high, medium, low)
   (d) driver/driven or shaft (axis) orientation
   (e) positive drive or slip
   (f) R.P.M. change possible driver/driven or not

230.16-1 Gas Turbines

The trainee will:

1. State the type of dynamic compressor used in the gas turbines of the standby generators in NGD.

2. Explain what is meant by "surging" and "stalling".

3. Given a schematic of a gas turbine generator system used in NGD label the diagram fully to include:

   (a) DC starter motor
   (b) multi-stage axial compressor
   (c) combustion chambers including fuel nozzle, igniter
   (d) two stage compressor turbine
   (e) one stage power turbine
   (f) reduction gear
   (g) standby generator
   (h) compressor outlet pressure ≈ 500 kPa
   (i) combustion chamber exhaust temp ≈ 600°C
   (j) free power turbine - operating speed 7200 RPM
                         - exhaust temp ≈ 450°C
   (k) standby generator operating speed 1800 R.P.M.

4. State the effect of the following on a gas turbine's output:

   (a) inlet ambient air temperature
   (b) inlet air pressure
   (c) build-up of combustion products on rotor/stator blades and other interior surfaces.