NUCLEAR TRAINING DEPARTMENT
COURSE PI34

NUCLEAR TRAINING COURSE # PI34

TIMS # PI3004

NUCLEAR TRAINING COURSE

COURSE PI-34

TURBINE & AUXILIARIES

INDEX

Turbine & Auxiliaries - Course PI 34

OBJECTIVES

Following the completion of this course the trainee will be able to:

334.00-1 The Steam Turbine

1. Identify and state the functions of the turbine:

   a) casing;
   b) rotor;
   c) shaft;
   d) blade wheel;
   e) diaphragm;
   f) nozzle;
   g) fixed blades;
   h) moving blades.

2. State the definition of a turbine stage.

3. Explain the difference between an impulse and a reaction turbine.

4. Explain the difference between double flow turbines and single flow turbines and explain the advantages of a double flow turbine.

5. Draw the pressure and velocity changes across the fixed and moving blades of a reaction and an impulse turbine.

6. State the purpose of a nozzle.

7. Explain why turbines usually have several stages.

8. Explain the relative advantages and disadvantages of the two types of turbine blading with respect to:

   a) stage efficiency;
   b) velocity ratio;
   c) moisture effects;
   d) axial thrust.

9. Explain the effect of steam flow on the pressure gradient through a large turbine.

234.00-1 Turbine Construction

1. Explain how moisture is removed from the steam in the steam system and turbine by each of the following:

   a) moisture separator;
   b) reheater;
   c) extraction steam;
   d) auxiliary moisture separators;
   e) water extraction grooves;
   f) turbine stage drains;
   g) steam piping design.

2. Explain the adverse effects of moisture in the steam passing through a turbine.

3. Explain how the following are utilized to reduce the adverse effects of moisture:

   a) stage type;
   b) shroudless moving blades;
   c) erosion shields.

4. Explain how steam expansion is compensated for in a large turbine unit.

5. Explain how axial thrust is handled or minimized.

6. Explain how the following compensate for axial differential expansion:

   a) blade clearance;
   b) double casing;
   c) carrier ring;
   d) drum rotor;
   e) heatup rate.

7. Explain how the following minimize thermal stresses:

   a) double casing;
   b) carrier rings;
   c) drum rotor;
   d) expansion loops;
   e) expansion joints.

8. Explain how the turbine unit at your station handles the following:

   a) moisture;
   b) axial thrust;
   c) steam expansion;
   d) differential axial expansion;
   e) thermal stresses in casing, rotor and steam piping.

334.00-3 The Steam System

1. Given a schematic diagram of a typical steam system label the following components:

   a) steam generator;
   b) safety valves;
   c) steam reject valves;
   d) balance header;
   e) steam isolating valve (boiler stop valve);
   f) emergency stop valve;
   g) governor steam valve;
   h) high pressure turbine;
   i) moisture separator;
   j) reheater;
   k) intercept valves;
   l) release valves;
   m) low pressure turbines
   n) reheat emergency stop valve (if applicable);
   o) exhausts to the condenser;
   p) main steam strainers.

2. List the major functions of each of the components in 1 and explain the basic construction of each component.

3. Explain how turbine speed is controlled after connecting the generator to the grid.

4. Explain the consequences of a failure of each valve listed below (consider for each valve two cases: the valve fails to the open position and will not shut; the valve fails to the shut position and will not open):

   a) steam generator safety valve;
   b) steam reject valve;
   c) emergency stop valve;
   d) governor steam valve;
   e) intercept valve (with/without) RESV;
   f) release valve.

5. Explain the essential difference between a safety valve and relief valve.

234.00-2 Steam Control To The Turbine

1. Explain how the steam control valves respond the the following:

   a) reactor trip;
   b) turbine trip;
   c) load rejection;
   d) normal startup and loading.

2. Explain how steam generator pressure is related to heat transport system temperature and power level.

3. Explain "poison prevent" operation including:

   a) when is it used?
   b) why is it necessary?
   c) where does the steam go?
   d) how long can it be maintained?

4. Explain how the Emergency Stop Valve and Governor Steam Valve are used to control steam to the turbine on a unit start-up.

5. Explain why the closure of the Emergency Stop Valve alone cannot guarantee the safety of the turbine on a fault condition.

6. Explain the difference between the following:

   a) steam release valve;
   b) reheater blow-off valve;
   c) reheater bursting disc.

7. Explain the advantages of dumping steam to atmosphere, a reject condenser or to the main condenser when the turbine is not available.

8. Discuss in writing the functions of extraction steam check valves including:

   a) why they are air motor assisted;
   b) why they are put on HP extraction lines;
   c) why they are put on LP extraction lines;
   d) why they are installed on the extraction steam lines to the deaerator;
   e) why some LP extraction lines don't have them.

334.00-7 The Condenser

1. State the major functions of the main condenser.

2. Identify and state the function of the following condenser components:

   a) inlet and outlet water box;
   b) air ejector suction;
   c) steam heating lanes;
   d) turbine exhaust;
   e) hotwell;
   f) sagging plates;
   g) tubes;
   h) shell;
   i) tube sheets;
   j) stay bars.

3. Explain why modern condensers have an expansion piece fabricated into the condenser shell.

4. Explain why air must be removed from the condenser.

5. Explain the operation of a steam jet air ejector.

6. Explain what a hogging ejector is and when it is used.

7. Explain the operation of an air extraction vacuum pump.

8. State the function and operation of the following condenser cooling water system components:

   a) course screen;
   b) band screen;
   c) chlorine injection.

9. State the possible causes of a loss or decrease of condenser vacuum.

10. Explain the effect of the season of the year on condenser vacuum.

11. State what parts of the turbine and condenser must be evacuated prior to startup.

12. Explain the method of drawing and maintaining a vacuum in the condenser.

13. For the CCW system, state:

   a) the maximum outflow temperature and _T allowed;
   b) the reason for these limits.

PI 25-6 The Mollier Diagram and the Turbine Processes

1. Sketch a Mollier diagram from memory. Label the following on your sketch:

   (a) constant enthalpy lines
   (b) constant entropy lines
   (c) saturation line
   (d) constant temperature lines
   (e) constant pressure lines
   (f) constant moisture content lines
   (g) constant degree of superheat lines

2. On the sketch of a Mollier diagram that you have drawn, illustrate these turbine processes:

   (a) expansion in the high pressure turbine
   (b) moisture separation
   (c) reheat
   (d) expansion in the low pressure turbine

3. Explain how moisture separation and reheat each:

   (a) increase the enthalpy of the steam at the LP turbine inlet
   (b) reduce the moisture content of the steam at the LP turbine outlet

4. Define throttling and, using a Mollier diagram, explain how throttling of the steam supplied to the turbine affects:

   (a) the pressure, temperature and moisture content of the steam at the turbine inlet
   (b) the amount of heat which can be converted into mechanical energy by the turbine.

334.00-8 Feedwater Heating Systemm - I

1. State the reasons why feedheating is necessary.

2. Given a sectional diagram of a feedheater, identify and give the function of the:

   a) extraction steam inlet;
   b) vent;
   c) tubes;
   d) baffles;
   e) drain outlet;
   f) feedwater inlet;
   g) feedwater outlet;
   h) shell.

3. Explain how the deaerator operates to heat feedwater and remove air.

4. Explain why feedheaters are vented to the condenser.

5. Explain why the deaerator has electric heaters.

334.00-9 Feedwater Heating System - II

1. List the sources of heating in a typical feedwater system and discuss in which components these sources are used.

2. For each feedheating system heat exchanger listed below, explain the source of heat energy:

   a) stator water cooler;
   b) gland exhaust condenser;
   c) air ejector condenser;
   d) drain cooler;
   e) low pressure feedheater;
   f) deaerator - storage tank;
   g) high pressure feedheater;
   h) preheater.

3. Explain why heat rejected to the generator hydrogen or stator water cooling systems can not be used to heat feedwater.

4. Explain why the deaerator - storage tank has three sources of heat energy.

234.00-7 Feedwater Control and Operation

1. Explain the operation and control of the following valves:

   a) feedwater regulating valve;
   b) deaerator storage tank level control valves;
   c) normal makeup valve;
   d) emergency makeup valve;
   e) condensate extraction pump recirculation control valve;
   f) boiler feed pump recirculation valve.

2. State and explain the sequence of events which occur in the feedwater system on an increase or decrease in power level including:

   a) level in steam generators;
   b) feedwater regulating valve;
   c) deaerator storage tank valve;
   d) deaerator storage tank level control valves;
   e) hotwell level;
   f) makeup valves;
   g) pump requirements;
   h) extraction steam flow;

3. Given a line diagram of a typical feedwater system label the following:

   a) condenser hotwell(s);
   b) condensate extraction pumps;
   c) condensate recirculation line;
   d) makeup water connections;
   e) gland exhaust condenser;
   f) air ejector condenser (if applicable);
   g) stator water cooling heat exchanger (if applicable);
   h) drain coolers;

i) LP feedheaters;
j) deaerator storage tank control valves;
k) deaerator;
l) boiler feedpump;
m) feedpump recirculation line;
n) HP feedheaters;
o) preheater (if applicable);
p) steam generators;
q) feedwater control valves;
r) extraction steam connections;
s) main steam connections;
t) feedheater drains;

4. Explain what is meant by a "cascading feedheating system".

5. Explain th reason for parallel arrangement of feedheaters and duplication of pumps and control valves.

6. Explain how extraction steam flow to a feedheater is self-regulating.

7. Explain the need for and method of level control in a feedheater.

8. List and briefly decsribe three effects of scale forming substances entering the secondary side of a steam generator.

9. List three main sources of scale forming substances in the secondary side of a steam generator. Briefly describe how each is a contributor to scale.

10. State the reason the feed system pH is kept at 8.8 - 9.2 which is lower than optimum for steel.

11. Briefly describe the harmful effects of Chloride; Oxygen; Ammonia; Carbon Dioxide in the feed system.

12. Define carryover, briefly describe two types.

13. State where and why the following would be added to a secondary heat transport system

    a) Morpholine
    b) Hydrazine (2 reasons)
    c) Cyclohexylamine

14. Briefly describe the purpose of blowdown for the steam generator.

15. Briefly describe using either written explanation or diagram, the difference between intermittent and continuous blowdown.

PI 25-7 Efficiency of the CANDU Turbine Cycle

1. (a) Explain how the thermal efficiency of the CANDU turbine cycle can be improved by raising boiler pressure.

   (b) State the main limitation on the improvement in (a).

2. (a) Explain how the thermal efficiency of the CANDU turbine cycle can be improved by lowering condenser pressure.

   (b) State two limitations on the improvement in (a).

3. (a) Explain how the thermal efficiency of the CANDU turbine cycle can be improved by superheating in the boiler.

   (b) State the main limitation on the improvement in (a).

4. (a) Explain how the thermal efficiency of the CANDU turbine cycle can be improved by:

      (i) reheating between the high and low pressure turbines

      (ii) using extraction steam for feedheating.

   (b) State the main limitation on each improvement in (a).

   (c) State two practical benefits of each improvement in (a).

5. (a) Explain how the thermal efficiency of the CANDU turbine cycle can be improved by moisture separation.

   (b) State the practical benefit of moisture separation.

234.00-3 Steam Valve Hydraulic Control

1. Define "dead time" and "reservoir effect".

2. Explain the advantages of Fire Resistant Fluid over turbine lubricating oil as a hydraulic fluid for steam operators.

3. Explain why a hydraulic fluid is used for governor steam valve actuation.

4. Explain the problems associated with an FRF control system.

5. Discuss the need for fluid purity and cleanliness in an FRF Control System.

234.00-4 Governor Operation

1. Explain the functions of the turbine governor.

2 Explain the control of turbine speed:

   a) on startup below operating speed;
   b) on startup at operating speed but not connected to the hydro grid;
   c) when connected to the hydro grid.

3. Explain what is meant by "speed droop", why it is built into a governor system and how it aids the stability of a generator operating in parallel with other generators.

4. Explain how the active power (real power) out of a generator is increased, for a large turbine/generator supplying the Ontario Grid System.

5. Explain how the speed of a turbine is varied when the generator is not connected to the grid.

234.00-5 Turbine Governors

1. Explain how the governor and steam control valves on the turbine at your station respond to a load rejection.

2. For a mechanical hydraulic governor, explain the sequence of events on an overspeed following a load rejection including the operation of the:

   a) electric anticipator;
   b) main governor;
   c) auxiliary gear;
   d) speeder gear;
   e) emergency trip plunger.

3. Explain the advantages on an electrical hydraulic governor over a mechanical hydraulic governor.

4. Explain the function of the load limiter.

334.00-10 The Lubricating Oil System

1. Explain the purpose of and state when the following pumps and components are used:

   a) main lube oil pump;
   b) auxiliary lube oil pump;
   c) dc emergency lube oil pump;
   d) turning gear lube oil pump;
   e) jacking oil pump;
   f) the lube oil purifier.

2. Explain why control oil is at a higher pressure than bearing oil.

3. Discuss the lube oil system including the purpose of:

   a) pumps;
   b) strainers;
   c) filter;
   d) purifier;
   e) coolers;
   f) pressure reducing valve.

334.00-11 The Turning Gear

1. Define "shaft hog" and "shaft sag". Explain how and why each of these occur and what can be done to avoid these conditions.

2. State and explain the sequence of events prior to starting the turning gear motor.

3. Explain why the turning gear operates at 10-30 rpm rather than some lower speed (say 3-4rpm).

4. Explain how the turning gear and jacking oil pump are controlled on a unit startup and shutdown.

234.00-6 Turbine Operational Problems

1. Discuss the factors affecting the severity of the following operational problems. Include in your discussion the possible consequences and the design and operational considerations which minimize their frequency or effect:

   a) overspeed;
   b) motoring;
   c) low condenser vacuum;
   d) water induction;
   e) moisture carryover;
   f) blade failure;
   g) expansion bellows failure;
   h) bearing failure.

234.00-8 Factors Limiting Startup and Rates of Loading

1. Explain the reasons for each of the following:

   a) COLD, WARM and HOT start up procedures;
   b) block load on synchronizing;
   c) limitation on rates of loading;
   d) HOLD and TRIP turbine supervisory parameters.

2. Discuss the factors which limit the rate at which a large steam turbine may be starter and loaded including:

   a) steam pressure;
   b) draining steam piping and turbine;
   c) condenser vacuum;
   d) thermal stresses in casing and rotor;
   e) differential expansion between casing and rotor;
   f) lube oil temperature;
   g) generator motor temperature;
   h) shaft eccentricity;
   i) vibration;
   j) critical speeds.

334.00-13 Ontario Hydro Nuclear Turbine Units

1. Classify a cross-sectional view of a turbine as to:

   a) number of HP and LP turbines;
   b) single or double flow turbines;
   c) type of compounding;
   d) moisture separators;
   e) reheaters.

2. Classify the turbine unit for your station using the twelve point classification system. You will be able to explain what is meant by each item. (Those who are not assigned to a generating station will be able to classify the Pickering Unit as it is more typical of large units).