# PALO VERDE
# NUCLEAR GENERATING STATION

## Mechanical Maintenance Training
## Heat Exchanger Inspection and Cleaning
## Classroom Lesson

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|---|---|
| **Mechanical Maintenance Training** | **Date: 11/1/2011 4:59:33 PM** |
| **LP Number: NMD40C000204** | **Rev Author: MARK TAGUE** |
| **Title: Heat Exchanger Inspection and Cleaning** | **Technical Review:**<br>Hankins, Charles W(Z41411)<br>Digitally signed by Hankins, Charles W(Z41411)<br>DN: cn=Hankins, Charles W(Z41411)<br>Reason: I have reviewed this document<br>Date: 2011.11.02 13:32:39 -07'00' |
| **Duration : 5 HOURS** | **Teaching Approval:**<br>Baker Sr, Lee E(Z07641)<br>Digitally signed by Baker Sr, Lee E(Z07641)<br>DN: cn=Baker Sr, Lee E(Z07641)<br>Reason: I am approving this document<br>Date: 2011.11.03 07:00:36 -07'00' |

**INITIATING DOCUMENTS**

Task Analysis of Tasks

**REQUIRED TOPICS**

None

**CONTENT REFERENCES**

Handbook of Heat Transfer, edited by Warren M. Rohsenow & James P. Hartnett, 1973, McGraw-Hill, NY, NY.

Heat Exchangers: Design and Theory Sourcebook, edited by N.H. Afgan & E. U. Schunder, 1979, McGraw-Hill, NY, NY.

Heat Exchanger Introduction, 1993, Williams Learning Network, Rockville, Maryland

PM Task #082115, 082116, 082128 (Heat Exchanger PMs)

VTM-W120-0001

VTM-C431-0001

TCSAI 2740095 Include more specific info in lesson plan supporting review questions.

**REVISION COMMENTS**

| | | |
|---|---|---|
| Nov 01, 2011 | Mark Tague | CRAI 3585615 to add system tie-in of Main Heat exchangers and Nuclear safety impacts. |

Tasks and Topics Covered

The following tasks are covered in Heat Exchanger Inspection and Cleaning :

| Task or Topic Number* | Task Statement |
|---|---|
| Lesson: | Heat Exchanger Inspection and Cleaning |
| HXCH001 | Maintain Heat Exchangers |

Total task or topics: 1

## TERMINAL OBJECTIVE:

1 Given a maintenance activity involving Heat Exchangers the Plant Mechanic will , state the steps necessary to clean and inspect heat exchangers as demonstrated by achieving a minimum score of 80% on a written examination.

1.1 State the Reasons for Cleaning and Inspecting heat exchangers.

1.2 Describe the processes used to mechanically clean heat exchanger tubes.

1.3 Describe the basic process used to chemically clean heat exchanger tubes.

1.4 Describe the processes used to perform on line cleaning of heat exchanger tubes.

1.5 Describe the processes used to clean heat exchanger shells.

1.6 Identify the cleaning methods used on the Main Condensers, MSR's and Feedwater Heaters at PVNGS.

1.7 Describe the general inspection procedures for the Moisture Separator/Reheaters.

1.8 Describe the general inspection procedures for the Main Condensers.

1.9 Describe the general inspection procedures for the Feedwater Heaters.

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| I. Motivation | Focus student attention on "What's In It For Me". |
| II. Pre-Job Brief | |
| A. Pre-job briefing on the day's activities modeling the use of the ***Palo Verde Standards & Expectations, Preventing Events*** | |
| B. Focus On Five (Task Preview)<br>Familiarize worker with the scope of work, task sequence, and critical steps. | |
| 1. Critical Steps (Terminal Objectives)<br>Given a maintenance activity involving Heat Exchangers the Plant Mechanic will state the steps necessary to clean and inspect heat exchangers as demonstrated by achieving a minimum score of 80% on a written examination | PVNGS Standards & Expectation book (Focus on five) Highlight the critical steps (Terminal Objectives) on the power point presentation. |
| 2. Identify error likely situations (error traps)<br>a. Discuss at least one specific error likely situation. | ( Look at Error Precursors in S&E book) |
| 3. Identify the Worst thing that can happen. | Apply to the setting you're in. (Lab versus Classroom) |
| 4. Identify specific error prevention defenses to be used. | What defenses can we employ to prevent the "Worst thing that could happen" |
| 5. Identify actions to assure proper configuration control. | This may not be applicable in every training setting. |
| C. Break policy | |
| 1. Two Minute Drill - After lunch at a minimum | At Instructor's discretion, not to interrupt class flow. |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| III. Lesson Enabling Objectives | Read and/or discuss the lesson objectives |
| EO01 State the reasons for cleaning and inspecting heat exchangers. | |
| EO02 Describe the processes used to mechanically clean heat exchanger tubes. | |
| EO03 Describe the basic process used to chemically clean heat exchanger tubes. | |
| EO04 Describe the processes used to perform on-line cleaning of heat exchanger tubes. | |
| EO05 Describe the processes used to clean heat exchanger shells. | |
| EO06 Identify the cleaning methods used on the Main Condensers, MSR's and Feedwater Heaters at PVNGS. | |
| EO07 Describe the general inspection procedures for the Moisture Separator/Reheaters. | |
| EO08 Describe the general inspection procedures for the Main Condensers. | |
| EO09 Describe the general inspection procedures for the Feedwater Heaters. | |

**TO: 1 Given a maintenance activity involving Heat Exchangers the Plant Mechanic will , state the steps necessary to clean and inspect heat exchangers as demonstrated by achieving a minimum score of 80% on a written examination.**

**EO: 1.1 State the Reasons for Cleaning and Inspecting heat exchangers.**

**Main Idea**

| CONTENT | METHODS & ACTIVITIES |
|---|---|

I. Maintain the operating efficiency of the condensers, MSR's, Feedwater heaters and auxiliary heat exchangers

   A. The heat transfer capabilities of the heat exchanger are calculated and designed with the tubes clean and free of scale, debris or plant growth

   B. The removal of scale from the heat exchanger will increase the heat transfer and make it more efficient

   C. Manufacturers calculate the operation of their heat exchangers based on a certain amount of fouling

      1. Fouling reduces the operational efficiency of the heat exchanger

      2. Efficiency is maintained by keeping the amount of scale and fouling to a minimum

II. Minimize the potential for corrosion of the tube materials due to chemical and electrolytic effects and processes

   A. Palo Verde uses all volatile chemistry to control the chemistry of the feedwater and the primary coolant

      1. This is to minimize the potential of scale buildup in the condensers and to minimize solids buildup in the steam generator

      2. The chemistry control also aids in minimizing the amount of corrosion of the heat exchanger construction materials

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| 3. What volatile chemistry control is:<br>a. VOLATILE chemicals boil off in the Steam Generator and condense in the Condenser<br>b. These chemicals are in a liquid state in the feed and condensate system<br>c. Are not as susceptible to plating out on the heat exchanger tube surfaces like "solid" chemistry control does | |
| B. Inspection for loose or damaged structural components minimizes the possibility of further damage | |
| 1. An extraction steam baffle's weld cracked and the baffle fell inside a high pressure feedwater heater, **rupturing fourteen tubes**<br>a. This required reducing power and securing the feedwater train to allow access to plug the damaged tubes and make weld repairs to the baffle<br>b. If the cracks had been discovered during a scheduled outage, hundreds of thousands of dollars could have been saved and the Unit's capacity factor would have been higher | Operating Experience |
| 2. MSR impingement screen failures have been identified during refueling outages in all three units<br>a. Early detection has prevented further damage<br>b. Minimized the cost of repairs | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| III. Cleaning precautions | |
| A. There are various safety precautions for cleaning heat exchangers | *This entire section [A.] is from the SME Prevent Events review* |
| 1. Permits/tagging | Ask them to identify tools they would use |
| a. Ensure the permit will isolate, drain, and vent | Prejob? Peer checking? |
| b. Ensure it is isolating the correct side or both sides if necessary | 2 minute drill? Procedure/tech manual? |
| 1) We need to ensure the heat exchanger is isolated from the system prior to chemical cleaning as the chemicals are not compatible with the process (system) fluids. | |
| c. This occurred at a plant where the wrong side was isolated | Review previous events? |
| During U2 plant startup on 7/31/03, personnel became overheated while working in the 2A condenser waterbox. | Operating Experience |
| Reactor power was being increased from 2 to 11% with SBCS Valve 1001 in service. This valve discharges to the "A" Condenser shell. | |
| Work group discussed conditions with Control Room, and steam load was shifted to a different SBCS valve (not discharging to 'A' Condenser). | |
| **What happened?** | |
| Personnel were put in danger by the lack of use of the established tagging and permit procedure. | |
| **Why did it happen?** | |
| This happened because this is the way that this had been done in the past and communications were not . | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|

**Can it happen at PVNGS?**

It did happen here and yes it probably can happen again.

**What can we do to mitigate an event if it does occur?**

Ensure that permit prevents steam from being introduced to the affected condenser and that everyone involved has verified that the component is in a safe condition to work.

1. Beware of changing plant conditions

   Communication with Operations may prevent events from happening if workers are made aware potential condition changes.

   a. Isolations have been known to leak

   b. Changing plant evolutions can put pressure on isolations where there was no pressure before

2. Confined spaces make the egress more difficult.

   Use Peer checking, 2-minute drill and Pre-job brief to identify hazards.

3. Confined space permit

   a. Many heat exchangers require them

   b. Ensure adequate ventilation and monitoring

| CONTENT | METHODS & ACTIVITIES |
|---|---|

4. Scaffolding/climbing hazards

   Use a Hazard Assessment to identify issues that might be of concern regarding Safety.

   a. Often the internals of a heat exchanger is slippery

   b. Erected scaffolding can be wet and slippery also

   c. Take fall precautions and precautions when moving around to preclude injury from slipping

B. Do not attempt to clean tubes by blowing them out with steam

   1. This could result in severe expansion of the tube and leakage at the tube to tubesheet joint

C. If the heat exchanger normally handles flammable materials do not use air to blow out the tubes

D. When mechanically cleaning the tubes do not use any method that will cause scraping, scarring or cutting of the metal of the tubes

   1. This precaution applies for both the internal and external surfaces of the tubes

**EO: 1.2 Describe the processes used to mechanically clean heat exchanger tubes.**

**Main Idea**

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| I. General information | |
| A. Mechanical cleaning is the most common cleaning method | |
| B. Done under shut down conditions when the condenser/heat exchanger is open for service and the tubesheet is accessible | |
| 1. Remember permit requirements<br><br>Use Self Check/ Peer Check to verify permit is in place and adequate. | |
| 2. Remember confined space requirements<br><br>Focus on Five- Are you qualified for confined space entry? | Ask them to identify a tool they would use |
| C. Abrasive methods of tube cleaning should be avoided to minimize the potential for damage to the tube surface | |
| II. Tube lancing with pressure systems | TO05 |
| A. Uses water or air pressure to drive brushes or plugs through the tube | |
| 1. Brushes scrub accumulation of material from the surfaces | |
| 2. Rubber plugs are used to remove loose slime from the tubes | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| 3. Metal plugs are used to attack hardened coatings and scale | |
| a. Care must be used with metal plugs to ensure that they do not score the tubes | |
| b. Most manufacturers do not recommend using metal plugs | |
| c. Recommended method for cleaning high levels of scale is usually chemical cleaning | |
| 4. Safety Concerns | SME identified Prevent Events tool |
| a. When air blowing, sagging tubes, when plugged, can build pressure and cause water to be shot back when air gun is released<br><br>Use Two- Minute Drill and Peer and self-checking. | |
| b. Water and air pressure can blow back on you if the tube has restrictions | |
| c. Stand clear of potential water shooting out | |
| d. Good practice to use a 2nd person and have communications set up between them to determine if tubes are plugged | |
| e. Person on other end needs to remember his tube sheet is a mirror image of the other tube sheet during communications | |
| f. Must stay clear of pressure/objects being ejected from the other end | |
| g. This needs to be part of the pre-job briefing – how to communicate & use of 3-way communications | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| B. Plugs are driven through to remove scale and other growth as needed<br>1. Care should be used to ensure plugs do not get stuck in the tubes<br>2. Tubes should be flushed after plugs are driven through<br>3. Accounting for all brushes/cleaners before and after the job ensures none are left behind | At one power plant after an outage, the plant started up and as they increased power one condenser's vacuum was low and started getting worse. After several checks, they reduced power, tagged out the condenser water boxes and went in for an inspection. They found approximately 20% of the tubes plugged with brushes left behind from tube lancing operations. |
| C. The use of tube lancing may not be effective for U-tube heat exchangers<br>1. The probability of getting a plug stuck is very high due to the turning of the tube | |
| III. The Hydro-Lazer pump, high pressure hoses and lancing gun are used to drive cleaners through the tubes | |
| A. CAUTIONS: | |
| 1. Hydro-Lazer pumps generate very high pressures (up to 10,000 psig) | |
| 2. Remember the precaution about blowback on plugged tubes. | P/E Tools<br>Communicate hazards that may develop with your co-workers. |
| B. If this pressure is directed toward unprotected skin it can cause severe damage. | |
| 1. Protect yourself and others from hazards you may be creating while performing work. | |
| C. Protective equipment including gloves and faceshield shall be worn when using this equipment | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|

IV. Water lancing

A. Tubes can be water lanced if fouling is minimal

B. Done by shooting water through the tubes with no plugs

V. For short length tubes or smaller heat exchangers manual lancing may be performed

A. Long handled brushes may be used

1. Brushes can be driven through the tubes

2. Tubes should be flushed after using the brushes

VI. Power tube cleaning equipment

A. Some manufacturers produce power tube cleaning equipment

B. Cleaning brushes are driven in a rotary motion by a flexible shaft inside a protection sleeve (similar to a speedometer cable) called a whip

C. The whip is driven by an air motor that may be mounted in a case containing the motor, air and water regulators and gauges

D. Water is fed through the drive shaft sleeve to provide cooling and lubrication to the whip and provides flushing for the brush on some models

**EO: 1.3 Describe the basic process used to chemically clean heat exchanger tubes.**

**Main Idea**

| CONTENT | METHODS & ACTIVITIES |
|---|---|

I. General Information

A. Purpose

1. Clean areas that are not easily accessible or are totally inaccessible

2. Dissolve some types of scale easier than mechanical cleaning

B. Chemical cleaning of heat exchanger tubes can be accomplished in a shutdown mode

C. Chemicals used should be compatible with the materials of construction to minimize any chemical reactions between heat exchanger materials and cleaning compounds

D. Heat exchanger should be completely flushed after cleaning process is complete

1. Remove any residual chemicals that could contribute to tube wear

2. Avoid cross contamination of fluids in heat exchanger

E. If acids are used,

1. Neutralizers may be needed to stop the chemical reactions

2. Flush is then performed until samples meet the chemistry specifications

II. Some possible cleaning solutions may include

A. Hot alkaline solutions

1. Can be used to remove oily deposits

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| B. A weak inhibited acid solution | |
| 1. Used to remove calcium deposits or silica scale | |
| C. Circulating hot wash oil or light distillate | |
| 1. Circulate through tube side at high velocity | |
| 2. May be used to remove sludge or similar soft deposits | |
| D. Hot fresh water | |
| 1. Effective for removing soft salt deposits | |
| E. There are many commercial cleaning chemicals available | |
| 1. May have to be analyzed by consulting chemistry experts and manufacturer's representatives | |
| 2. Manufacturer's technical manual should be consulted to ensure that materials used are compatible with the materials of construction | **Example:** Ingersol-Rand tech manual lists Tri-Sodium Phosphate as the recommended chemical cleaner for the shell side and Oxalic acid for the tube side of the instrument air compressor intercooler |
| III. Basic steps for chemical cleaning of heat exchangers | |
| A. Determine chemicals to be used | |
| B. Engineering and Chemistry evaluate the chemicals to be used | |
| 1. Ensure they will not damage the materials of the heat exchanger | |
| 2. Ensure compatibility with the system | |
| C. Set up flushing equipment | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| 1. Use all safety equipment to prevent personnel injury.<br>STAR- Are you using all required PPE properly to protect you?<br>a. Face Shields<br>b. Gloves<br>c. Any other protective gear<br>2. Flushing gear is usually skid mounted<br>3. Mixing tanks<br>4. Auxiliary pumps hose connections<br>5. Heaters<br>6. Filters<br>D. Isolate the heat exchanger from the fluid systems<br>E. Perform a flush to remove any fluids that may react with the cleaning chemicals<br>F. Connect flushing equipment and introduce the chemicals<br>G. Perform the required operations for the cleaning process<br>1. Operate pumps or heating of the system, etc.<br>H. Remove the chemical solutions from the heat exchanger after the recommended cleaning time<br>I. Properly dispose of chemical solutions in accordance with plant procedures<br>J. Perform flushes of the heat exchanger to remove all traces of the cleaning chemicals<br>DO NOT pour chemicals down the floor drain!<br>1. Chemical tests may be performed to verify that all chemicals have been removed | Prevent Events tool |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| K. If cleaning is satisfactory the system may be restored and returned to service<br>1. If heat exchanger is highly scaled, several chemical cleaning cycles may be required<br>L. If chemical cleaning does not remove the scale, mechanical cleaning may be necessary | |

**EO: 1.4 Describe the processes used to perform on line cleaning of heat exchanger tubes.**

**Main Idea**

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| I. PVNGS has no on-line cleaning system for the condensers and heat exchangers | |
| II. Some plants have on-line cleaning systems to clean tubes due to the source of cooling that they have available to them | |
| A. Some plants use a sponge foam ball that is pushed through the tubes to clean them | PPT Slide #48 |
| 1. The balls are slightly larger than the diameter of the tubes and they scour the tubes as they are forced through during condenser operation | |
| 2. They are driven by the pressure differential across the condenser during operation | |
| 3. A strainer system catches the balls and returns them to the system for reentry into the condenser | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|

B. Another similar system uses brushes to do the same function

   1. A valve arrangement allows for the driving force of the brushes through the tubes

   2. The normal valve line-up has the brushes held in baskets at the end of the tubes

      a. The baskets are designed to minimize the pressure drop that they cause

   3. When the valve arrangement is changed the brushes are driven through the tubes

   4. The valve arrangement is then returned to normal

      a. The brushes are driven through the tubes a second time

      b. The normal valve line-up is needed for normal operations

      c. The piping to drive the brushes through the tubes is smaller than the normal piping

**EO: 1.5 Describe the processes used to clean heat exchanger shells.**

**Main Idea**

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| I. The necessity of cleaning the shell side of a heat exchanger depends on the fluid that passes through it. | |
| A. For example, the need to clean the shell side of the main condenser is determined by the quality of the steam that passes through | |
| 1. Usually high quality steam with a minimum amount of carryover from the steam generator | |
| 2. Potential for scale buildup is small | |
| B. Shell side of an oil cooler, that has oil on the shell side, can be chemically cleaned if the materials of construction will not be affected by the chemicals | |
| C. Remember, the shell side of the heat exchanger is often a confined space. | |
| Are you qualified for confined space entry? | |
| 1. Get proper permit | |
| Use Self Check/ Peer Check to ensure permit is active and adequate | |
| 2. Follow the permit | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| II. Abrasive (mechanical) cleaning methods for the shell side of a heat exchanger should not be used on the tube bundle | |
| III. Normally, non-abrasive methods are used on the tube bundles | |
| A. Chemical cleaning by soaking in chemical baths and flushing down after the soak to remove chemicals | |
| B. Pressure sprayers can be used to remove soft scales and sludge | |
| C. Steam cleaners can be used on certain heat exchanger tube bundles if structural strength of bundle is sufficient | |
| D. **Caution** – the high temperatures of steam cleaning can cause thermal expansion of the tube bundle and cause tubes to loosen from the tube sheet. | |

**EO: 1.6 Identify the cleaning methods used on the Main Condensers, MSR's and Feedwater Heaters at PVNGS.**

**Main Idea**

| CONTENT | METHODS & ACTIVITIES |
|---|---|

I. Main condenser cleaning methods

A. Tube side cleaning includes the water boxes and the tubes

1. Epoxy coating inside the water boxes minimizes cleaning required

2. General cleaning is done using buckets, brooms, dust pans, rags, etc.

3. Tube cleaning using the Hydro-Lazer to water lance the tubes and to lance the tubes using sponge plugs was performed during construction

4. System cleanliness has not required frequent tube cleaning since construction

B. Shell side (condensate) of the condenser should not require cleaning due to the quality of the steam the plant uses

1. We use volatile chemistry control in the steam generators which minimizes scale buildup

2. Shell side is a Zone IV and class “C” cleanliness; therefore during inspections and repairs, general cleaning may be required to maintain class cleanliness

a. Foreign Material Exclusion inspections are required prior to close out

II. MSR cleaning methods

A. The MSR technical manual does not have any recommended cleaning methods

| CONTENT | METHODS & ACTIVITIES |
|---|---|

B. Since the steam quality is high on both the tube and shell sides,

1. Same quality steam as Main Condenser shell side is on both sides

2. Scale formation has not been a problem

III. Feedwater Heater cleaning methods

A. Westinghouse tech manual recommends chemical analysis of scale formation to determine the type and strength of cleaners to use

B. They recommend using inhibited acid solutions and flushing equipment to clean both the tube and shell sides

**EO: 1.7 Describe the general inspection procedures for the Moisture Separator/Reheaters.**

**Main Idea**

| CONTENT | METHODS & ACTIVITIES |
|---|---|

I. General information

A. System Tie-in

1. There are numerous heat exchangers at PVNGS. Anything from small sample coolers and oil coolers to larger heat exchangers for major systems like Turbine Cooling Water, Nuclear Cooling Water and Essential Cooling Water.

   The four major heat exchangers being discussed in this course are the Moisture Separator Re-heater, Main Condenser, Low Pressure Feed water heater and High Pressure Feed water heater. We will focus our discussion on these four.

2. Steam comes from the Steam generators to spin the High Pressure (HP) Main Turbine.

   a. Exhaust steam from the HP turbine is directed to the 4 Moisture Separator Re-heaters (MSR) where moisture will be removed from the steam and it will be re-heated and used to drive the three low pressure turbines.

   b. In the MSR this HP exhaust steam hits baffles which allow the moisture to be separated from the steam. Since the water droplets are heavier than the steam, the droplets go to the bottom of the MSR and exit through drains to the condensate system.

   c. The HP Exhaust steam rises and passes over the first and second stage re-heat tube bundles.

      1) Steam going **THROUGH the TUBES** of the first stage reheat bundle comes from an extraction point on the HP turbine.

| CONTENT | METHODS & ACTIVITIES |
|---|---|

2) HP exhaust steam passing over the outside of these tubes causes the steam to be re-heated once.

d. The HP Exhaust steam then rises and passes over the second stage re-heat tube bundles which have Main Steam running **THROUGH the TUBES**, which is hotter than the first stage re-heat bundle.

1) HP exhaust steam passing over these tubes is heated to its final temperature and is then directed to the three Low Pressure (LP) turbines.

3. The steam leaving the MSR passes through the combined intercept valves to the LP turbines to turn them.

a. After the steam goes through the LP turbine it is exhausted to the condenser.

4. The Condenser is a very large heat exchanger that has several heat exchange processes going on at once.

a. The condenser tubes, located in the lower portion of the condenser, have Circulation Water (CW) passing through them which makes them comparatively cool.

1) This Circulation water then travels to the cooling towers to be cooled and reused.

b. LP exhaust steam passing over these tubes causes the steam to be cooled down and condensed back into water where it drops to the hotwell.

c. The water in the bottom of the condenser or “hotwell” is directed to the Condensate pumps.

| CONTENT | METHODS & ACTIVITIES |
|---|---|

d. Three vertical Condensate pumps located on the 100' turbine bldg. East end, pump the water to the LP feed water heaters which are located in the upper portion of the Condenser just above the condenser tubes.

1) There are 4 LP Feed water heaters in each condenser section, for a total of 12 heaters.

5. The LP feed water heaters have extraction steam from various points in the LP turbine passing through the shell side.

a. The water or condensate, passes through the tubes in the LP feed water heater.

b. The LP turbine extraction steam passing over these tubes pre-heats the condensate before directing it to the suction of the feed water pumps.

6. Water supplied to the Feed water pump suction comes mostly from the condensate system.

a. Feed water heater extraction steam and drains system supply the remainder of water through the Heater Drain Pumps.

7. The Feed water pumps pump the feed water to two trains of High Pressure (HP) feed water heaters.

a. There are three feed water heaters in each train for a total of 6 HP feed water heaters, located on the 140' Turbine Bldg. West end.

(5A, 6A, 7A & 5B, 6B,7B)

8. The HP Feed water heaters are tube and shell design.

a. The tubes in these heat exchangers are U-tube design with the feed water entering in the bottom half and exiting from the top half.

| CONTENT | METHODS & ACTIVITIES |
|---|---|

b. Extraction steam from the HP main turbine supplies steam to the shell side to bring the feed water to its final temperature before entering the steam generators.

1) Temperature of feed water entering HP heater #5 is about 348ºF and leaves HP heater #7 at about 449ºF.

B. Nuclear Safety aspects

1. The largest NUCLEAR safety impact comes from the HP and LP Feed water heaters.

a. Anything that changes the temperature of the feed water can have an effect on reactivity.

1) When working on or around an operating heat exchanger ensure that communications with OPS is clear and concise.

2) Understand the risk involved BEFORE taking an action that might affect reactivity.

b. As Craftsman that means we need to ensure any maintenance performed on the heat exchangers is performed correctly.

1) Ensuring all plugs are installed securely so they won't break loose during operation and cause damage.

2) Capturing devices are installed securely and correctly.

3) Ensure that before closing up the heat exchanger all tools and equipment are removed and that no Foreign Material exists.

II. OPS engineering, ISI, is responsible for performing the MSR inspections

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| A. Maintenance opens the MSR's and assists in the inspection process | |
| B. MSR tech manual has instructions for performing inspections including lists of items to be inspected | |
| III. Basic construction | PPT Slide #48 |
| A. MSR's are large horizontal cylindrical pressure vessels | |
| B. Moisture separating and steam reheating elements mounted inside the vessel | |
| C. Vessels are mounted in the crossaround piping system | |
| D. Supported by solid rod hangers sized to be strong enough to support vessels when fully flooded | |
| IV. Shell side inspection procedure | |
| A. Remove lower (rear and front) and top manways | |
| 1. Contact Ops engineering to perform inspection and assist as necessary | |
| 2. Ensure permits in place | SME Identified Prevent Events tool |
| a. Confined space permit<br><br>Is the permit complete and signed and are conditions established? | |
| b. Energy isolation tagging permit | |
| B. Rear manway inspections | |
| 1. Enter rear manway and inspect rear head, rear bulkhead and tube bundle U-turn sections | PPT Slide #49 |
| 2. Pass through the MSR outlet section access door and inspect moisture separator vane panels, bottom of tube bundle and front bulkhead | PPT Slide #50 |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| 3. Exit outlet section, enter inlet plenum access door and inspect moisture separator vane panels, impingement baffles(screens), inlet nozzles, shell, front and rear bulkheads | |
| 4. Open interstage access doors and inspect top of first stage and bottom of second stage tube bundles | |
| 5. Close access doors, exit lower manway | |
| C. Enter top manway. | |
| 1. Inspect top of second stage tube bundle, shell, outlet nozzles, front and rear bulkhead surfaces and tube bundle clearances | |
| 2. Exit top manway, | |
| D. Enter lower front manway | PPT Slide #51 |
| 1. Inspect front bulkhead, front head, convoluted piping and tube bundle headers | |
| E. Tube bundle manways are not always opened to inspect the pass partitions, tubesheets, tube to tubesheet welds and piping connections, unless deemed necessary | |
| F. Inspection methods include | |
| 1. Visual inspection, looking for signs of erosion, cracked welds, coatings, etc. | |
| 2. Ultrasonic testing of eroded areas to ensure sufficient thickness of material remains | |
| 3. Magnetic particle testing of pressure boundary welds if visual inspection reveals defects | |
| 4. Magnetic particle and/or dye penetrant testing is performed on structural welds | |
| 5. Record findings for required repairs and problem trending | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|

V. Tube side inspection and tests

A. Steam leakdown test

1. Performed during shutdown,
2. Steam is secured from the tube bundles and the steam pressure is monitored for 1 hour
3. Pressure should not decay away more than 50% during the test period
4. If the steam leakdown indicates a problem further tests and inspections are performed

B. Air pressure test

1. Performed if steam leakdown test fails
2. Work order is generated to conduct air pressure test
   a. Install calibrated test gauge, air hoses and valve at steam control panel for the MSR
   b. Pressurize bundle to 100 psig and snoop line connection for leaks
   c. Document pressure drop
   d. Restore by disconnecting test equipment

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| C. Inspection of tube side | |
| 1. Safety checks | SME Identified Prevent Events tool |
| a. Confined space permit<br><br>Focus on Five – Are you qualified to enter a confined space? Is/are your co-worker/s? | Ask them to identify a tool they would use |
| b. Tagging permit for the tube side | |
| 2. Tube bundle headers are accessed through the upper manways on the sides of the MSR | |
| a. Under the side 24” manways (MSR shell) are 14” by 18” elliptical manways (tube bundle header) | |
| b. The MSR’s come with manway removal tooling that attaches to the MSR and to the elliptical manway to allow removal | |
| c. Inspection of the tubesheet, pass partitions, tube to tubesheet welds and internal piping connections can be performed | |
| d. To inspect the return side of the tubesheet, the pass partition cover must be opened | |
| e. Special tools are available to open and hold open the pass partition cover | |
| 3. GE supplies an individual tube leak tester to check individual tubes to find leaks | |
| 4. The tube sheet welds are inspected for cracks and erosion | |

**EO: 1.8 Describe the general inspection procedures for the Main Condensers.**

**Main Idea**

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| I. General information | |
| A. Ops engineering (ISI) is responsible for performing the inspections | |
| B. Maintenance opens the condenser and assists in the inspection process | |
| II. Construction of the main condenser | PPT Slides #52 |
| A. Multi-pressure, single-pass, shell and straight-tube, reheat type heat exchanger | |
| B. Three similar, separate sections fed from the three LP turbines | |
| C. Floor supported | |
| D. Temperature and pressure are progressively higher in each section | |
| 1. Due to CW flowing through the sections in series | |
| III. General procedures for inspection of the steam side of the main condenser | |
| A. Ensure individual safety is secure | |
| Prevent Events – Use Self Check/ Peer Check | |
| 1. Permits | |
| 2. Scaffolding | Ask them to identify a tool they would use |
| 3. Condition of footing surfaces – slippery? | |
| B. Contact engineering and assist as necessary | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| C. Inspect condenser for loose or damaged baffles, loose structural members, signs of erosion, etc. | |
| D. Record findings for needed repairs and problem trending | Utilities routinely assist Engineering in this inspection. |
| IV. General procedure for tube side inspection of main condenser | PPT Slide #53 |
| A. Open quick opening manways to access the condenser water boxes | |
| B. Contact engineering to perform inspection and assist as necessary | |
| C. Safety concerns<br><br>STAR – Ask any questions that arise and ensure that hey are answered prior to proceding. | SME Identified Prevent Events tool |
| 1. Tagging and confined space permits for tube side | |
| 2. Plant evolutions? | Ask them to identify a tool they would use |
| D. Upon completion of inspection assist/perform condenser close-out | |
| 1. Water box is a class “D” cleanliness and Zone IV housekeeping area | |
| 2. Foreign material exclusion inspections are required prior to close out | |

**EO: 1.9 Describe the general inspection procedures for the Feedwater Heaters.**

**Main Idea**

| | CONTENT | METHODS & ACTIVITIES |
|---|---|---|
| I. | General information | |
| | A. Operating parameters give indications of the performance of the Feedwater heaters | |
| | B. When problems are identified or suspected a work order is generated to access the heater for inspection | |
| II. | Construction of HP feedwater heaters | PPT Slide #54 |
| | A. Shell and U-tube | |
| | B. Extraction steam on shell side | |
| | C. Feedwater flows into bottom of tubes and exits from the top | |
| | D. Heaters #6 and #7 equipped with drain coolers | |
| III. | Construction of LP feedwater heaters | PPT Slide #55 |
| | A. Three parallel trains each consisting of four heat exchangers | |
| | B. Separate set of upper and lower tube bundles and hemispherical head | |
| | C. Condensate enters through lower tube bundle and exits through upper bundle | |
| IV. | Diaphragms on feedwater heaters | |
| | A. On both HP and LP heaters | |
| | B. ¼” steel plates welded on under manway | |
| | C. Serve as a gasket, not a pressure boundary | |
| V. | Inspection of tube side | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| A. Manway event at Seabrook | |
| 1. During the week of 6/8/98, two feedwater heaters were scheduled to be removed from service for tube plugging. Power was reduced to 90% to accommodate removing the heaters from service and work was begun on the first heater. | Caution: heaters with removable tube bundles should have both tube and shell sides tagged out. Mechanics have been killed and injured by opening heaters with only one side tagged out. |
| 2. The morning of 6/11/98, the plant was shutdown due to an inoperable Control Building Air Conditioning System, and permission was requested to begin work on the second feedwater heater that was not yet isolated or tagged out. | |
| 3. The work that was authorized was to *prepare for opening the heater and plugging tubes.* Included in the scope of preparatory work was removal of the heater manway. | |
| 4. A tagout was not done for the preparatory work because personnel felt they were not breaching the pressure boundary. | |
| 5. On 6/11/98, a maintenance crew removed the 18” diameter, pressure retaining, blind flange manway cover from an in-service feedwater heater. The feedwater system pressure and temperature were approximately 500 psi and 90F. | |
| 6. Beneath the manway cover, the manway is sealed utilizing a ¼” thick steel plate diaphragm, which is welded onto the manway opening. | |
| 7. The diaphragm acts only as a gasket that is sealed by means of welding. This diaphragm remained intact when the manway cover was removed. | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| 8. However, it did show signs of bulging and deformation due to system pressures. If the diaphragm had failed, it is likely that serious injury to the maintenance crew would have been the result. | STAR |
| 9. At the time of the event, the plant was shutdown with the Condensate System in service and flowing through the feedwater heater. | |
| 10. The maintenance crew recognized the abnormal condition and secured the job. | |
| VI. Ensure adequate conditions are established prior to beginning work | |
| A. Under the manway is a welded diaphragm | |
| 1. Diaphragm is just a gasket – not a pressure retainer | |
| 2. Must be ground out to access the heater | |
| 3. Verify permits in place and correct<br><br>Use Self Check/ Peer Check to verify this. | |
| B. Remove pass partition bolting, partitions and gaskets | |
| C. Contact Ops engineering for inspection and assist as necessary | |
| D. Eddy current testing and video boroscope inspections are used to inspect the tubes | |
| E. Record findings in work order for needed repairs, generate the necessary work orders and EER's | |
| 1. Tube plugging and replacement is performed per EER | |

| CONTENT | METHODS & ACTIVITIES |
|---|---|
| F. When work is complete, close out the heater (FME inspection), weld in diaphragm,<br>1. Weld requires NDE<br>2. After NDE re-install the manway and tighten per tech manual instructions | |

## SUMMARY OF MAIN PRINCIPLES

**The following items are things to consider in your lesson summary. They are not mandatory. You should develop your own summary.,**

### Objectives Review

Review the Lesson Objectives

Topic Review

Restate the main principles or ideas covered in the lesson. Relate key points to the objectives. Use a question and answer session with the objectives.

### Questions and Answers

Oral questioning

Ask questions that implement the objectives. Discuss students answers as needed to ensure the objectives are being met.

### Problem Areas

Review any problem areas discovered during the oral questioning, quiz, or previous tests, if applicable. Use this opportunity to solicit final questions from the students (last chance).

### Concluding Statement

If not done in the previous step, review the motivational points that apply this lesson to students needs. If applicable, end with a statement leading to the next lesson.

You may also use this opportunity to address an impending exam or practical exercise.

Should be used as a transitional function to tie the relationship of this lesson to the next lesson. Should provide a note of finality.