ROLPHTON

NUCLEAR TRAINING CENTRE

COURSE 233

NUCLEAR TRAINING COURSE

COURSE 233

2 - Level
3 - Equipment & System Principles
3 - REACTOR, BOILER & AUXILIARIES

Index

Reactor, Boiler, and Auxiliaries - Course 233

OBJECTIVES

The learning objectives contained in this section are based on extensive field analysis conducted by the Central Nuclear Training Department. The text has not yet been revised to reflect these objectives; therefore, relevant sections of this and other Nuclear Generation Division training course texts are referenced for each subject area. Some subject areas require information which will be supplied by the course instructor.

Only these objectives are testable. Any information contained in this text which does not relate to these objectives is for general interest only.

Also included is the recommended course structure.

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SUBJECT: REACTIVITY CONTROL

REFERENCE: 433.50-1 (Review); Instructor

LEARNING OBJECTIVES

1. State or identify the design intent(s) of:

   (a) the reactor regulating system,

   (b) the protective system.

2. State the difference between:

   (a) an absolute trip and a conditional trip,

   (b) a setback and a stepback.

3. State or identify the major purpose(s) of each of the following:

   (a) boosters,

   (b) control absorbers,

   (c) control adjusters,

   (d) liquid poison addition,

   (e) liquid poison injection,

   (f) liquid zones,

   (g) moderator dump,

   (h) shutoff rods.

4. State or identify the normal full power status of:

   (a) the liquid zones,

   (b) control absorbers,

   (c) control adjusters,

   (d) shutoff rods,

   (e) the liquid poison injection system,

   (f) boosters.

LEARNING OBJECTIVES

5. With respect to an overall loss of reactor regulation (LOR), state or identify:

   (a) reliable control room indications of the upset,

   (b) major concerns associated with the upset,

   (c) key operator and/or system responses that should occur in order to bring the unit to a safe, stable state.

RECOMMENDED COURSE STRUCTURE FOR:

REACTOR, BOILER, AND AUXILIARIES (233)

1.	THE REACTOR	2.	FUEL	3.	THE MODERATOR AND AUXILIARY SYSTEMS	4.	THE HEAT TRANSPORT AND AUXILIARY SYSTEMS	5.	SAFETY SYSTEMS	6.	STEAM SUPPLY
1.1	Reactivity Control	2.1	Fuel Performance	3.1	Moderator Heavy Water	4.1	Heat Transport Heavy Water	5.1	Shutdown Systems	6.1	The Main Steam Supply
1.2	The Annulus Gas System	2.2	The Fuel Handling System	3.2	The Main Moderator Circulation System	4.2	Main and Shutdown Heat Transport Circulation System	5.2	Emergency Coolant Injection System		
1.3	Shield Cooling Systems			3.3	The Covergas System	4.3	Heat Transport Pressure Control and Pressure Relief	5.3	The Negative Pressure Containment System		
				3.4	The Liquid Poison Addition System	4.4	Heat Transport Coolant Inventory				
				3.5	The Moderator Purification System	4.5	The Heat Transport Purification System				
						4.6	The Hydrogen Addition System				

January 1983

SUBJECT: THE ANNULUS GAS SYSTEM

REFERENCE: 233.40-3

LEARNING OBJECTIVES

1. State or identify three design intents of the annulus gas system.

2. State or identify:

   (a) how heat is removed from the annulus gas system,
   (b) how water is removed from the annulus gas system.

3. Identify how the rate of heat production in the annulus gas changes with the operating state of the unit.

4. Identify the operating limitation on the moisture content of the annulus gas.

5. State and/or distinguish between the three operating modes of the system. Indicate the preferred mode.

6. For the following situations, state or identify:

   (i) the reason for purging the annulus gas system
   (ii) the gas used to purge the annulus gas system

   (a) before maintenance on the system,
   (b) after completion of maintenance on the system.

7. For each of the following abnormal conditions, state or identify:

   (i) how the Unit First Operator would be alerted to the situation
   (ii) major operating concerns
   (iii) key operator or system responses

   (a) high or increasing moisture levels in the annulus gas,
   (b) high annulus gas pressure,
   (c) low annulus gas pressure,
   (d) an outleakage of the annulus gas,
   (e) air in the annulus gas.

SUBJECT: THE SHIELD COOLING SYSTEMS

REFERENCE: 233.40-1

LEARNING OBJECTIVES

1. State and/or distinguish between the design intents of:

   (a) a thermal shield,

   (b) a biological shield,

   (c) an end shield.

2. State or identify the purpose of the end shield cooling system.

3. Construct and label a block diagram that represents the removal of heat from the end shields when the unit is operated at:

   (a) full power,

   (b) shutdown.

   The diagram must represent or show:

   (i) the major source of heat energy
   (ii) the heat carriers
   (iii) equipment where heat exchange occurs
   (iv) the external heat sink

4. For each of the following end shield cooling water parameters, state or indicate:

   (i) why the parameter is controlled
   (ii) how it is controlled
   (iii) how the Unit First Operator knows that it is within its specified range

   (a) pH,

   (b) conductivity,

   (c) chloride concentration.

LEARNING OBJECTIVES

5. State or indicate:

   (a) What parameter the end shield coolant operating temperature and temperature limits are "tied" to.

   (b) Why maximum and minimum end shield coolant temperatures are "tied" to this parameter.

   (c) How the end shield coolant temperature is controlled.

6. State or identify what information or indications the Unit First Operator uses to ensure that the following parameters are "normal" and within their limits:

   (a) end shield cooling flow,

   (b) end shield coolant inventory,

   (c) end shield coolant temperature.

7. State or identify how the Unit First Operator would know that the rates of end shield heat production and removal are "matched."

8. For each of the following abnormal conditions, state or identify:

   (i) how the Unit First Operator would be alerted to the situation
   (ii) major operating concerns
   (iii) the key system or operator responses

   (a) loss of end shield cooling flow,

   (b) loss of computer control of end shield cooling temperatures.

SUBJECT: FUEL PERFORMANCE

REFERENCE: 233.70-2

LEARNING OBJECTIVES

1. For each of the following, state or identify:

   (i) the operating policy or limitation
   (ii) possible consequences of violating the policy or limitation

   (a) individual bundle power limit (non-numerical),

   (b) reactor power (non-numerical).

2. State or identify the information or indications that the Unit First Operator uses in order to ensure that the licenced bundle power limit is not exceeded by any bundle in any channel.

3. State or identify general factors that increase the probability of fuel failure.

4. Identify operating situations that would require increased monitoring for failed fuel.

5. State or identify practical methods or techniques for:

   (a) detecting failed fuel in the reactor,

   (b) locating failed fuel in the reactor.

6. With respect to failed fuel in the reactor, state or identify:

   (a) significant reactor safety and/or operational concerns,

   (b) operator priorities and responses.

SUBJECT: FUEL HANDLING

REFERENCE: Instructor; 233.70-2

LEARNING OBJECTIVES

1. State five primary design intents of the fuel handling system.

2. State, in order, the nine steps in a basic fuelling sequence.

3. State or identify:

   (a) criteria used to determine channel refuelling priorities,

   (b) who determines channel refuelling priorities,

   (c) who must approve refuelling,

   (d) the preferred reactor state for refuelling,

   (e) the Unit First Operator's responsibility regarding channel refuelling selections.

4. State or identify:

   (a) four checks required on new fuel bundles,

   (b) three potential operational consequences of not properly checking new fuel.

5. State or identify:

   (a) five major concerns associated with refuelling operations,

   (b) the main reason why refuelling is not done while the unit is shut down.

LEARNING OBJECTIVES

6. For each of the following, state or identify:

   (i) what is tested or checked
   (ii) possible consequences of not properly testing or checking

   (a) channel identity,

   (b) fuelling machine/channel seals,

   (c) closure plug seals.

7. State or identify the major concerns associated with each of the following situations:

   (a) loss of cooling of irradiated fuel anywhere in the fuel handling system,

   (b) movement of the bridge or fuelling machine while the machine is locked onto a channel,

   (c) a fuelling machine that is stuck on a channel.

8. State or identify the safest operator response when a fuelling machine appears to be stuck on a channel.

SUBJECT: MODERATOR HEAVY WATER

REFERENCE: 233.20-1

LEARNING OBJECTIVES

1. State the primary function of the moderator heavy water.

2. State or identify the reason why only heavy water of high isotopic purity is suitable as a moderator.

3. Identify the operating limit or constraint on each of the following moderator parameters:

   (a) isotopic,

   (b) pD (pH),

   (c) conductivity.

4. State or identify the primary radiological concerns (hazard, source, type) associated with moderator D_2O that:

   (a) have spilled or escaped from the moderator system,

   (b) are sealed within moderator pipework,
   . during powered operation
   . during a shutdown.

5. State or identify the information or indications that the Unit First Operator uses to ensure that the following parameters are either within their limits or are "normal":

   (a) moderator isotopic,

   (b) moderator impurity levels,

   (c) moderator pD (pH),

   (d) moderator inventory.

6. State or identify what chemical parameters the Unit First Operator monitors to ensure that D_2O returned to the moderator meets isotopic and purity requirements.

LEARNING OBJECTIVES

7. For the following abnormal conditions, in the moderator system, state or identify:

   (i) how the Unit First Operator is alerted to or can monitor the situation
   (ii) how the Unit First Operator can confirm suspicions
   (iii) key system or operator responses
   (iv) possible significant consequences of not recognizing the abnormality

   (a) sudden downgrading of the moderator isotopic (0.1% or greater),

   (b) high moderator conductivity,

   (c) oil in moderator D_2O.

SUBJECT: THE MAIN MODERATOR CIRCULATION SYSTEM

REFERENCE: 233.20-1

LEARNING OBJECTIVES

1. State the two primary design intents of the main moderator circulation system.

2. State the design intent of the following components, and either sketch and label a simple schematic diagram that indicates their locations within the system or identify their locations on a given schematic diagram:

   (a) the calandria,

   (b) circulating pumps,

   (c) heat exchangers.

3. Construct and label a block diagram that represents the normal removal of full power heat from the main moderator system, for each of the operating states listed below. The diagrams must show:

   (i) heat sources
   (ii) the cooling circuits used to transport heat
   (iii) required pumps
   (iv) equipment where heat exchange occurs
   (v) the external heat sink

   (a) full power (with 3 major heat sources),

   (b) after shutdown, with moderator in the calandria (with the major heat source).

4. State, show, or identify how moderator temperature is controlled.

5. For each of the following, state or identify:

   (i) the operating limitations or constraints
   (ii) possible consequences of violating or exceeding limitations or constraints

   (a) moderator maximum and minimum temperatures,

   (b) moderator temperature differentials,

   (c) reduced moderator level.

LEARNING OBJECTIVES

6. State or identify the information or indications that the Unit First Operator uses to ensure that:

   (a) the rate of heat production in the moderator matches the rate of heat removal from the moderator,

   (b) moderator flow rate is "normal".

7. For each of the following abnormal conditions, state or identify:

   (i) how the Unit First Operator is alerted to or can monitor the situation
   (ii) possible significant consequences
   (iii) key system or operator responses

   (a) loss of service water to the moderator heat exchangers,

   (b) moderator flow,

   (c) loss of moderator D_2O due to
   - a pipe rupture
   - a heat exchanger leak
   - a calandria tube leak.

SUBJECT: THE MODERATOR COVERGAS SYSTEM

REFERENCE: 233.20-3

LEARNING OBJECTIVES

1. State the four design intents of the covergas system.

2. State the design intent of the following components and either sketch and label a simple schematic diagram that indicates their locations within the system or identify their locations on a given schematic diagram:

   (a) the compressors,

   (b) flame arrestors,

   (c) heaters,

   (d) recombination units,

   (e) cooling jackets.

3. Identify factors that affect:

   (a) the rate of appearance of D_2 in the covergas,

   (b) the % concentration of D_2 in the covergas.

4. State or indicate:

   (a) why covergas circulation is necessary,

   (b) operating states that require covergas circulation,

   (c) when covergas purging is required.

5. Identify the operating restrictions on covergas composition.

LEARNING OBJECTIVES

6. State or identify the information or indications that the Unit First Operator uses to ensure that:

   (a) covergas pressure is "normal",

   (b) covergas flow is "normal",

   (c) D_2 in the covergas is within allowable limits,

   (d) N_2 in the covergas is within allowable limits,

   (e) the recombiners are operating properly.

7. For each of the following moderator covergas system abnormal conditions, state or identify:

   (i) possible significant consequences
   (ii) key system or operator responses

   (a) D_2 concentration
   - between 2% and 4%
   - above 4%,

   (b) N_2 concentration above 3%.

SUBJECT: THE LIQUID POISON ADDITION SYSTEM

REFERENCE: 233.20-5

LEARNING OBJECTIVES

1. State or identify the design intent of the liquid poison addition system.

2. State the design intent of:

   (a) the liquid poison tanks,

   (b) the delay tank.

3. Identify or sketch schematic system locations of:

   (a) the liquid poison tanks,

   (b) the delay tanks,

   (c) connections to and from moderator main circuit.

4. For each of the following operating situations:

   (i) state or identify why a poison is added to the moderator
   (ii) identify which poison is preferred
   (iii) identify how the poison's effectiveness is decreased

   (a) prior to initial start-up of the unit when it contains fresh fuel,

   (b) prior to overfuelling,

   (c) during an extended outage,

   (d) following start-up after a poison outage,

   (e) after certain power increases.

5. State why poison should be available for addition whenever the unit is operating.

6. State or indicate the method by which the Unit First Operator adds poison to the moderator.

LEARNING OBJECTIVES

7. State or identify the information or indications that the Unit First Operator uses to ensure that:

   (a) the moderator liquid poison tank is full,

   (b) the moderator liquid poison system is added to the moderator,

   (c) the correct amount of poison has been added to the moderator:
   - during a xenon transient
   - during an extended outage
   - during a Guaranteed Shutdown State.

8. State or identify how the Unit First Operator is alerted to or can monitor:

   (a) a blocked poison addition line,

   (b) inadvertent addition or removal of poison during full power operation.

9. State or identify possible significant consequences to the unit of:

   (a) inadvertent addition or removal of poison during full power operation,

   (b) inadvertent removal of poison during start-up operations,

   (c) use of Boron where Gadolinium is preferred.

10. State or identify key operator actions and/or system responses for:

    (a) a blocked poison addition line,

    (b) inadvertent addition of poison during full power operation,

    (c) inadvertent removal of poison during start-up operation.

SUBJECT: THE MODERATOR PURIFICATION SYSTEM

REFERENCE: 233.20-2

LEARNING OBJECTIVES

1. State the two primary design intents of the moderator purification system.

2. State or identify functions of:

   (a) the ion exchange columns,

   (b) strainers.

3. Identify or sketch schematic system locations of:

   (a) ion exchange columns,

   (b) strainers,

   (c) connections to and from the moderator main circuit,

   (d) resin addition and transfer lines,

   (e) resin screens.

4. State or identify how each of the following parameters are maintained:

   (a) purification flow,

   (b) ion exchange inlet temperature,

   (c) pressure in the purification system.

5. State or indicate:

   (a) why purification is required to remove
   - boron
   - gadolinium,

   (b) how the Unit First Operator knows that poison removal should be initiated or increased,

   (c) how the Unit First Operator controls the rate of poison removal,

   (d) abnormal operating conditions that require an increased rate of moderator purification.

LEARNING OBJECTIVES

6. State or identify the method by which the Unit First Operator can monitor:

   (a) ion exchange inlet temperature,

   (b) ion exchange flow,

   (c) the rate of poison removal,

   (d) the removal of impurities.

7. State or identify how the Unit First Operator would be alerted to each of the following situations:

   (a) failure of ion exchange resin retention screens,

   (b) spent resin for impurity removal,

   (c) spent or insufficient resin capacity for poison removal,

   (d) a blocked column or strainer.

8. State or identify significant operating consequences of each of the following situations:

   (a) high purification system inlet temperature,

   (b) high purification flow,

   (c) low purification flow,

   (d) escape of resin into the main moderator system,

   (e) continued use of spent resin for purification,

   (f) use of a saturated Boron column for Boron cleanup,

   (g) failure to valve out purification columns when Gadolinium is in use in the moderator.

9. State or identify normal operating procedure on notification or discovery of each of the following situations:

   (a) high purification inlet temperature,

   (b) a low purification flow for the current valve setting and column usage,

   (c) a suspected spent column.

SUBJECT: HEAT TRANSPORT HEAVY WATER

REFERENCE: 233.30-1

LEARNING OBJECTIVES

1. State the design intent of the heat transport heavy water.

2. Indicate the type of operating limitation or restriction on each of the following heat transport system chemical parameters or substances:

   (a) radioiodines,

   (b) chlorides,

   (c) pH (also identify typical operating values),

   (d) isotopic,

   (e) dissolved hydrogen,

   (f) neutron poisons.

3. State or identify the primary radiological hazards of heat transport D_2O that:

   (a) has spilled or escaped from the heat transport system,

   (b) is sealed within the heat transport system
   - during normal powered operation
   - during a shutdown.

4. State or identify the information or indications that the Unit First Operator normally relies upon to ensure that the following heat transport system chemical parameters are either within their limits or are "normal":

   (a) isotopic,

   (b) pH,

   (c) chlorides,

   (d) radioiodines,

   (e) dissolved hydrogen.

LEARNING OBJECTIVES

5. Identify the tests normally used to distinguish between moderator and heat transport heavy water.

6. State or identify how the Unit First Operator ensures that D_2O returned to the heat transport system meets isotopic and purity requirements.

7. For each of the following heat transport system chemical abnormal conditions, state or identify:

    (i) the major concern(s)
    (ii) key operator or system responses

    (a) low isotopic,

    (b) low pH,

    (c) high chloride concentrations,

    (d) high radioiodine levels,

    (e) high dissolved deuterium levels,

    (f) high dissolved oxygen levels,

    (g) high levels of insoluble impurities.

SUBJECT: MAIN AND SHUTDOWN HEAT TRANSPORT CIRCULATION SYSTEMS

REFERENCE: 233.30-1, 233.30-5, 233.30-6, 233.30-12

LEARNING OBJECTIVES

1. State the primary design intent of the main heat transport circulation systems.

2. State the primary design intent of:

   (a) the main heat transport pumps,

   (b) the steam generators.

3. Identify or sketch schematic system locations of the following components of a single loop heat transport system:

   (a) reactor outlet headers,

   (b) steam generators,

   (c) heat transport pumps,

   (d) reactor inlet headers,

   (e) connections to a shutdown or maintenance cooling system.

4. For each one of the operating states listed below, construct and label a power flow diagram that represents the removal of energy from the heat transport system. The diagram must show:

   (i) major heat sources
   (ii) the heat carriers
   (iii) the required pumps
   (iv) equipment where power transfers occur
   (v) external power sinks

   (a) full power, with rated electrical output to the grid (two major pathways),

   (b) poison prevent (major pathway only),

LEARNING OBJECTIVES

4. Continued

   (c) shutdown, with the heat transport system hot and pressurized (the major pathway for a unit that has a directly cooled shutdown system and the major pathway for a unit that has indirect shutdown cooling),

   (d) shutdown, using maintenance cooling,

   (e) thermosyphoning (major pathway only),

   (f) crash cooldown (major pathway only),

   (g) ECIS operation (major pathway only).

5. Rank power flow pathways for heat produced in the heat transport system according to decreasing heat removal capability.

6. For each of the following, identify or state:

      (i) the operating policy limitation or constraint
      (ii) possible consequences of violating or exceeding the operating policy limitation or constraint

   (a) coolant flow paths,

   (b) heat sinks,

   (c) alternate heat removal pathways,

   (d) bulk boiling,

   (e) maximum warm-up rate,

   (f) minimum temperature in shutdown or maintenance cooling loops,

   (g) temperatures at which shutdown cooling may be valved in.

LEARNING OBJECTIVES

7. For each of the following upsets and/or abnormalities, state or identify:

    (i) how the Unit First Operator is alerted to or can monitor the situation
    (ii) possible significant consequences
    (iii) key system or operator responses

    (a) main heat transport pump
        . motor failure
        . seal failure,

    (b) Class 4 power failure,

    (c) restricted flow through a fuel channel.

8. With respect to feeder freezing, state or identify:

    (a) the purpose of the Feeder Freezing System,

    (b) physical constraints on channel temperature, pressure, flow and fuel content,

    (c) how the channel is vented during freezing,

    (d) how the channel is drained after freezing,

    (e) the field indications that the ice plugs have formed,

    (f) the field test done on the ice plugs,

    (g) the key indications that an ice plug is in danger of failing,

    (h) two main concerns associated with a failed ice plug,

    (i) protective clothing requirements required when handling liquid nitrogen,

    (j) the hazards associated with handling liquid nitrogen.

SUBJECT: **HEAT TRANSPORT PRESSURE CONTROL AND PRESSURE RELIEF**

REFERENCE: 233.30-2, 233.30-8

LEARNING OBJECTIVES

1. For the following systems, state or identify:

   (i) the design intent
   (ii) the normal operational status

   (a) heat transport pressure control,

   (b) heat transport pressure relief.

2. Given an unlabelled schematic diagram, label, or identify the location of:

   (a) the pressurizer (when included),

   (b) the bleed condenser,

   (c) the bleed cooler,

   (d) the purification system,

   (e) the D_2O storage tank,

   (f) the feed pumps,

   (g) bleed valves,

   (h) feed valves,

   (i) steam bleed valves (when included),

   (j) bleed condenser level control valves,

   (k) overpressure relief valves.

3. State or identify the function(s) of the following pressure control components, during both "normal" and "solid state" heat transport operational modes:

   (a) the pressurizer,

   (b) the bleed and feed system.

LEARNING OBJECTIVES

4. State or identify the functions of the bleed and feed system of a unit that does not have a pressurizer.

5. State or identify the function(s) of:

   (a) steam bleed valves,

   (b) bleed valves,

   (c) feed valves,

   (d) the bleed condenser,

   (e) the bleed cooler,

   (f) the bleed condenser level control valves,

   (g) the feed pumps,

   (h) the D_2O storage tank.

6. State or identify the two methods for controlling bleed condenser pressure while the heat transport system is hot. Indicate which one of the methods is used as a back up.

7. State or identify how the pressurizer maintains heat transport pressure at a set point.

8. With respect to wide and narrow range pressure control modes, identify:

   (a) which mode has the higher gain,

   (b) which mode is used at full power.

9. State or identify the Operating Policies on heat transport pressure.

10. State or identify the information or indications that a Unit First Operator would use to monitor:

   (a) heat transport pressure,

   (b) heat transport temperature.

LEARNING OBJECTIVES

11. With respect to heat transport pressure <u>in general</u>, state or identify:

    (a) the initial operator interpretation of pressure control trouble,

    (b) possible consequences of unexpected changes in heat transport pressure,

    (c) <u>direct</u> system actions for reducing high heat transport pressure,

    (d) an <u>indirect</u> method for reducing high heat transport,

    (e) operating guidelines for dealing with pressure upsets.

12. Predict how each of the following abnormal conditions would tend to affect heat transport pressure, should it occur during normal full power operation:

    (a) loss of boiler feed,
    (b) main steam line rupture,
    (c) steam release through reject or safety valves,
    (d) loss of Class IV power,
    (e) loss of regulation (LOR),
    (f) loss of coolant accident (LOCA),
    (g) continuous bleed, but inadequate feed flow,
    (h) continuous feed, but inadequate bleed flow,
    (i) failure of a pressure relief valve (liquid or steam),
    (j) failure of pressurizer on bleed condenser heaters.

13. For the following abnormal conditions, state or identify:

    (i) how the Unit First Operator is alerted to or can monitor the situation
    (ii) key system or operator responses

    (a) a feed pump failure,

    (b) a failed OPEN overpressure relief valve.

SUBJECT: HEAT TRANSPORT COOLANT INVENTORY

REFERENCE: 233.30-9, 233.30-10

LEARNING OBJECTIVES

1. State or identify the major purpose of each of the following systems or components:

   (a) the D_2O transfer system,

   (b) the heat transport D_2O storage tanks,

   (c) the heat transport D_2O collection system,

   (d) the miscellaneous D_2O collection system,

   (e) the liquid D_2O recovery system,

   (f) the vapour recovery system.

2. Identify the operating limits on D_2O inventory in the storage tank.

3. State or identify the information or indications that the Unit First Operator uses to ensure that:

   (a) heat transport inventory is adequate or "normal",

   (b) the vapour recovery system is operating properly.

4. For each of the following abnormal conditions, state or identify:

   (i) how the Unit First Operator is alerted to and can monitor the situation
   (ii) the possible significant consequences
   (iii) key system or operator responses

   (a) an abnormally high D_2O recovery and/or loss rate (over a period of time),

   (b) a pressure tube leak,

   (c) a boiler tube leak,

   (d) moderate leaks that are not classified as loss of coolant accidents,

   (e) breaches of the heat transport system that are classified as loss of coolant accidents.

SUBJECT: THE HEAT TRANSPORT PURIFICATION SYSTEM

REFERENCE: 233.30-3

LEARNING OBJECTIVES

1. State or identify the two primary design intents of the Heat Transport Purification System.

2. State or identify the function of:

   (a) the ion exchange columns,

   (b) the strainers,

   (c) the bleed filters.

3. Identify or sketch schematic system locations of:

   (a) bleed filters,

   (b) ion exchange columns,

   (c) strainers,

   (d) connections to the feed and bleed system,

   (e) bypass connections.

4. Identify the method used to control each of the following heat transport parameters:

   (a) pD,

   (b) chlorides and other soluble ionic impurities,

   (c) radioiodine,

   (d) particulate impurities,

   (e) storage tank covergas impurities,

5. State or identify how each of the following purification system parameters are maintained:

   (a) temperature,

   (b) flow,

   (c) pressure.

LEARNING OBJECTIVES

6. State or identify:

   (a) specific operating circumstances that require an increase in the rate of removal of heat transport impurities,

   (b) how the Unit First Operator could increase the rate of heat transport purification.

7. State or identify how the Unit First Operator normally monitors each of the following parameters:

   (a) purification system inlet temperature,

   (b) purification system flow,

   (c) purification system inlet pressure,

   (d) D_2 and O_2 concentrations in the D_2O storage tank covergas.

8. State or identify the most likely initial Control Room indications of each of the following situations:

   (a) a plugged bleed filter,

   (b) an exhausted ion exchange column,

   (c) a plugged ion exchange column,

   (d) strainers plugged with ion exchange resin,

   (e) inadvertent isolation of the system,

   (f) high inlet temperature.

9. State or identify significant concerns and/or consequences associated with each of the following situations:

   (a) high ion exchange resin temperature,

   (b) escape of ion exchange resin into the heat transport system,

   (c) inadequate purification temperature control,

LEARNING OBJECTIVES

9. Continued

   (d) continued use of an exhausted ion exchange column,

   (e) high D_2 concentration in the D_2O storage tank covergas.

10. State or identify system responses and/or operating procedures for each of the following situations:

   (a) a plugged bleed filter,

   (b) a plugged or exhausted ion exchange column,

   (c) a high purification system inlet temperature,

   (d) a high purification system inlet pressure,

   (e) a high D_2 concentration in the D_2O storage tank covergas.

SUBJECT: THE HYDROGEN ADDITION SYSTEM

REFERENCE: 233.30-7

LEARNING OBJECTIVES

1. State or identify the purpose of hydrogen addition to the heat transport system.

2. Identify or sketch schematic location of the following system components:

   (a) the hydrogen source,

   (b) a pressure regulating valve,

   (c) the throttling valve,

   (d) the check valve,

   (e) the isolating valve,

   (f) the connection to the main heat transport system.

3. Identify situations or operating states when the hydrogen addition system would not normally be in use.

4. Identify or state how hydrogen flow and pressure are normally:

   (a) regulated,

   (b) monitored.

5. State or identify how a Control Room or a Field Operator would be alerted to each of the following situations:

   (a) hydrogen leaks from system components or couplings,

   (b) low hydrogen supply pressure.

LEARNING OBJECTIVES

6. State or identify the major concern(s) associated with each of the following situations:

   (a) hydrogen gas leaks,

   (b) unavailability of the hydrogen gas system,

   (c) a high rate of hydrogen addition.

7. State the key operator response(s) to each of the following situations:

   (a) unavailability of the hydrogen addition system,

   (b) a high reported usage rate of bottled hydrogen,

   (c) low hydrogen supply pressure.

SUBJECT: SHUTDOWN SYSTEMS

REFERENCE: 236.02-2

LEARNING OBJECTIVES

1. State the design intent of a shutdown system.

2. State the two general categories of process system failure that require a rapid reactor shutdown.

3. For each of the following, state or identify the normal operational requirement or restriction:

   (a) availability of the shutdown systems,

   (b) capability of shutdown systems,

   (c) authorization for modifications or maintenance to the shutdown systems,

   (d) authorization for adjustment of trip setpoints,

   (e) the preferred reactor state for shutdown system maintenance,

   (f) the preferred reactor state for testing a shutdown system,

   (g) selection of more than one channel at a time for testing or maintenance.

4. State or identify:

   (a) when conditional trips must be armed,

   (b) how conditional trips are armed,

   (c) how the Unit First Operator knows that conditional trips are armed.

5. State or identify the information or indications that the Unit First Operator uses to ensure that:

   (a) trip lines are energized,

   (b) shutoff rods are poised,

LEARNING OBJECTIVES

5. Continued

   (c) flux detectors are operable,

   (d) moderator dump or poison injection valves are closed.

6. For each of the following, state or identify:

   (i) what is tested
   (ii) the possible consequences of not testing

   (a) trip tests,

   (b) partial drop tests of shutoff rods,

   (c) full drop tests of shutoff rods.

7. State or identify the major concern associated with each of the following abnormal conditions:

   (a) a Level 1 impairment of a shutdown system,

   (b) a Level 2 impairment of a shutdown system,

   (c) a Level 3 impairment of a shutdown system,

   (d) a shutoff rod stuck in the core,

   (e) a single channel trip,

   (f) a complete reactor trip.

8. State or identify the Unit First Operator response to each of the following abnormal conditions:

   (a) Level 1 impairment of a shutdown system,

   (b) Level 2 impairment of a shutdown system,

   (c) Level 3 impairment of a shutdown system,

   (d) a shutoff rod stuck in the core,

   (e) a single channel trip,

   (f) a complete reactor trip.

SUBJECT: THE EMERGENCY COOLANT INJECTION SYSTEM

REFERENCE: 233.30-11

LEARNING OBJECTIVES

1. State the primary design intent of the emergency coolant injection system.

2. List, in order, the THREE phases of emergency coolant injection system response to a Loss of Coolant Accident. For each phase, state the function of the system.

3. For each of the following, state or identify the normal operational requirement or restriction:

   (a) availability of the Emergency Coolant Injection System,

   (b) blocking the Emergency Coolant Injection System,

   (c) authorization for modifications or maintenance to the Emergency Coolant Injection System,

   (d) unit operational status during maintenance to the Emergency Coolant Injection System.

4. State or identify how the Unit First Operator would block or unblock the emergency coolant injection system.

5. State or identify the information or indications that the Unit First Operator uses to ensure that the emergency coolant injection system:

   (a) is poised and ready to operate,

   (b) is blocked,

   (c) is operating as intended during the following phases of a LOCA
   - blowdown
   - injection
   - recovery.

LEARNING OBJECTIVES

6. For the following, state or identify:

   (i) what is tested
   (ii) the possible significant consequences of not testing

   (a) routine availability tests on emergency injection system components,

   (b) tests on emergency injection system components after maintenance.

7. State or identify the major consequences or concerns associated with each of the following emergency coolant injection system abnormal conditions:

   (a) failure to block the system before depressurization of the heat transport system,

   (b) a Level 1 impairment,

   (c) a Level 2 impairment,

   (d) a Level 3 impairment.

8. State or identify the Unit First Operator response to each of the following abnormal conditions:

   (a) a Level 1 impairment of the emergency coolant injection system,

   (b) a Level 2 impairment of the emergency coolant injection system,

   (c) a Level 3 impairment of the emergency coolant injection system,

   (d) emergency coolant injection system operation during Loss of Coolant Accidents.

SUBJECT: NEGATIVE PRESSURE CONTAINMENT SYSTEM

REFERENCE: 233.40-2

LEARNING OBJECTIVES

1. State the four design intents of the negative pressure containment system.

2. State or identify the function(s) of:

   (a) air locks and transfer chambers,

   (b) the containment envelope,

   (c) the dousing system,

   (d) the main vacuum pumps,

   (e) pressure relief valves
   - controlled
   - noncontrolled,

   (f) the upper vacuum chambers,

   (g) the vacuum ducts.

3. State or identify:

   (a) how the vacuum is maintained in the upper and lower chambers,

   (b) how the pressure relief valves operate,

   (c) what containment box/button is and how it occurs,

   (d) how dousing is initiated.

4. State in nonnumerical terms, the operational requirement or restriction on each of the following:

   (a) negative pressure containment system
   - availability
   - maintenance
   - modifications,

   (b) vacuum building
   - temperature
   - pressures
   - total water inventory,

LEARNING OBJECTIVES

4. Continued

   (c) emergency storage water
   - temperature
   - inventory,

   (d) dousing water seals,

   (e) pressure relief valves,

   (f) air lock/transfer chamber doors.

5. State or identify the information or indications that the Unit First Operator uses to ensure:

   (a) proper vacuum is being maintained,

   (b) the vacuum building is poised for dousing,

   (c) the pressure relief valves are poised,

   (d) containment is being maintained,

   (e) box up occurs during a LOCA,

   (f) pressure relief valves operate as intended during a LOCA,

   (g) the dousing system operates as intended during a LOCA.

6. For the following, state or identify:

   (i) what is being tested
   (ii) the possible significant consequences of not testing

   (a) pressure relief valves,

   (b) box up,

   (c) containment integrity,

   (d) vacuum building integrity,

   (e) air locks.

LEARNING OBJECTIVES

7. State or identify the major consequences or concerns associated with each of the following pressure containment system abnormalities:

   (a) a Level 1 impairment,

   (b) a Level 2 impairment,

   (c) a Level 3 impairment.

8. State or identify the key Unit First Operator actions with respect to the containment system during a LOCA.

SUBJECT: THE MAIN STEAM SUPPLY SYSTEM

REFERENCE: 233.60-1

LEARNING OBJECTIVES

1. State or identify the design intent(s) of a unit's:

   (a) steam generators (boilers),

   (b) preheaters,

   (c) steam reject valves (SRVs),

   (d) steam generator relief valves (boiler safeties).

2. For units with or without a pressurizer, identify sketch graph representations of:

   (a) reactor power versus steam drum pressure setpoint,

   (b) reactor power versus main steam temperature,

   (c) reactor power versus steam drum level setpoint,

   (d) reactor power versus steam or feedwater flow.

3. State four basic reasons for rejecting steam, and indicate which of the four are normally handled by:

   (a) the small steam reject valves,

   (b) the large steam reject valves.

4. For each of the following situations, identify the status of:

   (i) small steam reject valves
   (ii) large steam reject valves
   (iii) steam generator relief valves

   (a) normal full power,

   (b) turbine run up (unsynchronized),

   (c) warmup or cooldown of the heat transport system,

   (d) turbine runbacks,

LEARNING OBJECTIVES

4. Continued

   (e) turbine trip,

   (f) load rejection,

   (g) poison prevent,

   (h) Loss of Coolant Accident.

5. For each of the following operating parameters, state or identify:

   (i) the operating policy, limitation, or constraint
   (ii) the most significant consequences of exceeding or violating the operating policy limitation or constraint

   (a) steam drum water level,

   (b) steam quality,

   (c) steam relief capacity,

   (d) steam reject capacity.

6. State or identify the information or indications that the Unit First Operator uses to ensure that:

   (a) steam and feedwater flows are balanced and adequate,

   (b) steam drum pressure is "normal",

   (c) steam drum level is "normal".

7. With respect to steam generator relief valve testing, state or identify:

   (a) what is tested,

   (b) significant operating consequences of not testing,

   (c) action(s) to be taken on test failure.

LEARNING OBJECTIVES

8. State or identify how the Unit First Operator is alerted to or can monitor:

   (a) a loss of boiler feedwater,

   (b) a main steam line break,

   (c) failures or impairments of the steam reject system
   - valves failed OPEN
   - valves failed CLOSED,

   (d) failures or impairments of the steam generator relief system
   - valves failed OPEN
   - valves failed CLOSED.

9. State or identify the significant consequences or operating concerns associated with:

   (a) a loss of boiler feedwater,

   (b) a main steam line break,

   (c) failure or impairment of the steam reject system,

   (d) excessive or prolonged opening of the steam generator relief valves.

10. State or identify the key operator or system responses necessary to return the unit to a safe state in the event of:

   (a) a loss of boiler feedwater,

   (b) a main steam line break.