Condensate and Feedwater Systems

Section 7.2

HRTD
Human Resources
Training & Development

Learning Objectives

1. **List in proper flowpath order and state the purpose of the following condensate and feedwater system components:**
   - **a. Condenser**
   - **b. Condensate (hotwell) pump**
   - **c. Demineralizers**
   - **d. Low pressure feedwater heaters**
   - **e. Main Feed Pumps (MFPs)**
   - **f. High pressure feedwater heaters**
   - **g. Feedwater control and bypass valves**
   - **h. Feedwater Isolation Valves (FWIVs)**
   - **i. Steam Generators (SGs)**
   - **j. Startup Auxiliary Feedwater AFW pump**
   - **k. Heater drain System**
   - **l. Condensate Storage Tank (CST)**

Learning Objectives (cont-2)

2. **List the components and connections located in the Seismic category I portion of the feedwater system piping, and explain the purpose of each.**

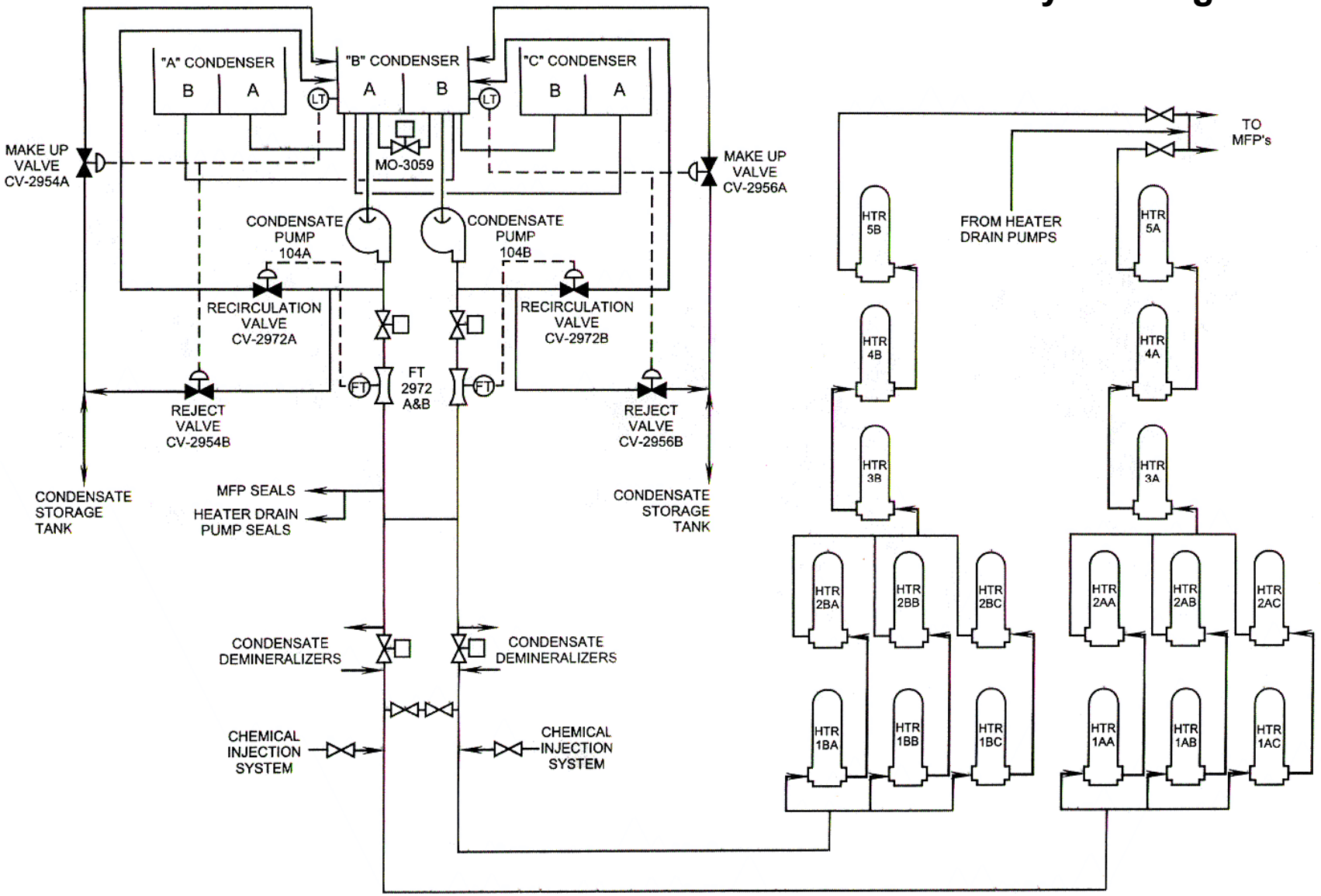
3. **Explain how cascading heater drains increase plant efficiency.**

Condensate and Feedwater Systems

The Purposes of the Condensate and Feedwater Systems are:

- To transfer water from the main condenser to the steam generators and to preheat it,
- To collect and distribute the condensation from the feedwater heater drains, and
- To purify secondary water and to maintain secondary chemistry control

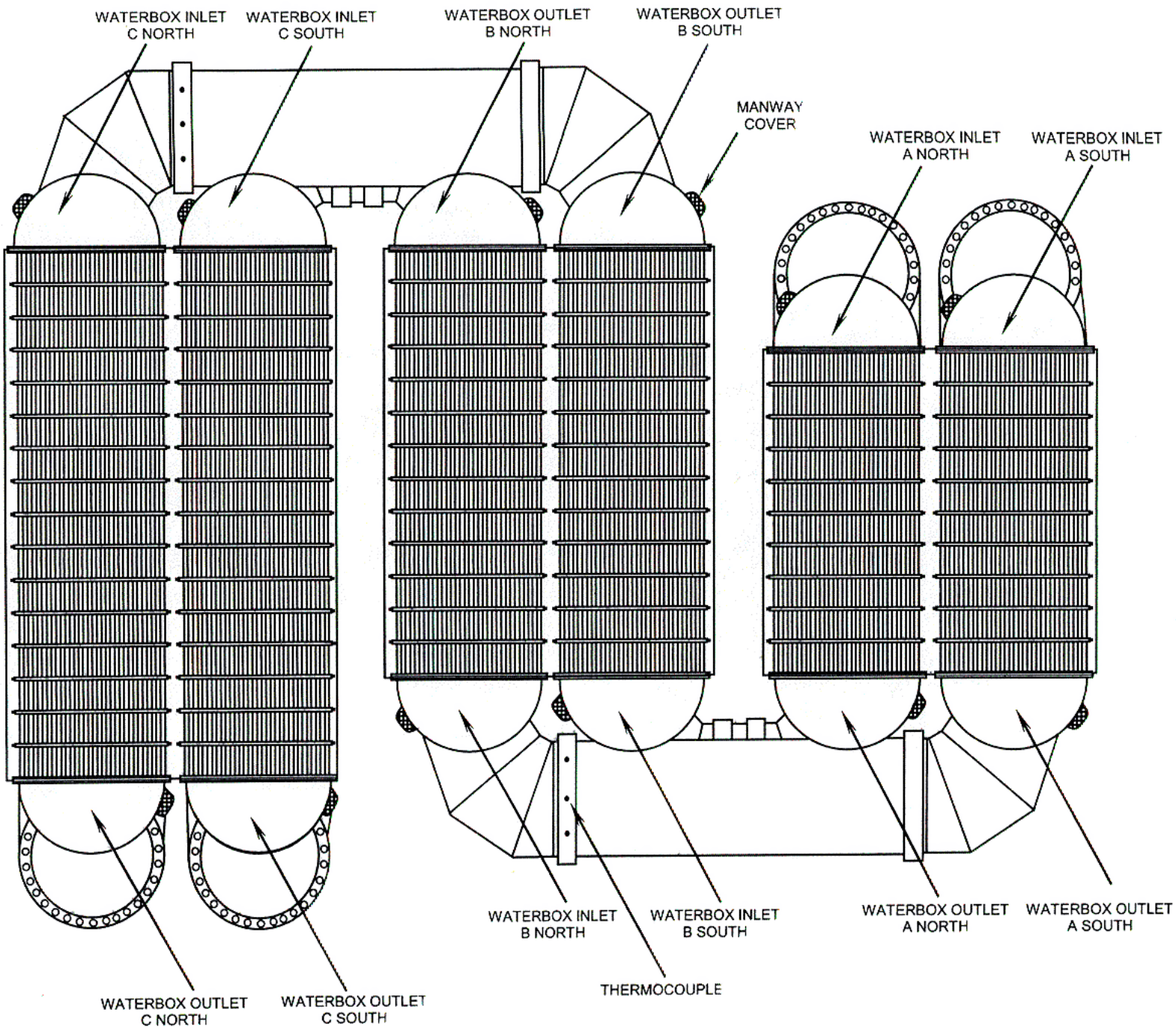
Condensate System Fig 7.2-2



Main Condenser Objective 1.a

- Purpose - Provides a heat sink to condense the steam exhausted from the three LP turbines, the main feedwater pump turbines, and the Steam Dumps.
- 3 shell, multi-pressure, deaerating, surface condenser.
  - **One condenser connected to each LP turbine.**
  - **Air ejectors maintain vacuum during operations.**
  - **Condensed steam collected in hotwell.**

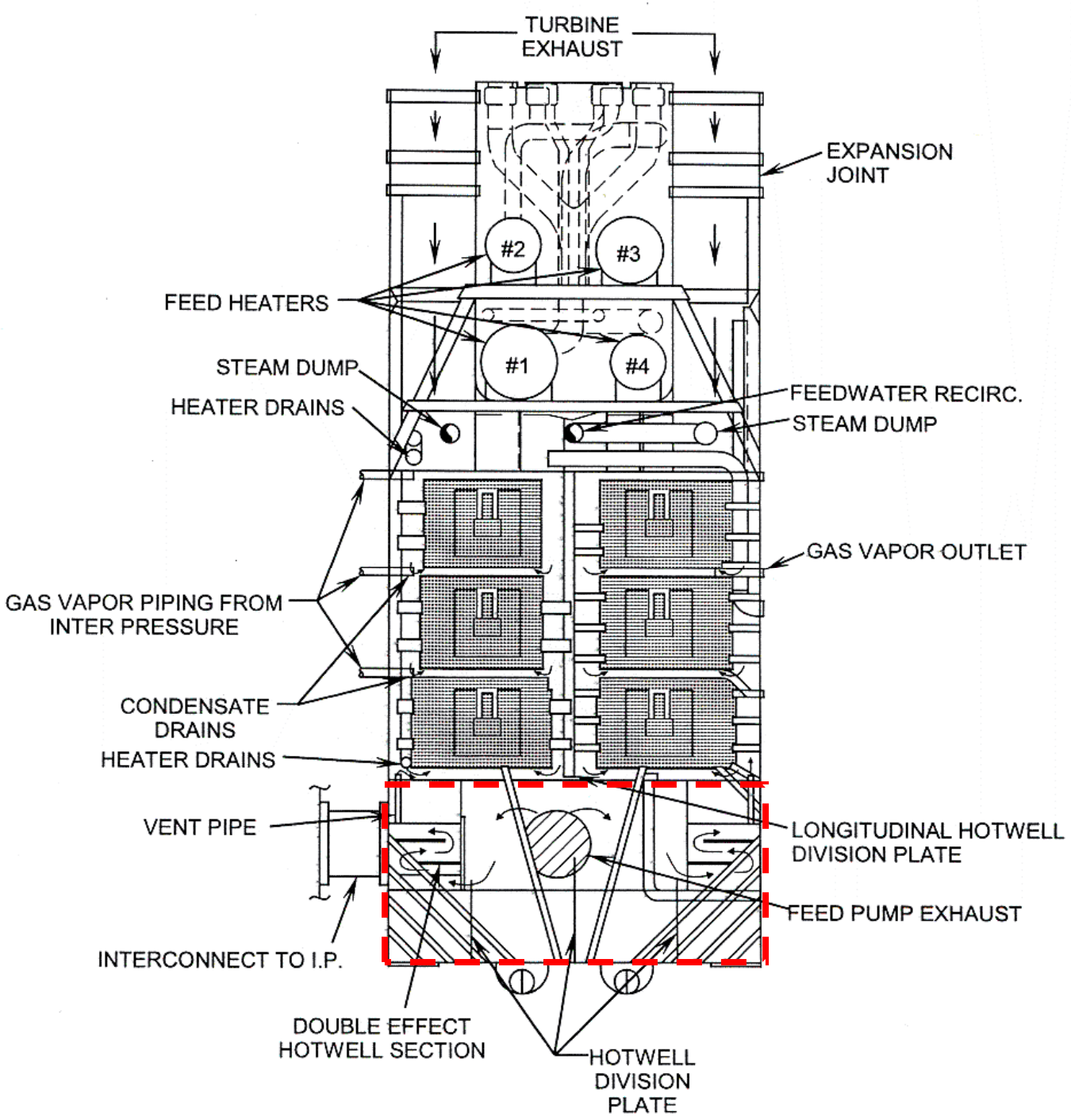
7.2-10


WATERBOX INLET C NORTH
WATERBOX INLET C SOUTH
WATERBOX OUTLET B NORTH
WATERBOX OUTLET B SOUTH
MANWAY COVER
WATERBOX INLET A NORTH
WATERBOX INLET A SOUTH
WATERBOX INLET B NORTH
WATERBOX INLET B SOUTH
WATERBOX OUTLET A NORTH
WATERBOX OUTLET A SOUTH
THERMOCOUPLE
WATERBOX OUTLET C NORTH
WATERBOX OUTLET C SOUTH

Condenser Hotwell Objective 1.a

- Purpose - Provides a storage reservoir for condensed steam.
- Hotwell is located in the bottom section of the condenser.
- Condenser Hotwell level control via makeup and rejection connections to the Condensate Storage Tank (CST).

Fig. 7.2-9


TURBINE EXHAUST
EXPANSION JOINT
#2
#3
#1
#4
FEED HEATERS
STEAM DUMP
HEATER DRAINS
FEEDWATER RECIRC.
STEAM DUMP
GAS VAPOR OUTLET
GAS VAPOR PIPING FROM INTER PRESSURE
CONDENSATE DRAINS
HEATER DRAINS
VENT PIPE
LONGITUDINAL HOTWELL DIVISION PLATE
FEED PUMP EXHAUST
INTERCONNECT TO I.P.
DOUBLE EFFECT HOTWELL SECTION
HOTWELL DIVISION PLATE

Condensate Pumps Objective 1.b

- Purpose - Take a suction on their associated hotwell train, raise pressure of condensate & transport it through demineralizers and LP feedwater heaters to the suction of the MFPs.
- 8 stage, vertical, centrifugal pump.
- ~ 4000 HP, ~ 11,000 gpm each, non-vital AC power.
- One pump sufficient for ~ 70% plant power.

Demineralizer Systems Objective 1.c

- Used for purification and chemistry control of the condensate & feedwater systems during plant S/U.

- During power operations, used for clean up if a contaminant is introduced into the secondary. (e.g. condenser tube leak)

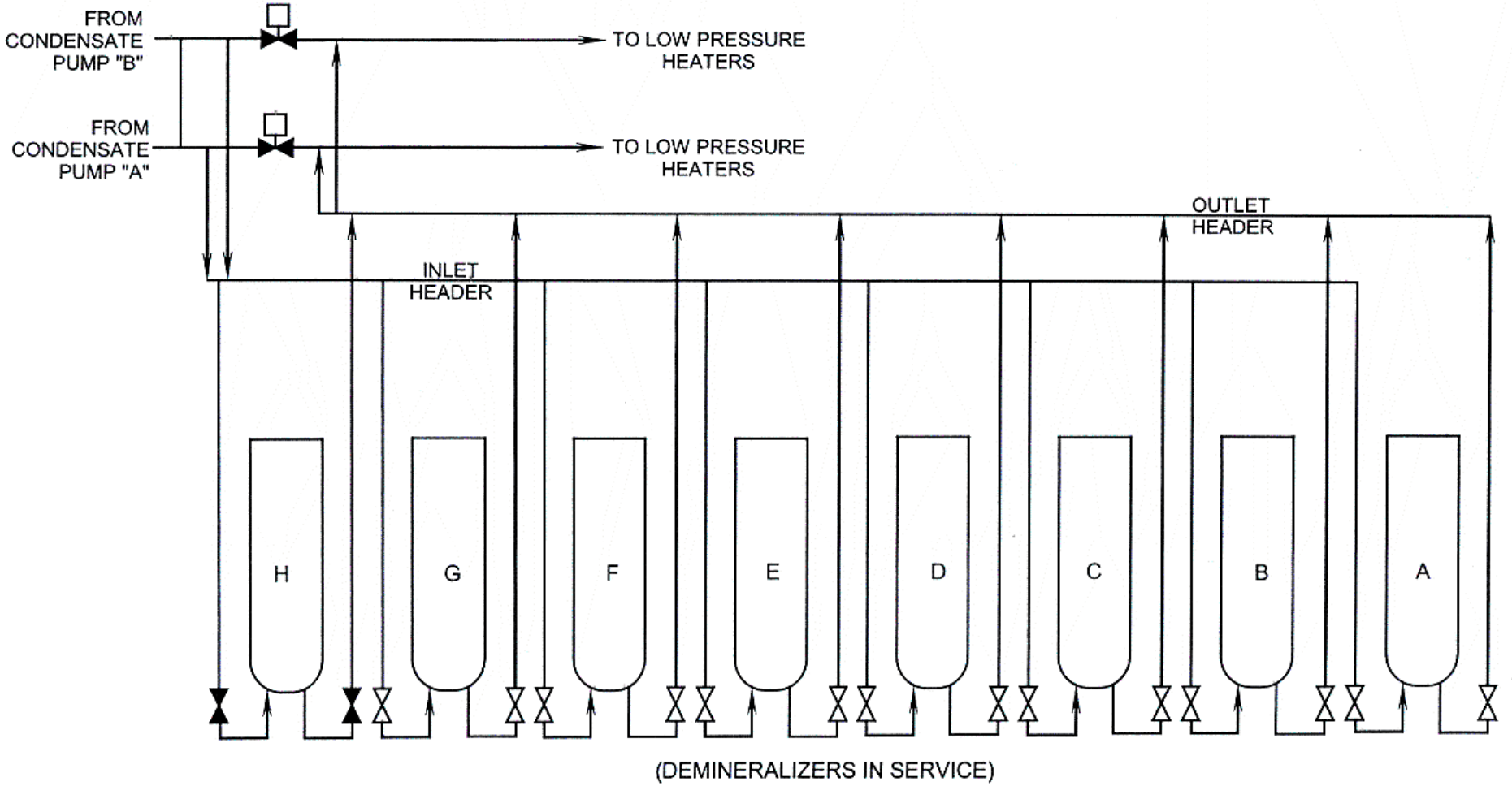

FROM CONDENSATE PUMP "B"
FROM CONDENSATE PUMP "A"
TO LOW PRESSURE HEATERS
TO LOW PRESSURE HEATERS
OUTLET HEADER
INLET HEADER
H
G
F
E
D
C
B
A
(DEMINERALIZERS IN SERVICE)

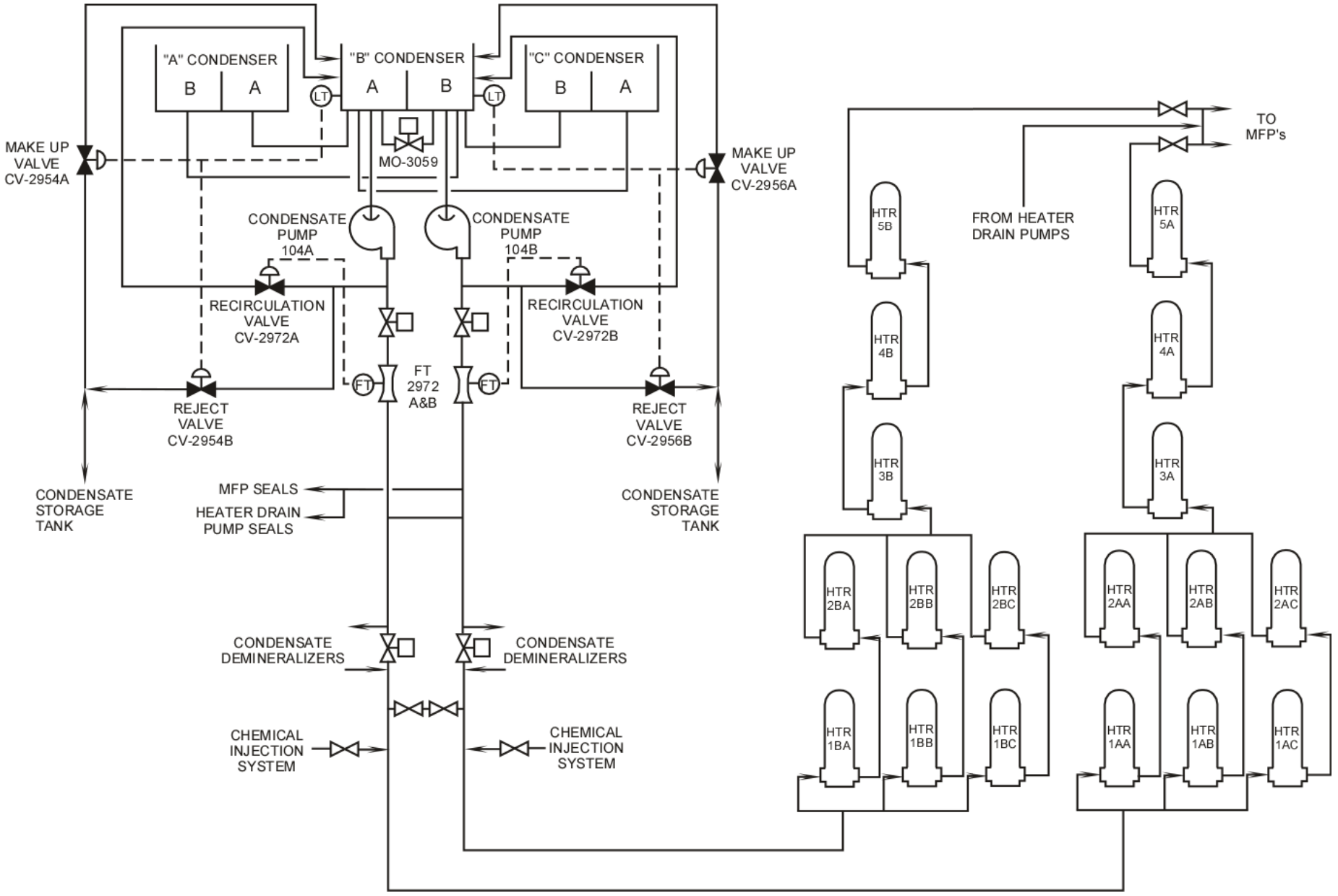
Fig. 7.2-3

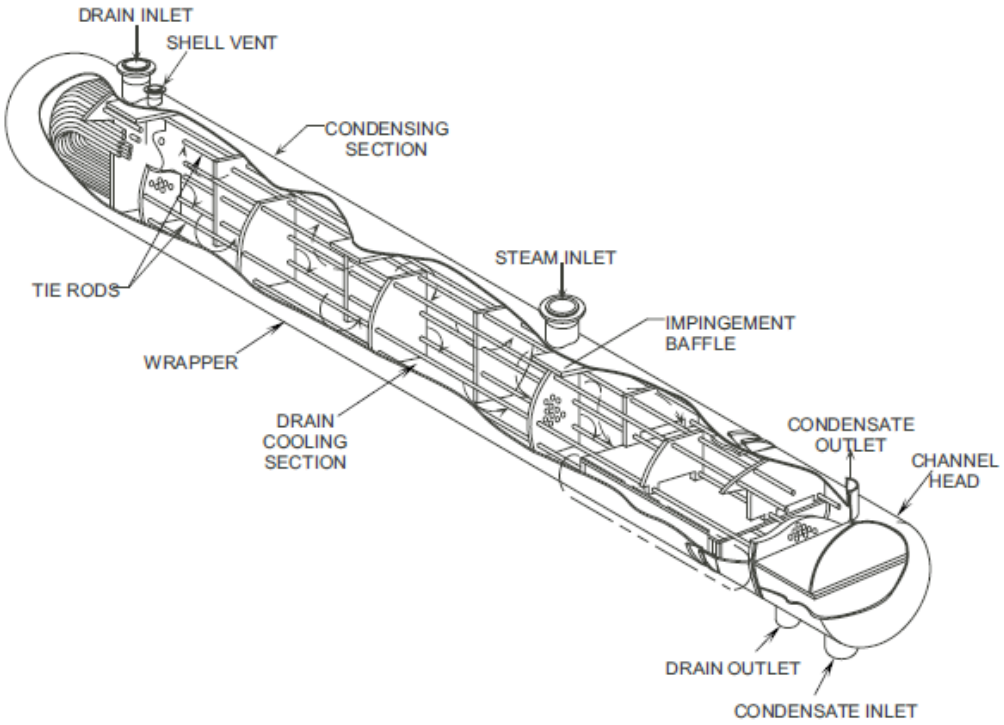
Low Pressure Feedwater Heaters

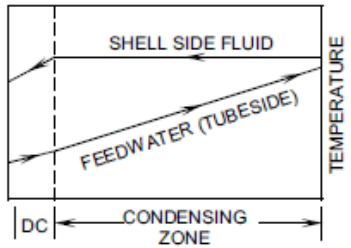
Objective 1.d

- Purpose - Transfer heat from turbine extraction steam to the feedwater to improve overall plant efficiency.
- Raise condensate temperature from ~ 120 deg. to ~ 360 deg.
- (LP turbine extraction – Heaters #1 – 4)
- (HP turbine exhaust – Heater #5)
- Heaters # 1 & 2 located in main condenser.

Fig. 7.2-2


"A" CONDENSER
B
A
"B" CONDENSER
A
B
"C" CONDENSER
B
A
LT
LT
MO-3059
MAKE UP VALVE CV-2954A
MAKE UP VALVE CV-2956A
CONDENSATE PUMP 104A
CONDENSATE PUMP 104B
RECIRCULATION VALVE CV-2972A
RECIRCULATION VALVE CV-2972B
FT
FT
FT 2972 A&B
REJECT VALVE CV-2954B
REJECT VALVE CV-2956B
CONDENSATE STORAGE TANK
CONDENSATE STORAGE TANK
MFP SEALS
HEATER DRAIN PUMP SEALS
CONDENSATE DEMINERALIZERS
CONDENSATE DEMINERALIZERS
CHEMICAL INJECTION SYSTEM
CHEMICAL INJECTION SYSTEM
FROM HEATER DRAIN PUMPS
TO MFP's
HTR 5B
HTR 5A
HTR 4B
HTR 4A
HTR 3B
HTR 3A
HTR 2BA
HTR 2BB
HTR 2BC
HTR 2AA
HTR 2AB
HTR 2AC
HTR 1BA
HTR 1BB
HTR 1BC
HTR 1AA
HTR 1AB
HTR 1AC





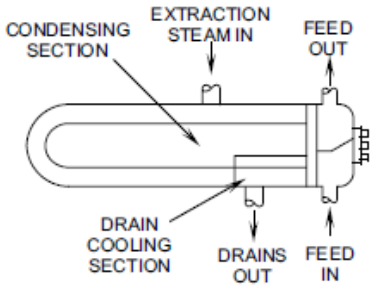
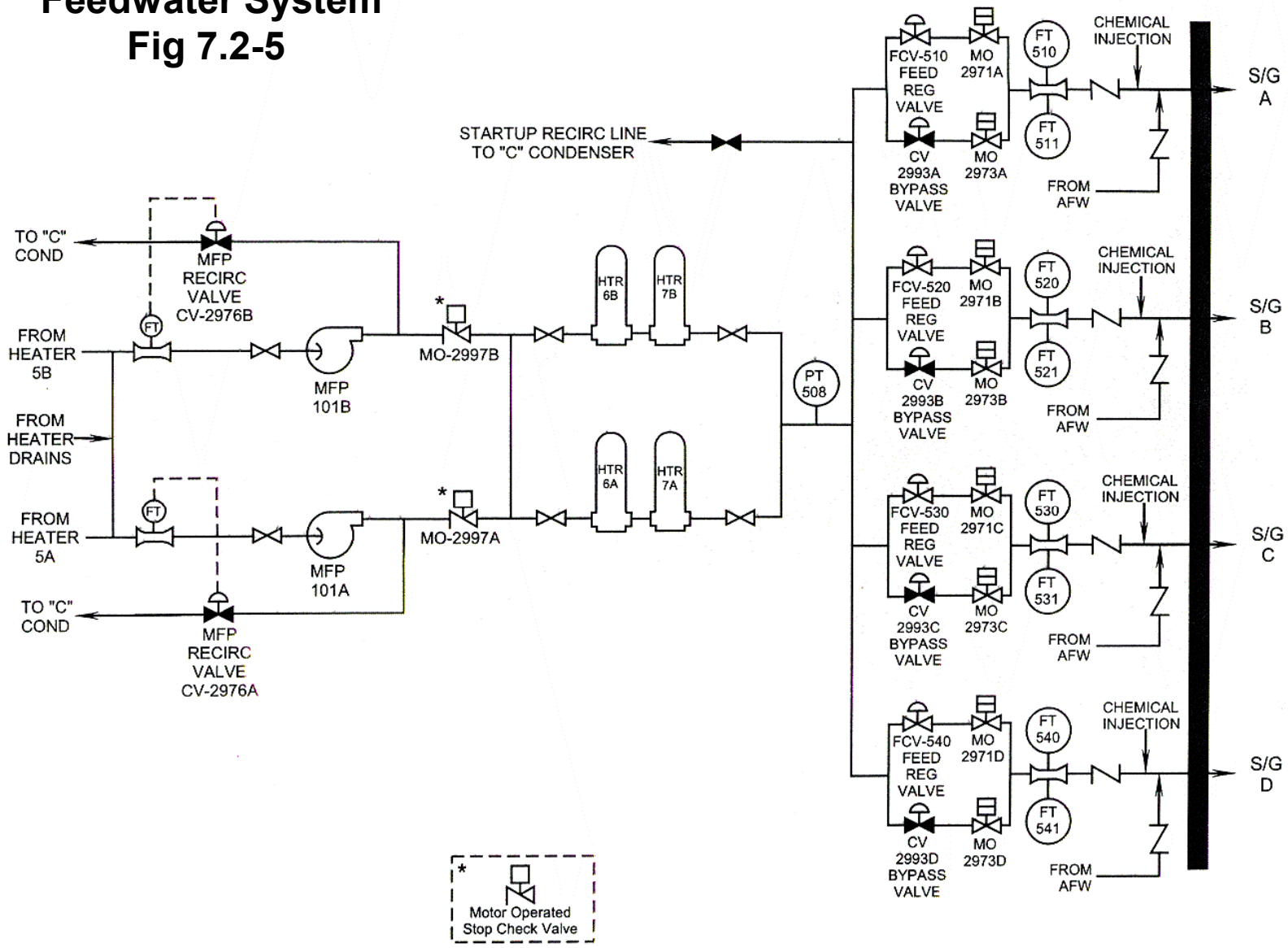


Figure 7.2-4 Feedwater Heater

Condensate Storage Tank Objective 1.I

- Provides makeup water for the condensate and feedwater system & the primary source of water for the AFW system.

Feedwater System
Fig 7.2-5



Main Feedwater Pumps Objective 1.e

- Purpose - Take a suction from Condensate System and the Heater Drain Pumps, raise the pressure of the feedwater, and transport it through the HP feedwater heaters to the S/Gs.

High Pressure Feedwater Heaters

Objective 1.f

- Purpose - Transfer heat from HP turbine extraction steam to the feedwater to improve overall plant efficiency.

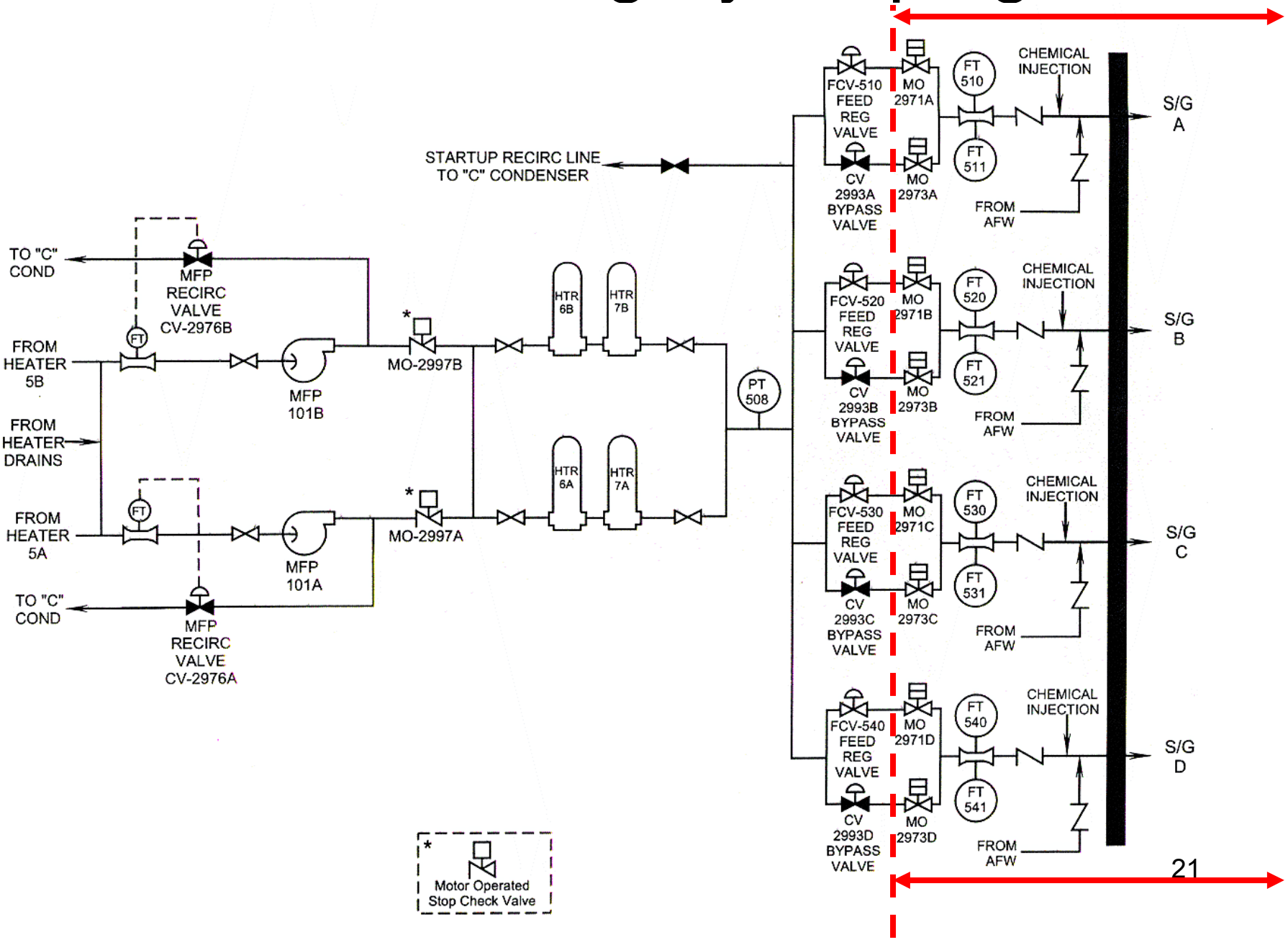
Feedwater Control Valves (FRV)

Objective 1.g

- Also called Feedwater Regulating Valves (14”):
  - Automatically control main feedwater flow to S/Gs > 15% power.
  - Can be manually operated.
  - Air operated.

- Bypass Feedwater Regulating Valves (6”):
  - Used to manually control main feedwater flow to S/Gs < 15% power.
  - Air operated.

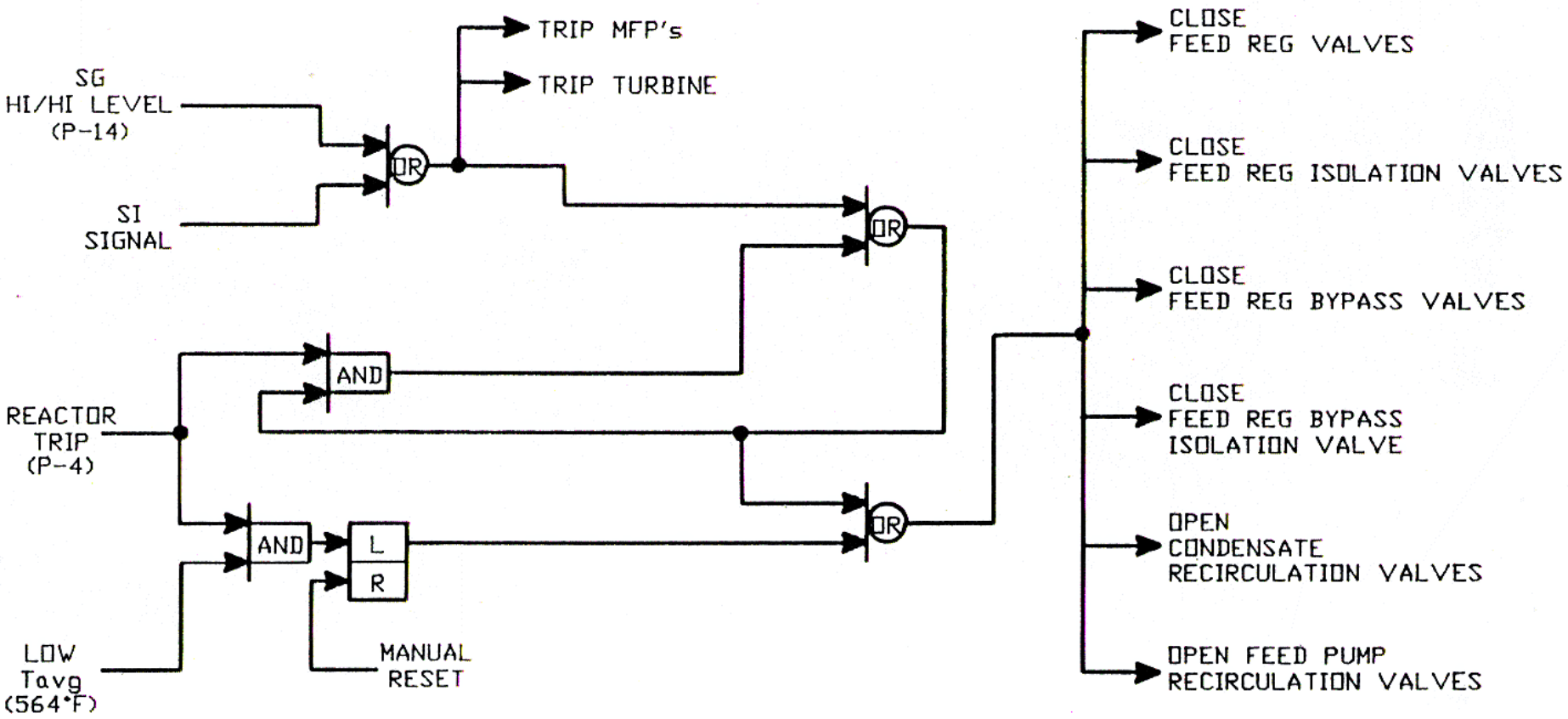
Seismic Category I Piping



Feedwater Isolation Valves (FWIV)

Objective 1.h

- Automatically isolates main feedwater to the S/Gs to prevent excessive cooldown of the RCS.
- Hydraulically operated gate valve – one for each FRV & bypass valve.
- Seismic Category I
- Auto close on feedwater isolation signals:
  - **SI signal**
  - **High High S/G level (> 69%) (P-14)**
  - **Rx trip (P-4) and Low Tave (2/4 < 564 deg.)**



Feedwater Isolation Logic

Other Seismic Cat I Components

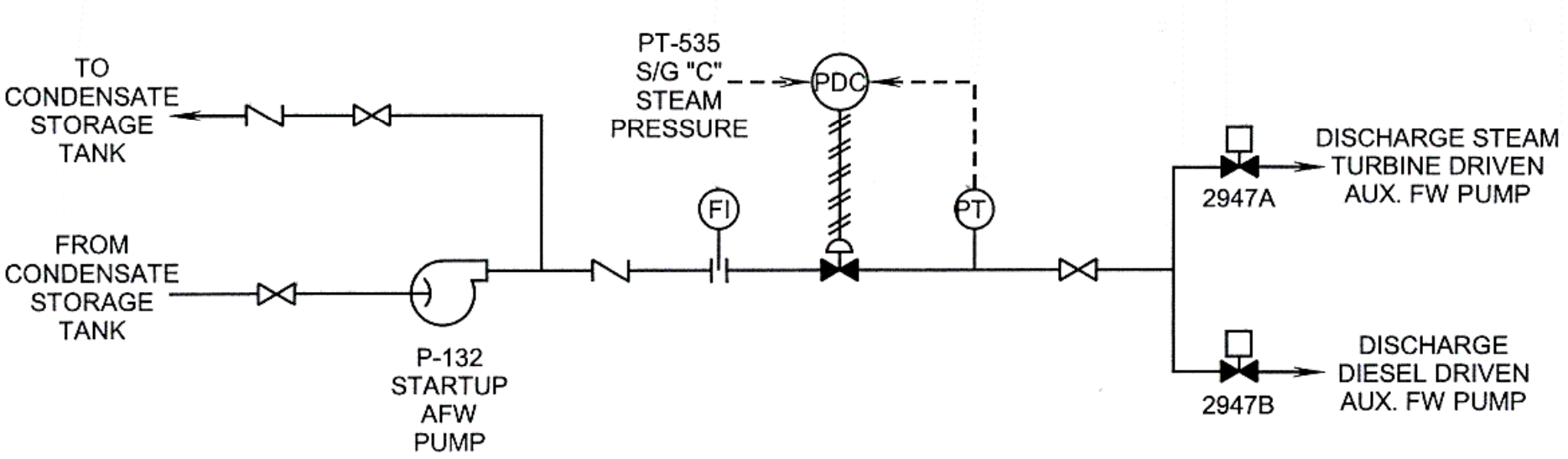
Objective 2

- Flow venturi with two flow transmitters:
  - provides feedwater flow signal to Feedwater Control System and Rx Protection System.
- Check valve: prevents the loss of S/G inventory from a feedwater system break upstream of the check valve.
- Chemical Injection Connection: for chemical addition to the S/Gs when plant is S/D.
- AFW Connection: provides a flow path for AFW to the S/Gs to remove decay heat.

Startup Auxiliary Feedwater Pump

Objective 1.j

- Provides feedwater flow to the S/Gs during normal startups & shutdown periods when main steam and MSR steam are not available.

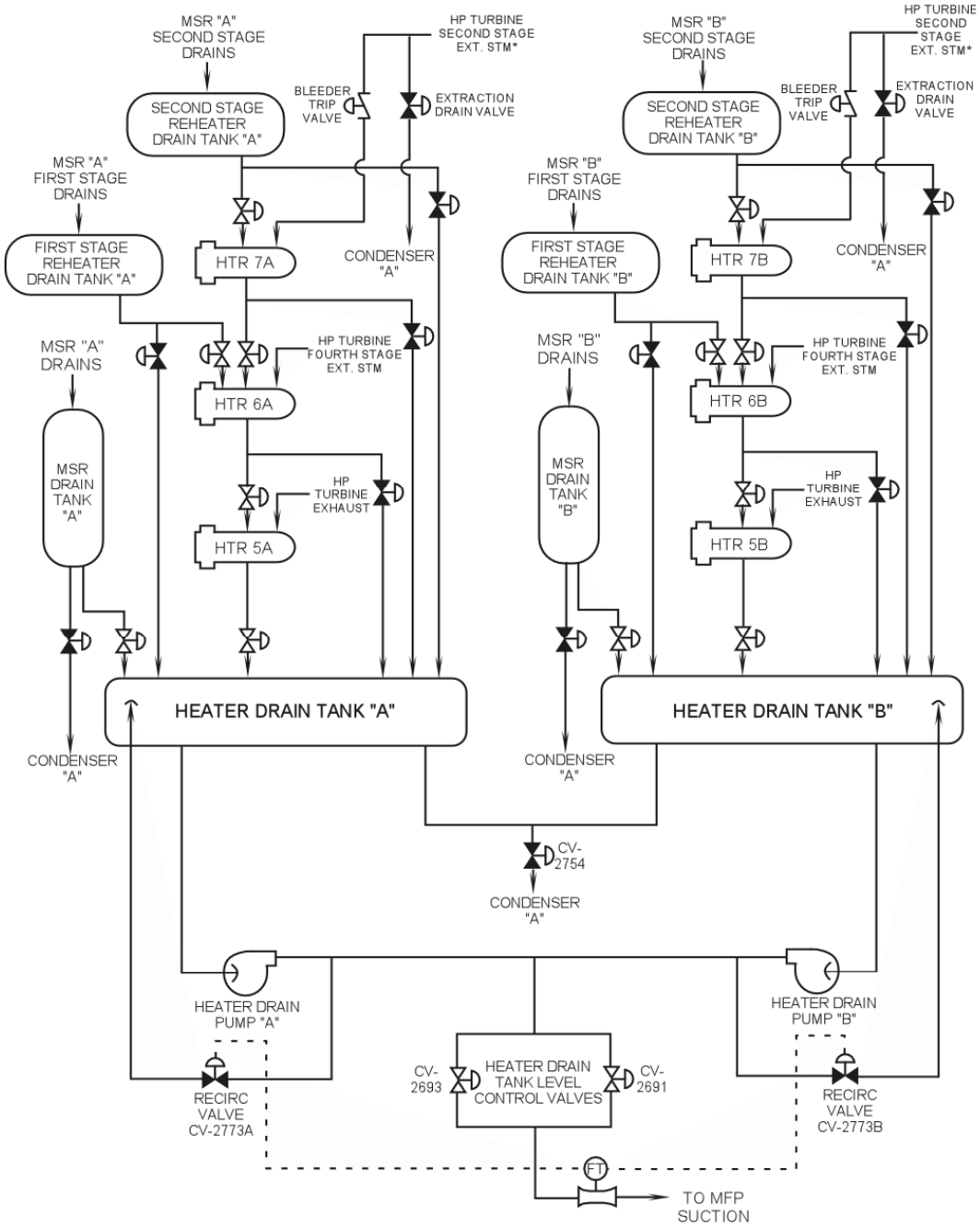


Steam Generators Objective 1.i

- Transfer energy from the primary to the secondary to produce dry, saturated steam for use in the main steam system.

- Provide a boundary between the primary and the secondary (U-tubes).

Fig 7.2-6
Heaters & Drains



*EXTRACTION STEAM SUPPLY AND DRAIN ARRANGEMENT TO EACH HEATER IN THIS FIGURE IS SIMILAR TO THAT SHOWN FOR HEATERS 7A & 7B. THE ARRANGEMENT IS NOT REPEATED FOR SIMPLICITY.

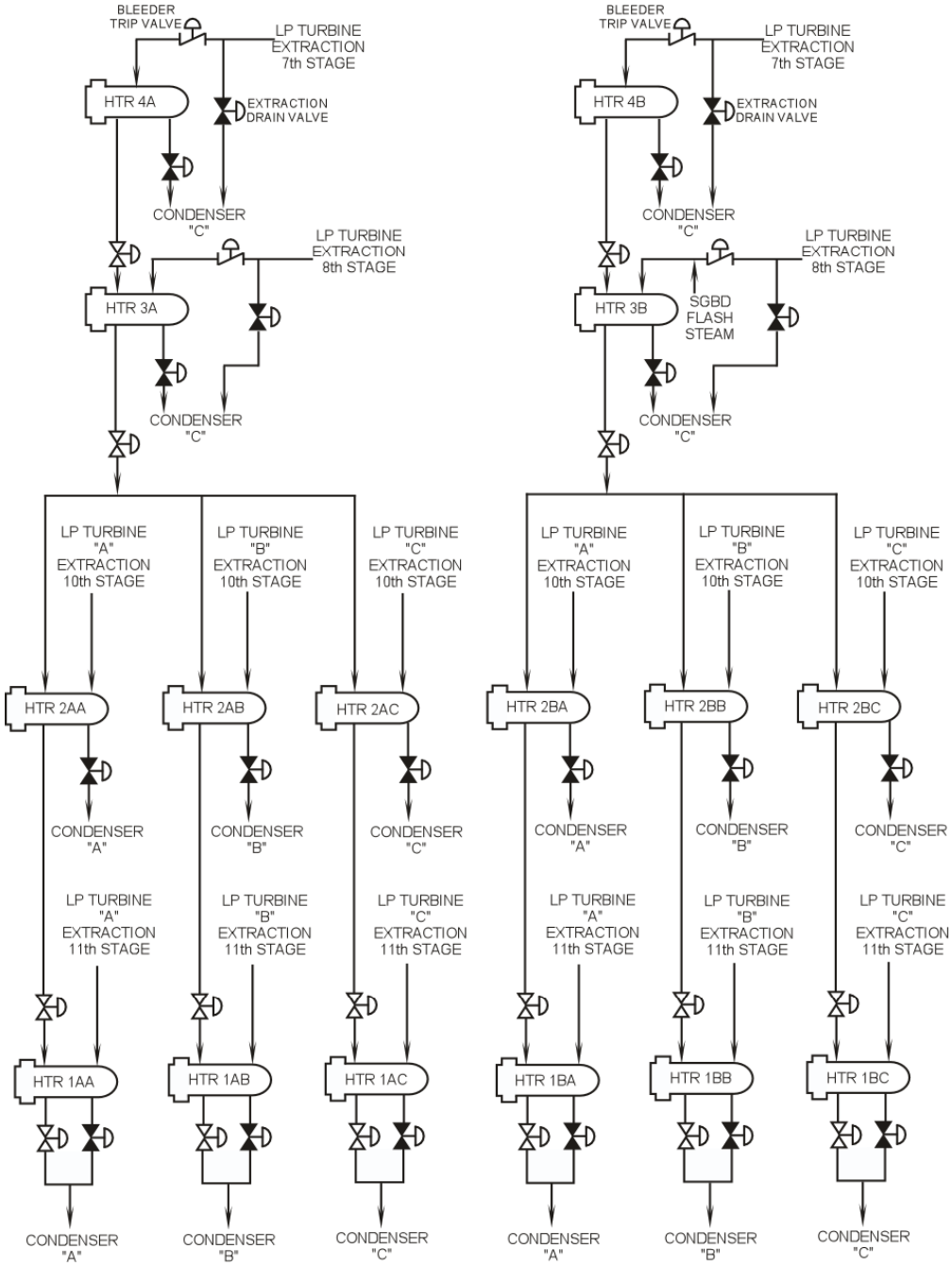
Heater Drain System Objective 1.k

- Collects condensed steam from MSRs and from high & low pressure feedwater heaters.
- Returns condensed steam from MSRs & HP FW HTRS to Heater Drain Tanks.
- Heater Drain Pumps supply suction of MFPs.
  - HDPs supply ~ 1/3 of the total suction flow to MFP.
- Returns condensed steam from LP FW HTRS to condenser.

Cascading Heater Drains Objective 3

- Improves secondary plant efficiency by allowing the repeated use of relatively hot water (condensed extraction steam) for FW heating.

Fig. 7.2-7


BLEEDER TRIP VALVE
LP TURBINE EXTRACTION 7th STAGE
HTR 4A
EXTRACTION DRAIN VALVE
CONDENSER "C"
LP TURBINE EXTRACTION 8th STAGE
HTR 3A
CONDENSER "C"
BLEEDER TRIP VALVE
LP TURBINE EXTRACTION 7th STAGE
HTR 4B
EXTRACTION DRAIN VALVE
CONDENSER "C"
LP TURBINE EXTRACTION 8th STAGE
HTR 3B
SGBD FLASH STEAM
CONDENSER "C"
LP TURBINE "A" EXTRACTION 10th STAGE
LP TURBINE "B" EXTRACTION 10th STAGE
LP TURBINE "C" EXTRACTION 10th STAGE
HTR 2AA
HTR 2AB
HTR 2AC
HTR 2BA
HTR 2BB
HTR 2BC
CONDENSER "A"
CONDENSER "B"
CONDENSER "C"
LP TURBINE "A" EXTRACTION 11th STAGE
LP TURBINE "B" EXTRACTION 11th STAGE
LP TURBINE "C" EXTRACTION 11th STAGE
HTR 1AA
HTR 1AB
HTR 1AC
HTR 1BA
HTR 1BB
HTR 1BC
CONDENSER "A"
CONDENSER "B"
CONDENSER "C"