U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Normal Residual Heat Removal System (RNS)

AP1000 Technology Section 6.1

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Learning Objectives

1. State the purpose of the Normal Residual Heat Removal System (RNS).

2. Describe the major differences between the AP1000 RNS and current operating Westinghouse plants Residual Heat Removal (RHR) System.

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RNS System Purposes

1. Remove heat from the core and the RCS during shutdown operations.
2. Provide RCS and refueling cavity purification flow to CVCS during refueling operations.
3. Provide cooling for the in-containment refueling water storage tank.
4. Provide low pressure makeup to the reactor coolant system.
5. Remove heat from the core and the RCS following successful mitigation of an accident by the passive core cooling system.

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RNS System Purposes (cont.)

6. Provide low temperature overpressure protection (LTOP) for the RCS during refueling, startup, and shutdown operations.
7. Provide long-term, post-accident makeup flowpath to the containment inventory.
8. Provide backup for cooling the spent fuel pool.

Shutdown Cooling

- The RNS reduces the temperature of the reactor coolant system from 350° to 125°F within 96 hours after shutdown.
- The system maintains the RCS temperature at or below 125°F for the plant shutdown.
- First phase of cooldown performed by primary-to-secondary heat transfer reduces the RCS temperature to less than or equal to 350°F and 450 psig.

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RNS Shutdown Cooling

- 1st Phase of cooldown takes 4 hrs.
- RNS placed I/S at 350°F and 450 psig.
- RNS is designed to reduce RCS temperature from 350 to 125°F within 96 hours.
- With only one train I/S RNS can still perform this task, it just takes longer.

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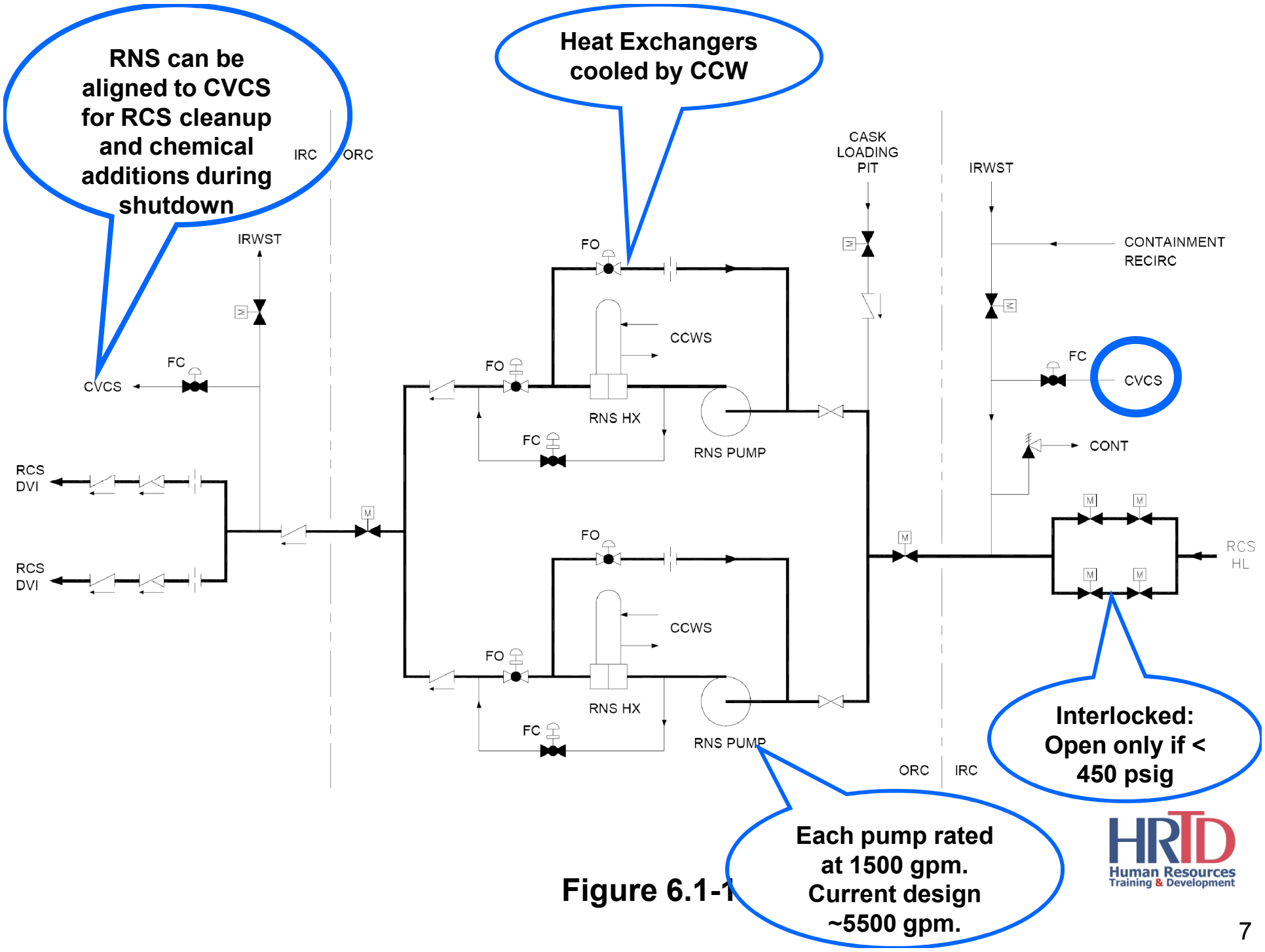

Figure 6.1-1

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RNS Hx Arrangement

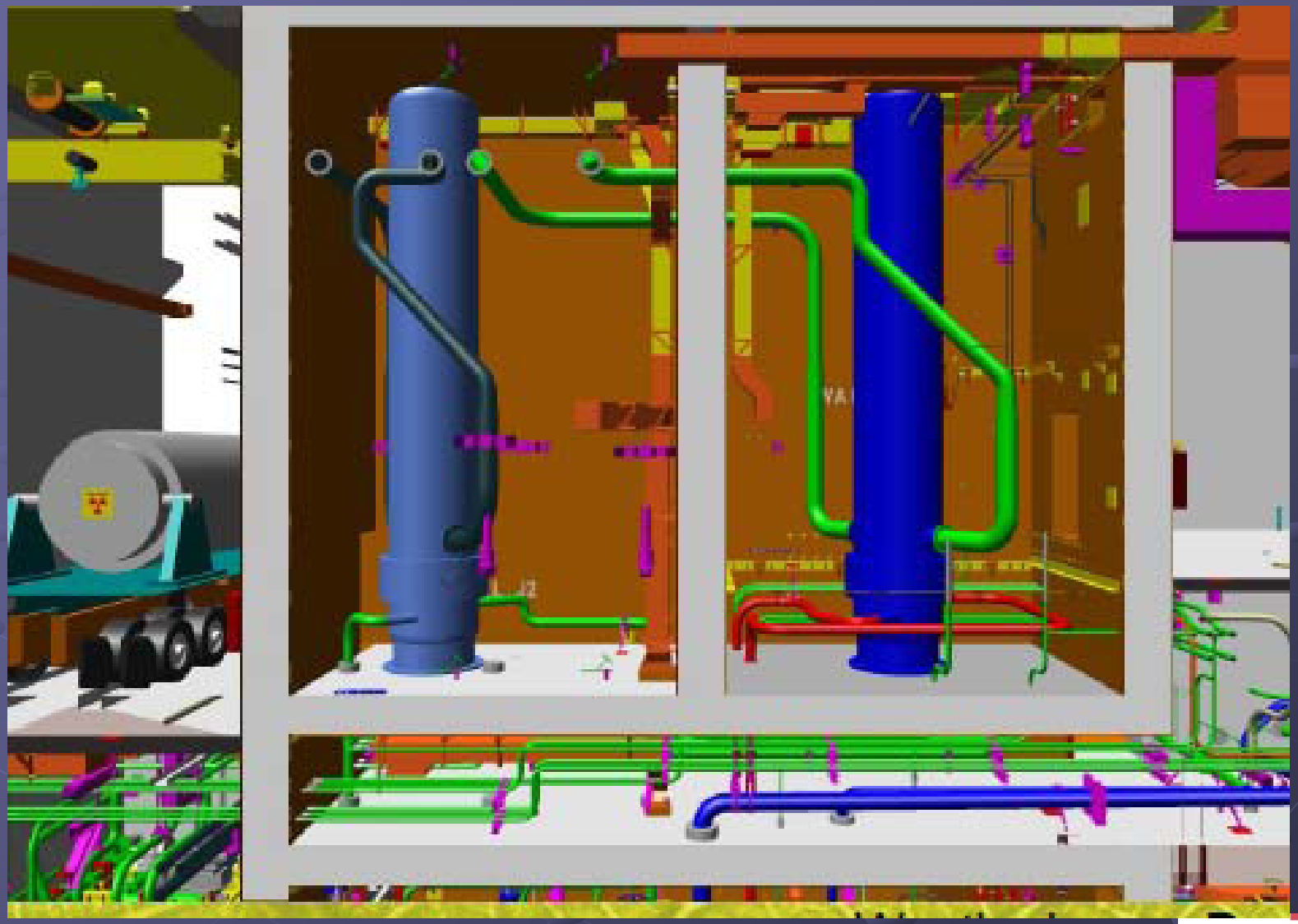
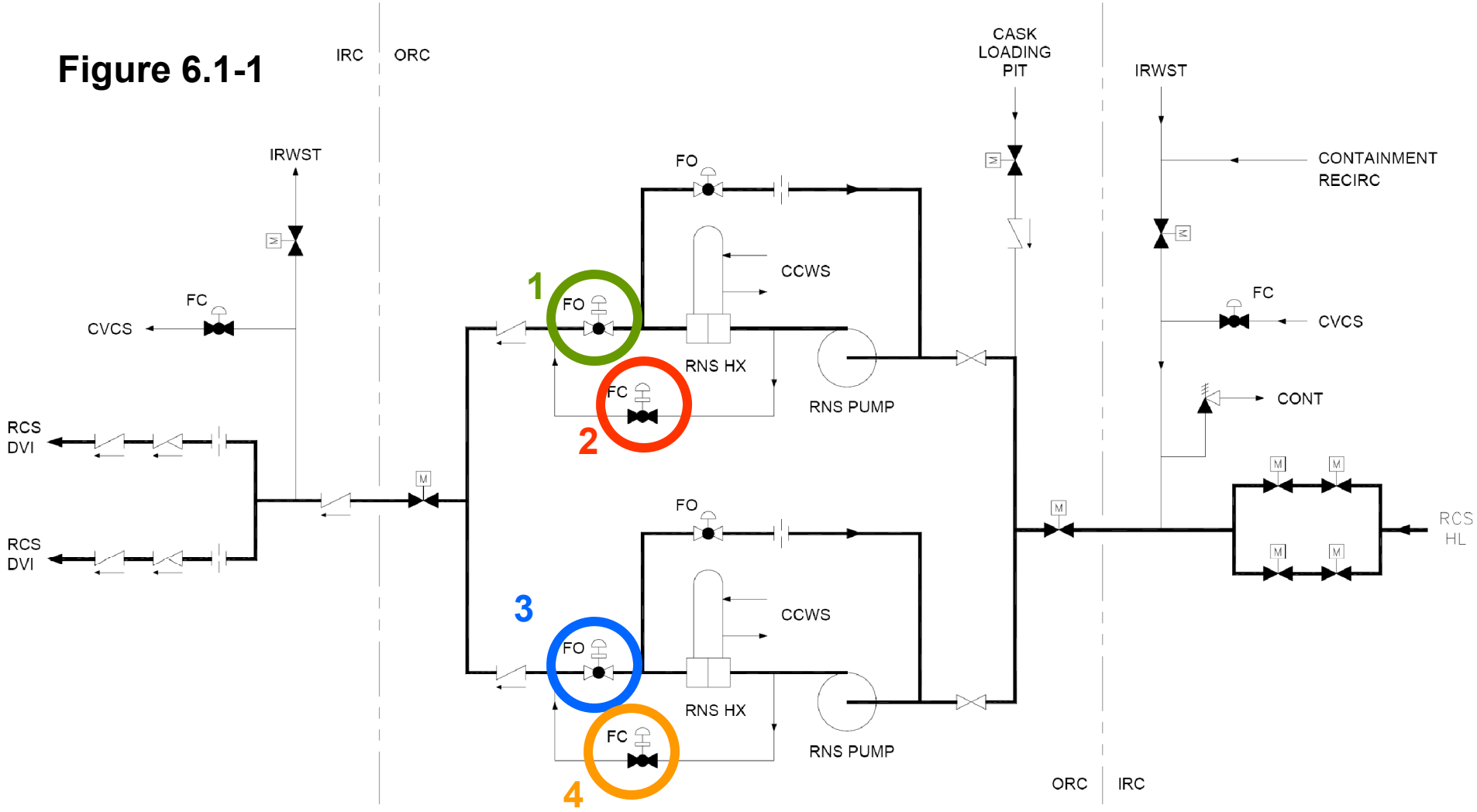


Figure 6.1-1



To perform cooldown and control temperature operator adjusts the positions of valves 1, 2, 3, & 4.

By bypassing flow trough the RNS Hx Cooldown (& heatup) rates can be changed.

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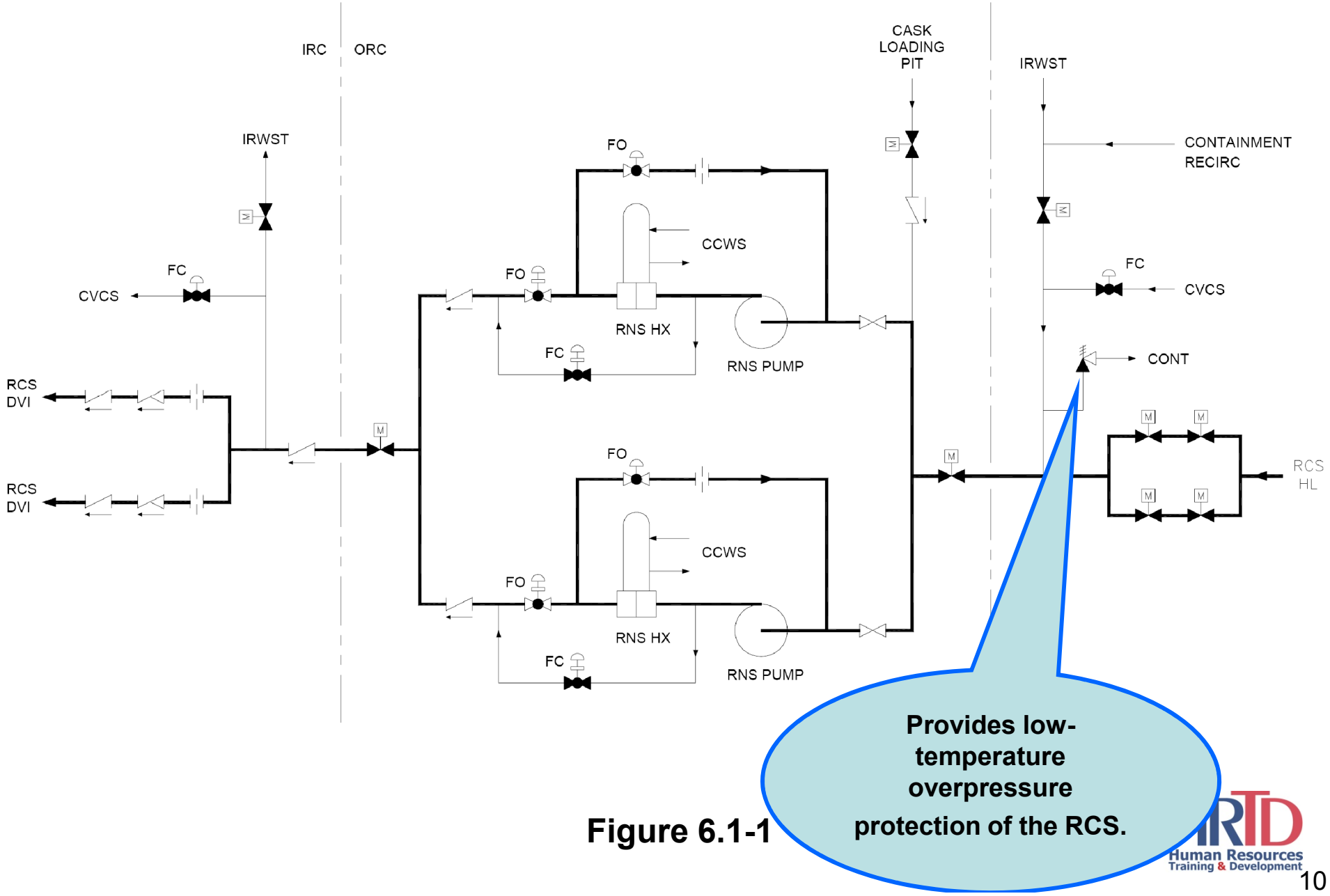

Figure 6.1-1

Provides low-temperature overpressure protection of the RCS.

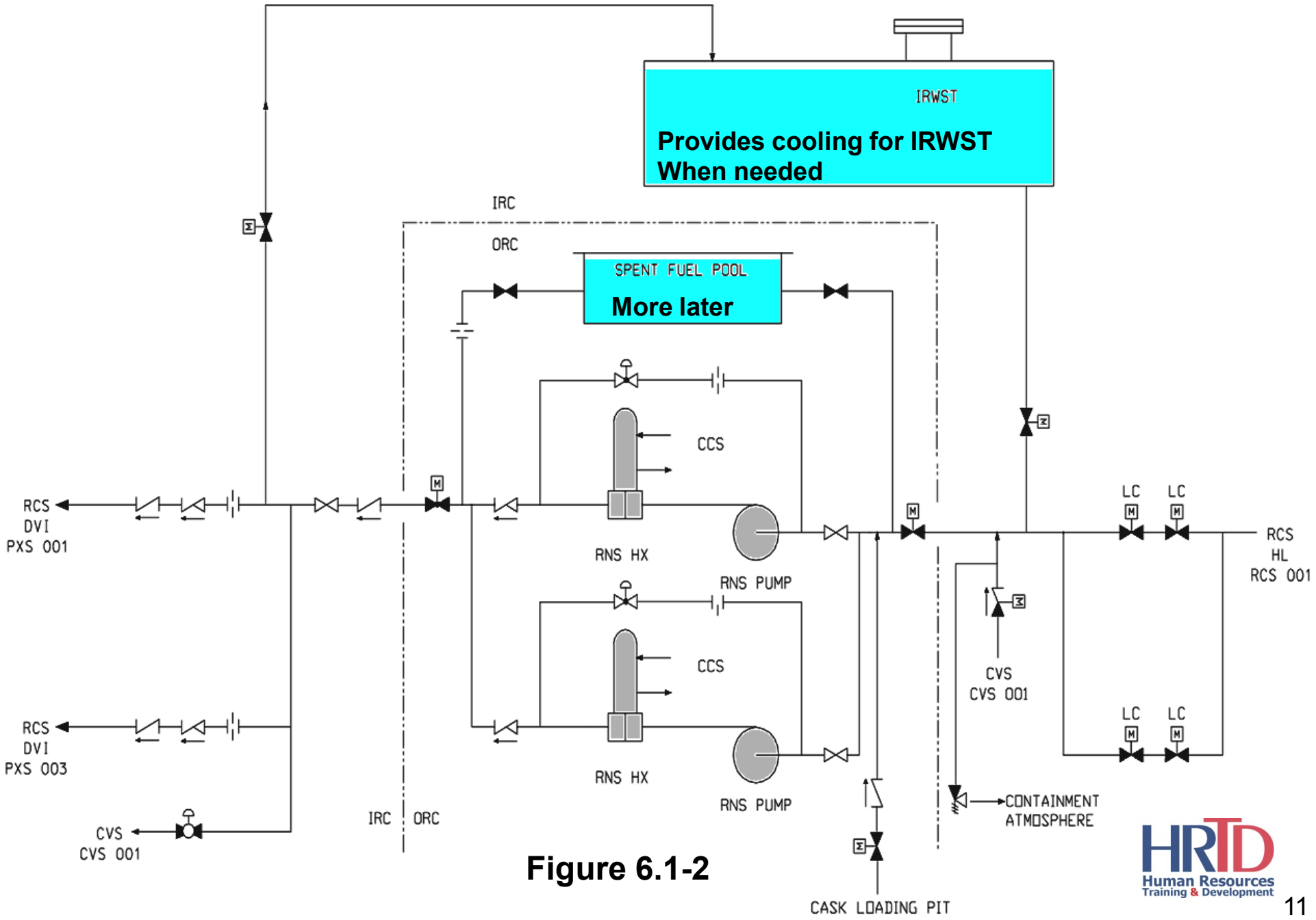

Figure 6.1-2

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Design Features Addressing Intersystem LOCA (SECY 90-016)

- Portions of RNS from the RCS to the outside containment iso valves are designed to RCS operating pressure.
- The isolation valve in the pump suction line from the RCS is designed to the RCS pressure.
- Relief valve in the high pressure portion of the pump suction line reduces the risk of overpressurizing the low pressure portions of the system.
- Suction isolation valves are interlocked to prevent their opening at RCS pressures above 450 psig.

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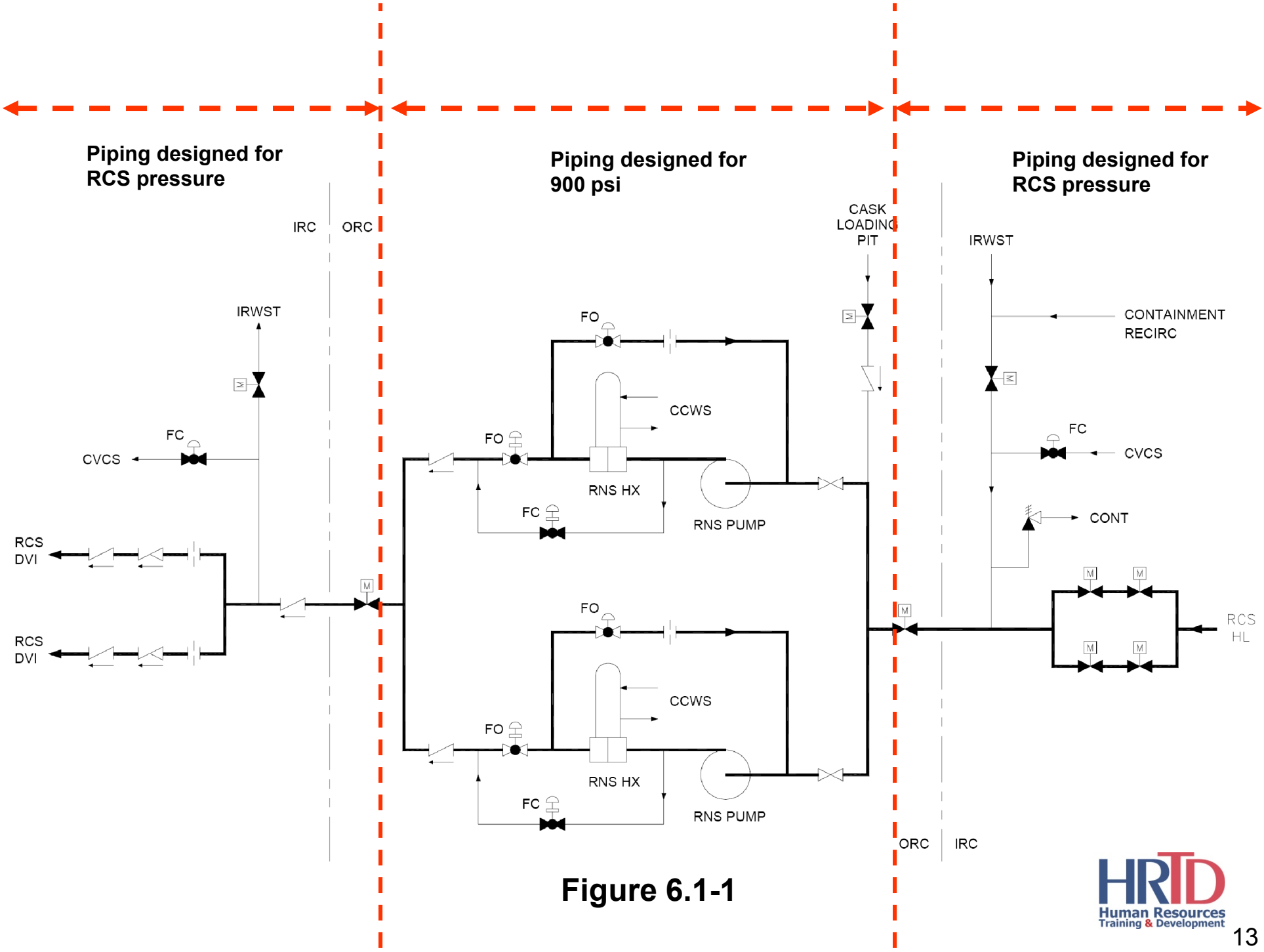
Piping designed for RCS pressure
Piping designed for 900 psi
Piping designed for RCS pressure
IRC
ORC
IRWST
FC
CVCS
RCS DVI
RCS DVI
FO
CCWS
FO
RNS HX
FC
RNS PUMP
FO
CCWS
FO
RNS HX
FC
RNS PUMP
CASK LOADING PIT
IRWST
CONTAINMENT RECIRC
FC
CVCS
CONT
RCS HL
ORC
IRC

Figure 6.1-1

Design Features Addressing Shutdown and Mid-Loop Operations (GL 88-17)

- RCS hot legs and cold legs are vertically offset.
- Step-nozzle connection to the RCS hot leg.
- The RNS pumps are designed to minimize susceptibility to cavitation.
- Self-Venting Suction Line.
- WR pressure and hot leg level instrumentation.

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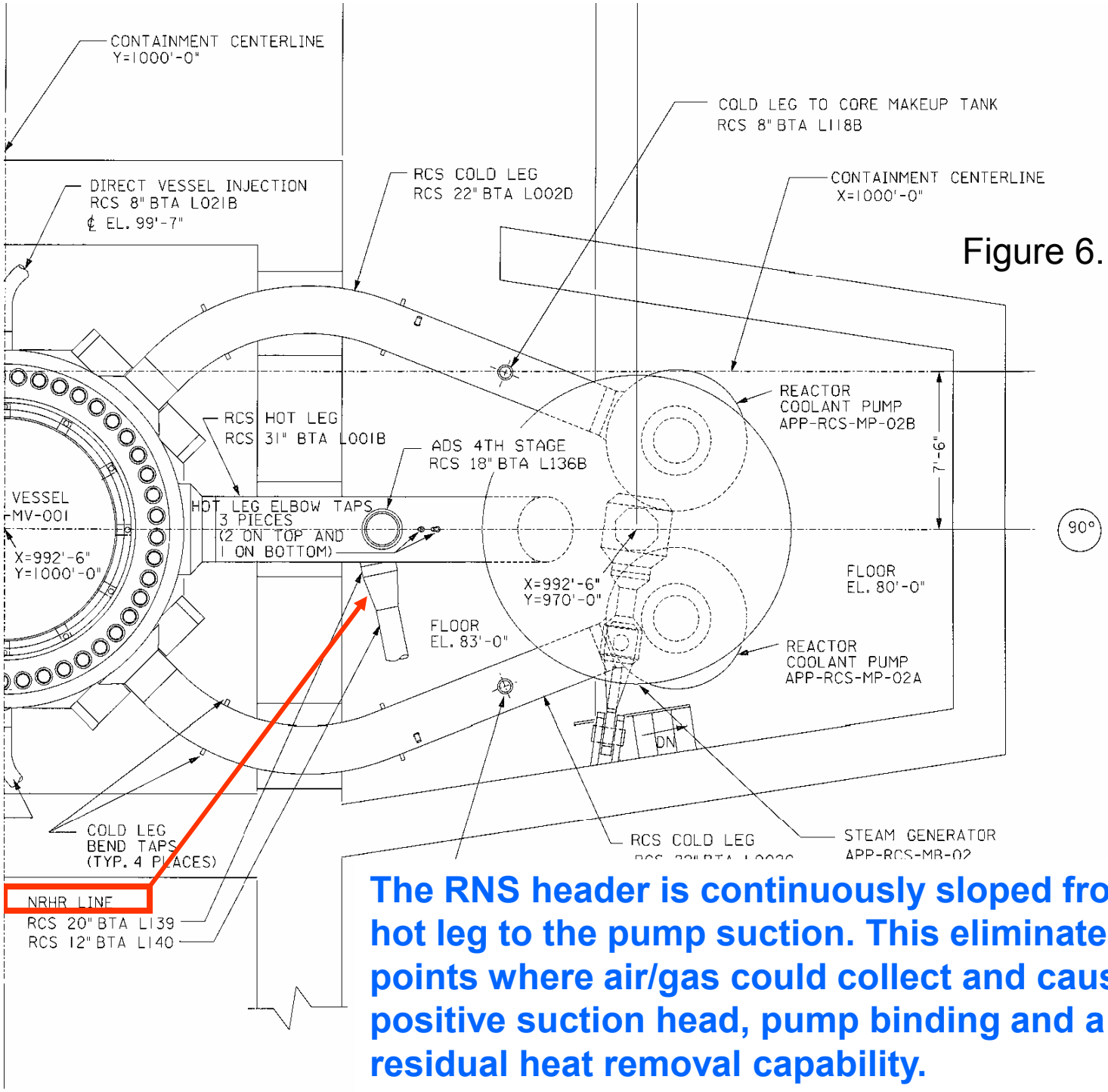

Figure 6.1-3

The RNS header is continuously sloped from the RCS hot leg to the pump suction. This eliminates local high points where air/gas could collect and cause low net positive suction head, pump binding and a loss of residual heat removal capability.

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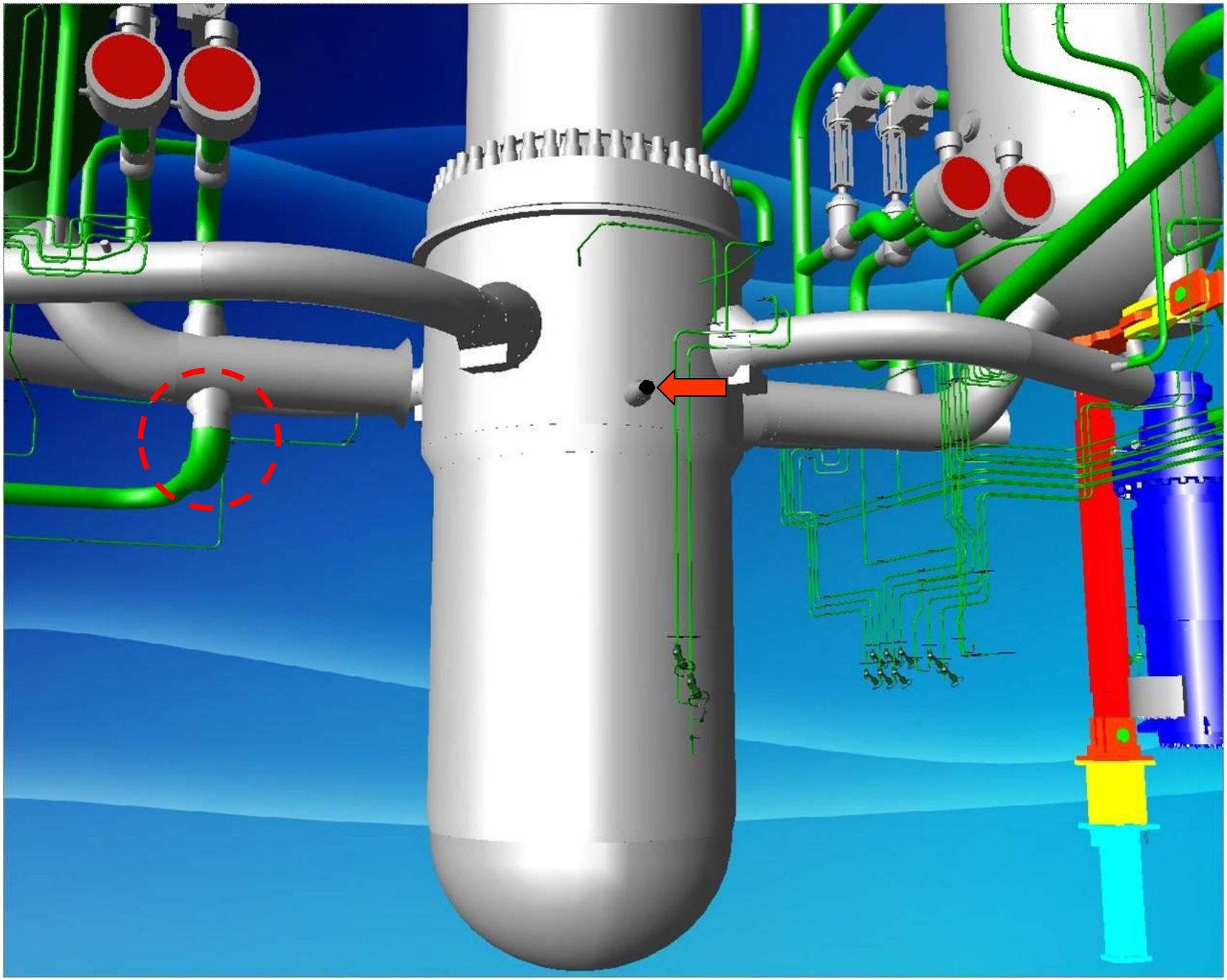
Step-nozzle Connection



Questions?

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Which one of the following is NOT a function of RNS?

A. Removes decay heat when < 350°F in RCS.
B. Provides high pressure injection during accidents.
C. Provides cooling for the IC RWST.
D. Provides a flowpath for RCS cleanup during shutdown operations.

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When RNS is operated in the decay heat removal mode, it takes a suction on _____ and discharges to _____.

A. the IC RWST, the RCS hot legs
B. an RCS hot leg, the Rx vessel
C. an RCS cold leg, the Rx Vessel
D. the IC RWST, the RCS cold legs

One feature that protects the RNS against over pressurization is…

A. Auto closure of RNS discharge valves on high RCS pressure.
B. A power operated relief valve (PORV) on the RNS suction line.
C. Interlock to prevent the opening of RNS suction valves when RCS pressure is high.
D. The RNS minimum flow bypass line.