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USE OF PCV-18 IN EMERGENCY COOLDOWN

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WANL-TME-818

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INTRODUCTION

In the event of a nozzle or main propellant line failure during the NRX-A2 test, emergency coolant flow can be supplied only through the emergency purge line in the pressure vessel dome. The ambient GH_2 flow rates required for dome end cooling are shown in figure 5-39 of WANL-TNR-148 for various core exit temperatures. This memo presents the results of an analysis of the present emergency purge line plus modifications to the line that will meet the emergency cooling requirements of WANL-TNR-148.

SUMMARY

An analysis based on the requirements of WANL-TNR-148 was performed and the results indicated that the maximum requirement of 25 lb/sec could be met with a PCV-18 upstream pressure of 3,000 psi. The analysis was extended to include a more conservative PCV-18 upstream pressure of 1,400 psi, as might be expected near the end of a test.

To flow 25 lb/sec with a PCV-18 upstream pressure of 1,400 psi, the following modifications to the line are deemed necessary: (1) remove the present 1.7 inch diameter orifice from the 3 inch line and install an orifice in the 6 inch section downstream of the valve with a diameter of 3.5 inches. (2) Replace the 3 inch schedule 160 line upstream of the 4 inch plug section with 4 inch schedule 160 line. This modification is shown in figure 2. It is also recommended that a relief be provided for this line, and that an orifice be installed downstream of OBV-83 valve in the 3 inch helium line for the purpose of measuring flow.

ANALYSIS

The present emergency purge line is shown in figure one. The following equations were used to describe the flow in the PCV-18 line:

$$1. \dot{W} = 0.00611 C_D A_V P_u f \left(\frac{P_i}{P_u} \right) \quad \text{PCV-18}$$

$$2. \dot{W} = 0.525 d^2 \sqrt{\frac{P \rho}{K}} \quad \text{Piping}$$

$$3. \dot{W} = 0.00611 C_D A_O P_d f \left(\frac{P_e}{P_d} \right) \quad \text{Orifice}$$

$$4. \dot{W} = 0.525 Y d^2 \sqrt{\frac{P \rho}{K}} \quad \text{Piping}$$

$$5. \dot{W} = 0.1 P r \quad \text{Reactor}$$

where:

$\dot{W}$ = Flow rate - lb/sec

C_D = Coefficient of discharge

A_V = Net orifice area of PCV-18 - 3.8 in²

P_u, P_a, P_d = Pressure - Psig

P_e, P_f

$$f \left(\frac{P_a}{P_u} \right) = \frac{C_1}{C_2} \left(\frac{P_a}{P_u} \right) \quad 1/K \sqrt{1 - \left(\frac{P_a}{P_u} \right) \frac{K-1}{K}}$$

$$C_1 = g \sqrt{\frac{2K}{R(K-1)}} \quad C_2 = g \sqrt{R \left(\frac{K+1}{2} \right) \frac{K+1}{K-1}}$$

Y = Net Expansion Factor

d = I.D. of Pipe - In

ρ = Density - lb/ft³

A_O = Orifice Area - in²

A trial and error solution of the five above equations gave a flow rate of 25.5 lb/sec with a PCV-18 upstream pressure of 3,000 psi. With a PCV-18 upstream pressure of 800 psi, a trial and error solution of the above equations gave a flow rate of 6.5 lb/sec.

It was known that a PCV-18 upstream pressure of 3,000 psi would meet the emergency cooling requirements of 25 lb/sec. This pressure could be obtained if the tank was still fully pressurized to its pre-run level, but if the emergency occurred when the tank was at a pressure less than the pre-run level the emergency cooling requirements could not be met. To meet the emergency cooling requirements with a PCV-18 upstream pressure of 1,400 psi, modifications must be made to the line. All modifications include only the piping inside the flow control room.

From the calculations made on the present line it was noted that the 1.7 inch diameter orifice was the limiting component in the line. Additional calculations indicated that the following modifications would enable the line to meet the emergency cooling requirements: (1) Remove the present 1.7 inch diameter orifice in the 3 inch line and install an orifice with a diameter of 3.5 inches in the 6 inch section downstream of PCV-18, (2) Replace the 3 inch schedule 160 line with 4 inch 160 line which would mate with the 4 inch section in the FCR wall. These proposed modifications are shown in figure two.

PRESENT EMERGENCY
PURGE LINE

NOTE:
FOR TEST CAR PIPING
SEE DWG. 709J832

FIGURE 1

PROPOSED EMERGENCY
BURGE LINE

FIGURE 2