SNUPPS
Standardized Nuclear Unit
Power Plant System

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SLNRC 81-97 FILE: 0278
SUBJ: Event V Program

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Docket Nos.: STN 50-482, STN 50-483, and STN 50-486

Dear Mr. Denton:

In a meeting on June 9-10, 1981 with the NRC's Mechanical Engineering Branch, the SNUPPS applicants agreed to submit a program for periodic leak testing the isolation between low pressure systems and the reactor coolant pressure boundary.

Transmitted herewith is a report of the SNUPPS Event V program. Since some of the valves involved in the Event V program are in direct contact with the reactor coolant system, radiation levels may become high during the life of the plant and unnecessary maintenance should be avoided to minimize exposure. It is therefore desirable to establish an allowable leakage rate for these valves, based upon the plant specific design, which will not compromise safety and will not adversely effect plant maintenance requirements.

As noted in the attached evaluation, the NRC has considered check valve leakage rates of greater than 5 gallons per minute to be unacceptable. However, for the SNUPPS design, a leakage rate of up to 20 gallons per minute would not compromise safety. SNUPPS plans to use an allowable leakage rate criterion of ≤10 gallons per minute.

Very truly yours,

N A Petrick

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Enclosures

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I. INTRODUCTION

The Reactor Safety Study, WASH-1400, identified that plants with pressurized water reactors have the probability of sustaining an intersystem loss of coolant accident (LOCA) which is a significant contributor to the risk of core melt accidents (Event V). The design examined in WASH-1400 contained in-series check valves isolating the high pressure piping (Reactor Coolant System) from the low pressure piping. The scenario used which led to the Event V accident was initiated by in-series check valves failing to function as a pressure isolation barrier. The Reactor Safety Study then concluded that this accident causes an overpressurization and rupture of the low pressure piping thereby resulting in a LOCA that bypasses containment.

The Nuclear Regulatory Commission (NRC) has determined that the probability of failure of the in-series pressure isolation barrier check valves can be significantly reduced if these valves receive periodic leak testing or the pressure at each valve is continuously monitored.

II. GENERAL

In order for the SNUPPS piping system to have an Event V valve configuration, the following items must be fulfilled:

1. The high pressure system must be connected to the

Primary Coolant System;

2. There must be a high pressure/low pressure interface present in the line;
3. This same piping must eventually lead outside containment;
4. The pipe line size must be greater than 1" in diameter;
5. One of these valve configurations must be present.

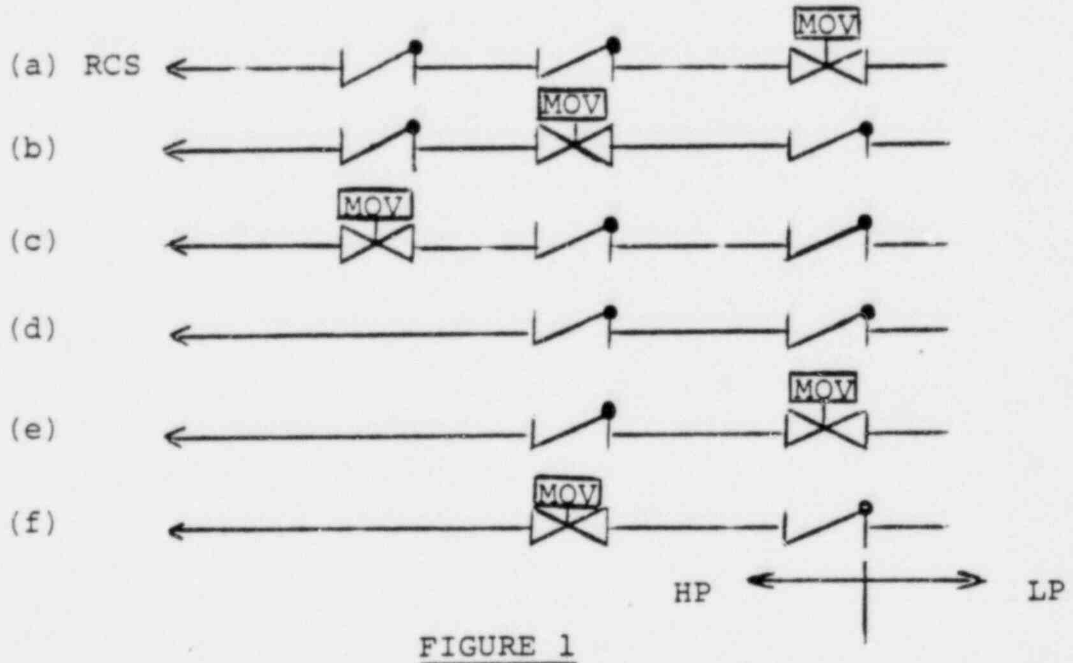


FIGURE 1

The SNUPPS design has two subsystems which satisfy the Event V valve configuration, that is, the cold leg injection system and the hot leg injection system. Specifically, these systems conform to the requirements of 1 thru 4 and have a valve line up identical

to 5(a).

III. EVENT V CRITERIA

The purpose of the Event V valve testing is to reduce the probability of an intersystem LOCA to acceptable levels. To accomplish this, the NRC has stated that each in-series check valve should be periodically tested. The NRC mandated that testing may be accomplished by direct volumetric leakage measurement or by other equivalent means. The preferable test, as viewed by the NRC, is the volumetric leakage test. In the Franklin Research Center Report, the NRC's established criteria for frequency of testing, test conditions, and acceptable leakage rates were cited.

The frequency of testing is (1) at every refueling period or (2) every time the plant is placed in a cold shutdown condition for 72 hours, if testing has not been accomplished in the preceeding 9 months or (3) each time the check valve moved from the fully closed position or (4) prior to returning the valve to service after maintenance.

The hydrostatic pressure criteria requires that leakage tests be conducted at functional pressures, if possible. When leakage tests are conducted at pressure differentials lower than function pressure differentials, then calculations approximating the required adjustment will be performed.

The leakage rates which the NRC deems acceptable are:

1. Leakage rates $\leq$ 1.0 gpm are unconditionally acceptable.
2. Leakage rates $>$ 5.0 gpm are unacceptable.
3. Leakage rates $>$ 1.0 gpm but $\leq$ 5.0 gpm are acceptable if the latest measured rate has not exceeded the rate determined by the previous test by an amount that reduces the margin between measured leakage rate and the maximum permissible rate of 5.0 gpm by 50% or greater. If this rate is exceeded, it is deemed unacceptable.

IV. TECHNICAL EVALUATION

The NRC's criteria and methodology for reducing the probability of an intersystem LOCA is, in part, an acceptable approach. However, the maximum leakage rate limitation of 5.0 gpm is not technically justified. In addition, the NRC did not take into account that the valves identified on Figure 2 were performance tested per ASME Section XI, Subsection IWV nor did they account for the pressure relief valves located in the low pressure piping being used.

Since the NRC's approach was not completely substantiated with supportive information, SNUPPS believes that alternate approaches should also be considered. One approach which is analogous to the NRC's

approach in reducing the probability of an intersystem LOCA is a go-no go flow test.

In order for an Event V LOCA to occur in the SNUPPS design, two in-series pressure isolation check valves must fail. This failure would result in one of two leakage modes, which SNUPPS defines as minor leakage ($\leq$ 20 gpm) or major leakage ($>$ 20 gpm). This division is based on the relief valve capacities shown in Table 1.

TABLE 1

RELIEF VALVE NO.	SET POINT (PSIG)	CAPACITY (GPM)
8842	600	20
8851	1750	20
8855 A	1750	20
8855 B	1750	20
8856 A	600	20
8856 B	600	20

As indicated in Section II of this report, the SNUPPS design has two subsystems which meet the Event V criteria. For clarity each system, that is, the cold leg injection system and the hot leg injection system will be discussed separately.

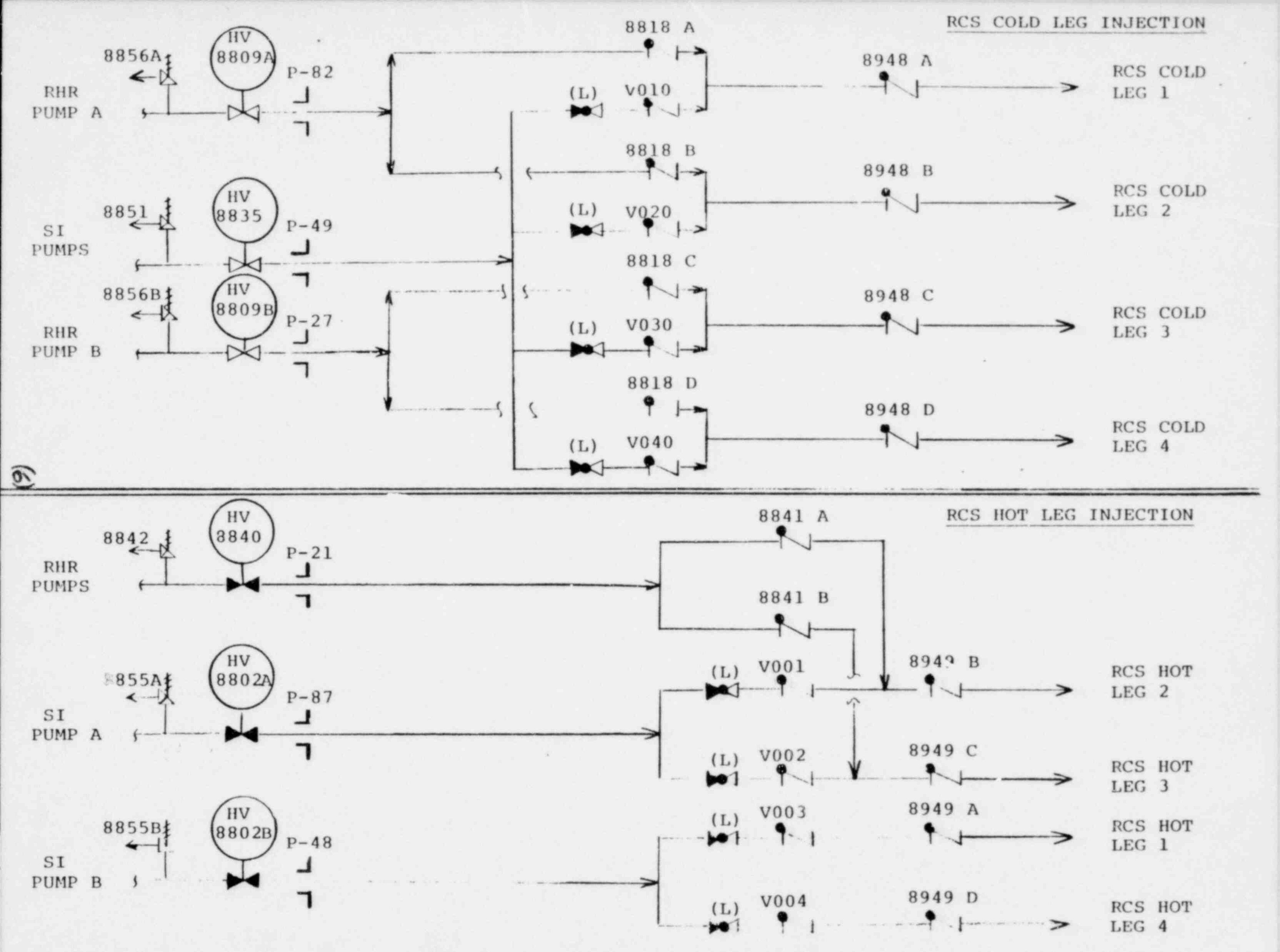

RCS COLD LEG INJECTION
8856A
HV 8809A
P-82
RHR PUMP A
8818 A
(L)
V010
8948 A
RCS COLD LEG 1
8818 B
8948 B
RCS COLD LEG 2
8851
HV 8835
P-49
SI PUMPS
(L)
V020
8818 C
8856B
HV 8809B
P-27
RHR PUMP B
8948 C
(L)
V030
RCS COLD LEG 3
8818 D
8948 D
(L)
V040
RCS COLD LEG 4
RCS HOT LEG INJECTION
8842
HV 8840
P-21
RHR PUMPS
8841 A
8841 B
8855A
HV 8802A
P-87
SI PUMP A
(L)
V001
8949 B
RCS HOT LEG 2
(L)
V002
8949 C
RCS HOT LEG 3
8855B
HV 8802B
P-48
SI PUMP B
(L)
V003
8949 A
RCS HOT LEG 1
(L)
V004
8949 D
RCS HOT LEG 4

FIGURE 2

V. COLD LEG SAFETY INJECTION SYSTEM

The SNUPPS plants have been designed with a permanently installed system capable of measuring leakage in the cold leg safety injection system check valves associated with the postulated Event V accident. This system is shown diagramatically in Figure 3 for the cold leg injection line to RCS cold leg loop 1 and is typical for the cold leg safety injection system to all four reactor coolant loops.

The lower pressure rated piping associated with the cold leg safety injection system is located outside containment, upstream of the normally open MOV. This piping which is subjected to the postulated Event V is protected from the gradual buildup of pressure due to postulated "minor leakage" with relief valves. The relief valve capacities are identified in Table 1 of Section IV. These relief valves assure plant safety for all "minor leakage" postulated.

To assure that "major leakage" is prevented in the SNUPPS plants and thereby eliminating the postulated Event V accident from occurring, each in-series check valve in the cold leg safety injection system will be tested at the required intervals to assure that 1) leakage is limited to 20 gpm or less (i.e., only minor leakage exists); 2) that the check valve has not failed; and 3) that the check valve is not stuck open. Although the safety of the plant is not compromised by an intersystem "minor leakage" rate of 20 gpm, the acceptance criteria to be used on the SNUPPS plants will be a

"minor leakage" rate of 10 gpm or less.

As stated above, the SNUPPS plants have been designed with a permanently installed system which will be used to perform these tests on the cold leg safety injection system check valves. A typical procedure to perform these tests is given below. See Figure 3 for further clarification.

Testing of check valves BB-8948A, B, C, and D; 8818A, B, C, and D and EP-V010, EP-V020, EP-V030 and EP-V040 will be performed to detect gross valve failure, valve discs which may be stuck in the open position and to measure backleakage of these check valves. Testing will be performed during startup from cold shutdown conditions with the RCS at 800-1000 psig and the accumulator isolation valves (8808A, B, C, and D) initially closed, as follows:

a) Depressurize the check valve test line initially, and between tests on different check valves, by venting via valves HV-8871, HV-8964, and the appropriate air operated test valve upstream of the check valve to be tested.

b) Provide a source of backpressure to the check valve being tested. In the case of the check valves nearest the RCS, the backpressure is the RCS pressure. For the check valves in series with these first valves, an accumulator tank will supply

the backpressure.

c) Align the test line to the check valve to be tested.

d) Determine if backleakage exists through the valve by monitoring the test line pressure indicator (P1-929) with valve HV-8871 open and HV-8964 closed.

e) If leakage is indicated, the leak rate can be determined by opening valve HV-8964 and reading the flow rate on flow indicator FI-928A or B.

f) If leakage is measured of a magnitude to indicate a failed valve or a stuck-open valve, action will be taken to repair the valve prior to bringing the plant to power.

g) If the leakage measured is not of a magnitude to indicate a failed valve or a stuck-open valve, check valve backleakage will be measured on flow indicator FI-928A or B.

1. The following procedure would be used to test the first check valve (nearest the RCS) 8948A with a similar procedure for valves BB-8948B, C, and D.

   a) Depressurize the check valve test line by opening valves HV-8871, HV-8964 and HV-8879A. Then close HV-8964.

b) Monitor the test line pressure indicator PI-929. Any increase in pressure would indicate check valve 8948A leakage.

c) Open valve HV-8964 and measure leakage using flow indicator FI-928A or B.

2. The following procedure would be used to test the second in-series check valves in the cold leg safety injection system (RHR cold leg check valves EP-8818A, B, C, and D and SI cold leg check valves EP-V010, EP-V020, EP-V030 and EP-V040):

   a) Verify that the accumulator isolation valves HV-8808A, B, C, and D are closed.

   b) Depressurize the accumulator discharge lines by opening test valves HV-8879A, B, C, and D and depressurize the test line by opening valves HV-8871 and HV-8964. When these lines are depressurized, close HV-8964 and test valves HV-8879A, B, C, and D.

   c) Close RHR cold leg isolation valves 8809A and B and SI cold leg isolation valve HV-8835. Open test valves HV-8823 and HV-8890A. If pressure at PI-929 increases, depressurize the test header by opening HV-8964. Reclose HV-8964 when header is again depressurized.

   d) Establish backpressure on valves 8818A and EP-V010

by opening accumulator isolation valve HV-8808A. Monitor PI-929. Any increase in pressure may be indicative of back leakage through either check valve 8818A or EP-V010 or through test valves HV-8877A or HV-8879A.

e) If leakage is indicated in step (d), test leak tightness of test valves HV-8877A and HV-8879A by first closing the accumulator isolation valve HV-8808A and depressurizing the test header by opening HV-8964. Reclose HV-8964 when PI-929 is less than 50 psig. Next, close HV-8890A and HV-8823 and reopen accumulator isolation valve HV-8808A. Observe pressure at PI-929 for several minutes. Any pressure increase at PI-929 would indicate that either 8877A or 8879A leaked. Further check valve testing may be nullified unless the leak tightness of these two test valves can be verified.

f) If leakage is indicated in step (d) and the leak tightness of test valves 8877A and 8879A is verified by step (e), either check valve 8818A or EP-V010 is the source of the leak. The faulty check valve can be determined by opening HV-8890A with HV-8964 and HV-8823 closed and the test header depressurized, and observing the pressure at PI-929. Any pressure increase would indicate that check valve 8818A leaked.

If no leakage is indicated, close HV-8890A and open HV-8823. Any pressure increase would indicate that check valve EP-V010 leaked.

g) If leakage is indicated through either check valve 8818A or EP-V010, the magnitude of the leak is determined by opening the test header valve HV-8964, with the applicable test valve HV-8890A or HV-8823 still open, and observing the flow indicated at FI-928A or B.

h) To test the following RHR cold leg and SI cold leg check valve combinations, (8818B/EP-V020, 8818C/EP-V030, 8818D/EP-V040), repeat steps (b) through (g) and substitute the appropriate check valve, test valve and accumulator isolation valve numbers.

VI. HOT LEG SAFETY INJECTION SYSTEM

The SNUPPS plants have been designed with a permanently installed system capable of monitoring the integrity of the hot leg safety injection system check valves associated with the Event V accident. This system is shown diagramatically in Figure 4.

The probability of an Event V accident occurring via the hot leg safety injection system is less than the cold leg safety injection system since the normal valve line up for this system is two in-series

closed check valves and one normally closed motor operated valve (MOV). This piping has a design pressure rating equal to that of the reactor coolant system. The lower pressure rated piping is limited to that piping outside containment upstream of the normally closed MOV. Thus, for an Event V to occur leakage would have to exist past three valves in series (two check valves and a motor operated gate valve). Nevertheless, the in-series check valves are capable of being tested to insure their integrity.

If "minor leakage" occurs in the hot leg safety injection system in-series check valves, a gradual buildup of pressure in the piping up to the normally closed MOV will occur. This in itself does not present any safety concerns. However, if the MOV is inadvertently opened, relief valves are provided in the low pressure piping to prevent overpressurization. If "major leakage" occurs (i.e., a stuck-open or failed check valve), the normally closed MOV again prevents an Event V accident from occurring.

Accordingly, the integrity of each in-series check valve will be tested at the required intervals to assure that 1) leakage is limited to 20 gpm or less (i.e., only "minor leakage" exists); 2) that the check valve has not failed; and 3) that the check valve is not stuck open. Although the safety of the plant is not compromised by an intersystem "minor leakage" rate of 20 gpm, the acceptance criteria to be used on the SNUPPS plants will be a "minor leakage" rate of 10 gpm or less.

Valves 8949A, B, C, and D and 8841A and B will be volumetric leakage tested.

Valves EM-V001, EM-V002, EM-V003 and EM-V004 will not be volumetric leakage tested but will be verified to retain pressure. This is considered acceptable since any undetected "minor leakage" past these valves will not directly result in pressurization of low pressure piping.

As stated above, the SNUPPS plants have been designed with a permanently installed system which will be used to demonstrate the integrity of the check valves in the hot leg safety injection system. A typical procedure to perform these tests is given below. See Figure 4 for further clarification.

1. The following procedure will be used to test the first check valve (nearest the RCS) 8949A with a similar procedure for valves 8949B, C, and D. This test will be performed during startup from cold shutdown conditions with the RCS at approximately 800-1000 psig to provide the backpressure on the check valves.
   a) Depressurize the check valve test line by opening valves HV-8871, HV-8964 and HV-8889A. Then close HV-8964.
   b) Monitor the test line pressure indicator PI-929. Any increase in pressure would indicate check valve

8949A leakage.

c) Open valve HV-8964 and measure leakage using flow indicator FI-928A or B. If leakage te is unacceptable, make repairs prior to bringing the plant to power.

2. The following procedure will be used to test RHR hot leg check valves 8841A and B using the SI pump discharge pressure as the constant backpressure source. This test will be performed during startup from cold shutdown conditions with the RCS at approximately 1700 psig.

   a) Verify that all test valves are closed. Close the SI cold leg isolation valve HV-8835 and the RHR hot leg isolation valve HV-8840.

   b) Start one SI pump and open the SI hot leg isolation valve HV-8802A. Open the test valve HV-8881 and the test header valve HV-8871. The pressure at PI-929 should read approximately 1500 psig. The backpressure on RHR check valves 8841A, B is also approximately 1500 psig.

   c) Depressurize the test header and test the leak tightness of test valve HV-8881 and HV-8889B, C by first closing HV-8881, then opening HV-8964. Reclose HV-8964 when the test line, as indicated by PI-929, is depressurized. Monitor the pressure

at PI-929. Any pressure increase at PI-929 would indicate that test valve HV-8881 or HV-8889B, C leaked. Further check valve testing may be nullified unless the leak tightness of these test valves can be verified.

d) With the leak tightness of test valves HV-8881 and HV-8889B, C verified and the test header depressurized, open test valve HV-8825. Monitor the pressure at PI-929. Any pressure increase indicates that either check valve 8841A or 8841B leaked. The magnitude of the leak can be established by opening the test header valve HV-8964 and measuring the flow at FI-928A or B.

3. The following procedure will be used to test the SI hot leg check valves EM-V001, EM-V002, EM-V003 and EM-V004 and will use the SI pumps to initially pressurize the hot leg safety injection lines. This test will be performed during startup from cold shutdown conditions with the RCS at approximately 1700 psig.

a) Assuming that this test immediately follows 2d) above, close test valve HV-8825 and the SI isolation valve HV-8802A, then stop the operating SI pump.

b) Open test valve HV-8881, with HV-8964 open.

Reclose HV-8964 when the test header is depressurized.

c) Monitor the pressure at PI-929. Any increase in pressure may be indicative of back leakage through either check valve EM-V001 or EM-V002. (The leak tightness of test valves HV-8889B, C was verified in sub-paragraph 2c above).

d) If no leakage was indicated by sub-paragraph (c), close test valve HV-8881 and open test valve HV-8889B. Monitor pressure at PI-929. If check valve EM-V001 did not leak during the sub-paragraph (b) operations, PI-929 should immediately indicate a pressure greater than 1000 psig. If check valve EM-V001 leaked during that sub-paragraph (b) operation, the pressure at PI-929 would remain less than 50 psig.

e) Next test check valve EM-V002. First close test valve HV-8889B. If, as a result of the sub-paragraph (d) operations the pressure at PI-929 is greater than 50 psig, open test header valve HV-8964. Reclose HV-8964 when the test header is depressurized.

f) Open HV-8889C. If check valve EM-V002 did not leak during sub-paragraph (b), PI-929 should immediately indicate a pressure greater than

1000 psig. If check valve EM-V002 leaked during the sub-paragraph (b) operation, the pressure at PI-929 would be less than 50 psig.

g) To test check valves EM-V003 and EM-V004, verify that all test valves, with the exception of test header valve HV-8871, are closed. Next, close HV-8802A and open HV-8802B to align the SI pumps to check valves EM-V003 and EM-V004.

h) Start one SI pump. With the test header depressurized and test header valve HV-8964 closed, monitor the pressure at PI-929. Any pressure increase at PI-929 would indicate that test valve HV-8824 or HV-8889A, D leaked. Further check valve testing may be nullified unless the leak tightness of these test valves can be verified.

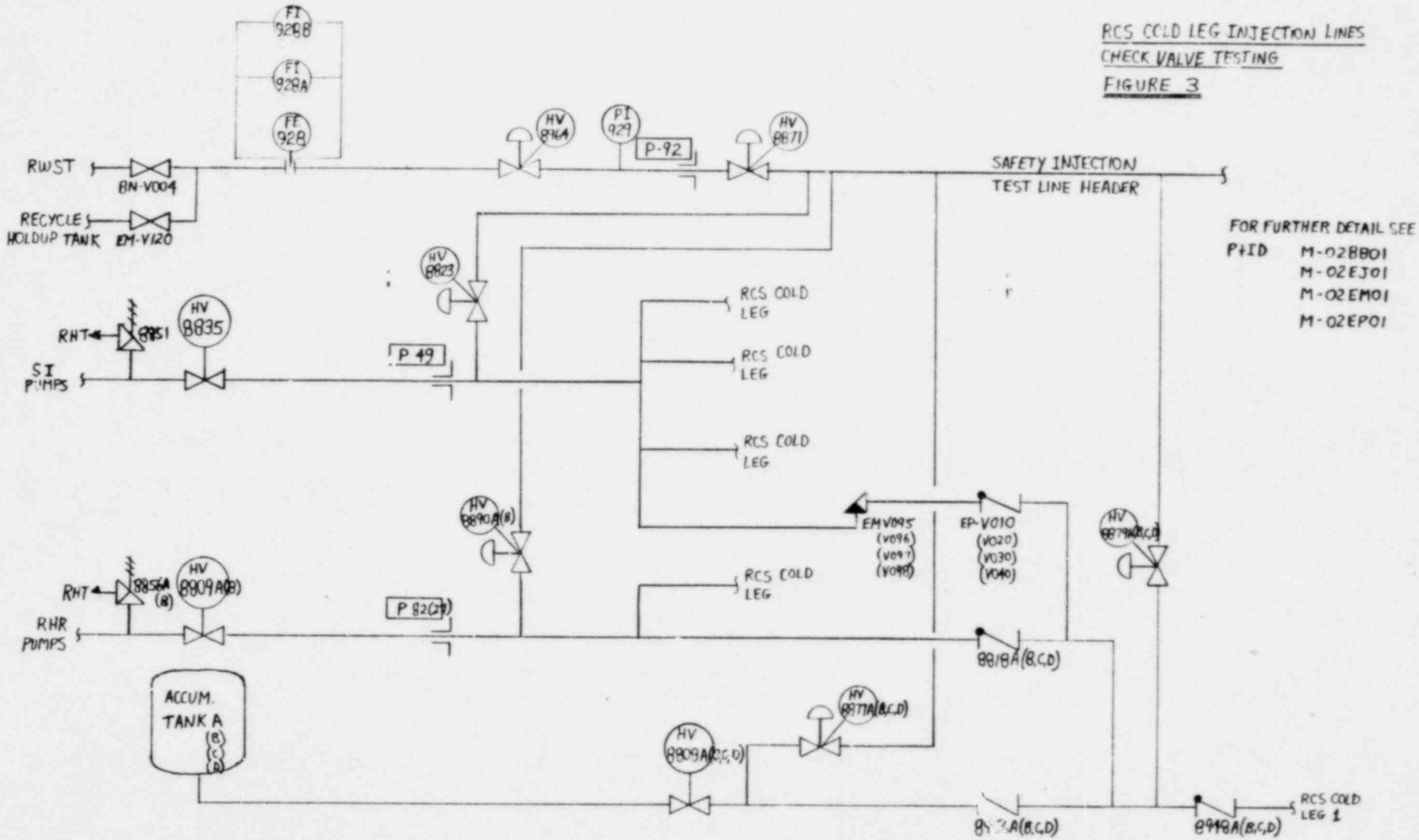
i) With the leak tightness of test valves HV-8824 and HV-8889A, D verified, close the SI pump isolation valve HV-8802B, then stop the operating SI pump.

j) Open test valve HV-8824 and test header valve HV-8964. Reclose HV-8964 when the test header is depressurized.

k) Monitor the pressure at PI-929. Any increase in pressure may be indicative of back leakage through either check valve EM-V003 or EM-V004.

l) Close test valve HV-8824 and open test valve HV-8889A. Monitor PI-929 pressure. If check valve EM-V003 did not leak during the sub-paragraph (j) operations, PI-929 should immediately indicate a pressure greater than 1000 psig. If check valve EM-V003 leaked during the sub-paragraph (j) operation, the pressure at PI-929 would remain less than 50 psig.

m) Next test check valve EM-V004. First, close test valve HV-8889A. With the test header depressurized, open test valve HV-8889D. Monitor PI-929 pressure. If check valve EM-V004 did not leak during the sub-paragraph (j) operation, PI-929 should immediately indicate a pressure greater than 1000 psig. If check valve EM-V004 leaked during that sub-paragraph (j) operation, the pressure at PI-929 would remain less than 50 psig.

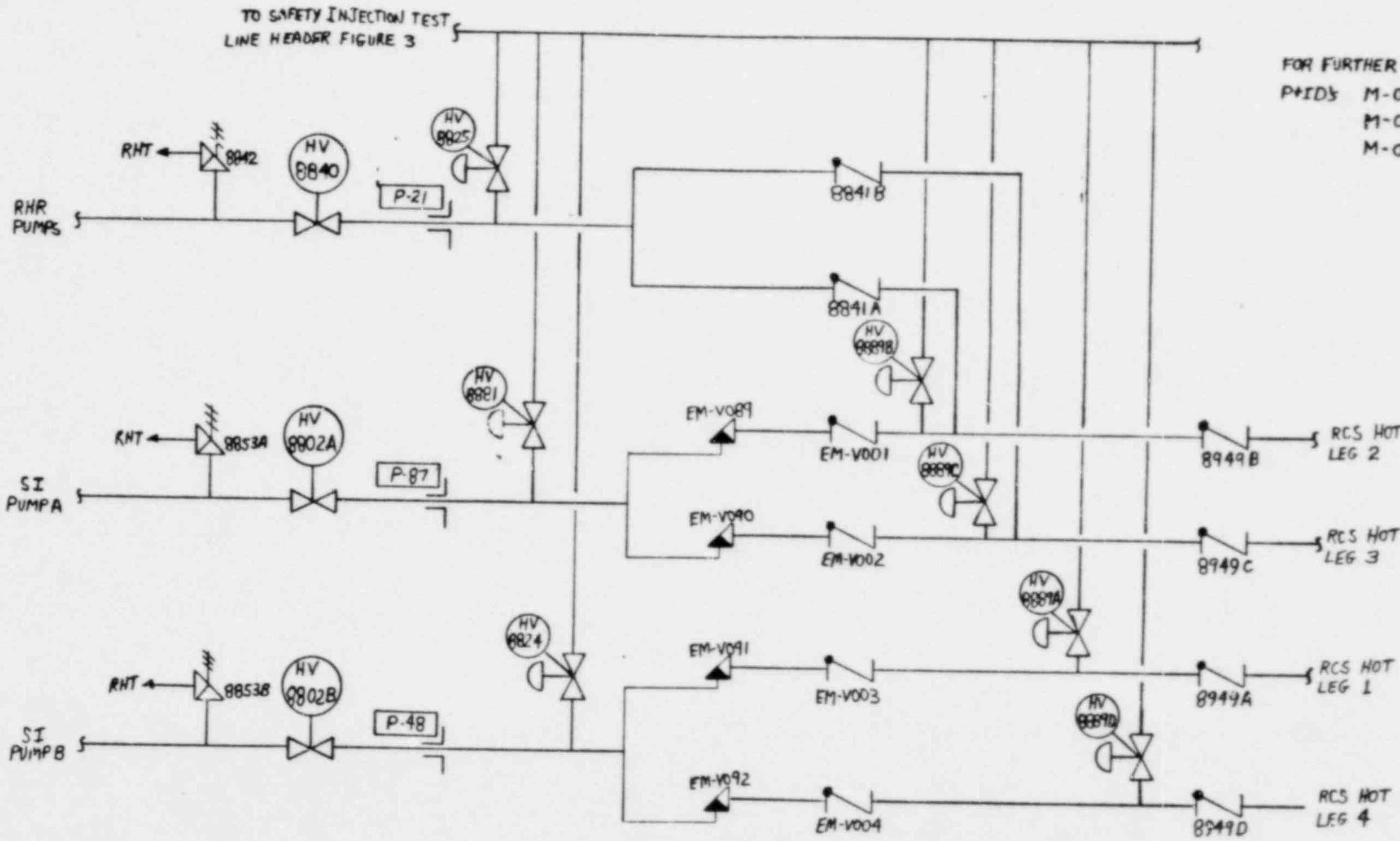


RCS COLD LEG INJECTION LINES
CHECK VALVE TESTING
FIGURE 3

NOTE: SHOWN FOR RCS COLD LEG LOOP 1 - TYPICAL FOR ALL COLD LEGS

RCS HOT LEG INJECTION LINES
CHECK VALVE TESTING
FIGURE 4

FOR FURTHER DETAIL SEE :
P+ID's M-02BB01
M-02EJ01
M-02EM01



VII. CONCLUSION

In order for the SNUPPS design to have an Event V accident, two in-series check valves must fail. By failure, it is meant that leakage from a high pressure system to the low pressure system will cause an overpressurization condition and rupture the piping. This, of course, can only happen with major leakage.

As discussed in Sections V and VI, the SNUPPS design can accomodate minor leakage without incurring an Event V accident. In fact, it was shown that the SNUPPS plants could accomodate up to a 20 gpm leak and still remain in operation; however, it was also pointed out that SNUPPS does not want intersystem leakage this high even though it does not compromise the safety of the plant. Accordingly, if the amount of pressurized flow detected is greater than 10 gpm, then the valve under test is declared unacceptable for service.

The alternative approach described in this report has demonstrated that the go-no go test is an effective means in substantially reducing the overall risk of an intersystem LOCA and, ultimately, an Event V accident. The testing identified in Sections V and VI assures that the valve's integrity is intact without undue restriction on plant operation.