ENCLOSURE 1

INDEPENDENT EVALUATION OF SAFETY INJECTION SYSTEM VALVE SURVEILLANCE TEST RESULTS AND THE PROPOSED PERIODIC TESTING AT SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1

Prepared for

SOUTHERN CALIFORNIA EDISON COMPANY

MAY 27, 1986

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1. INTRODUCTION AND SUMMARY

The failure of the safety injection system valves to open during a September 3, 1981 incident at SONGS Unit 1 had necessitated design modifications in the SIS system (References 1, 3). In addition to verifying that the design modifications did eliminate the root cause of the failures by extensively testing the modified SIS system in October 1981, a periodic surveillance testing was implemented by Southern California Edison (Reference 2). The main objective of these interim surveillance tests was to establish that there is sufficient margin between the available actuator force and the force required to open the SIS valves after they have been sitting in the closed position for a long time with differential pressure across them. Six functional tests have been performed during the last fuel cycle in accordance with the procedures approved by NRC. Based on the successful performance of the valves during these tests and a quantification of the available margin in the valve opening force vs. actuator force, SCE has proposed long-term surveillance tests which do not require the plant operation to be interrupted.

Kalsi Engineering, Inc. was engaged to independently review the results of the six interim surveillance tests performed to date and to review the SCE proposed long-term surveillance testing program from the standpoint of demonstrating the operability of the safety injection system valves HV-851 A and B.

This report summarizes the results of this independent review. The review includes a worst case error analysis of the force measurements based upon the accuracy of the instruments, the recording system, and the method used in calculating the force from pressure measurements across the piston. All the critical parameters for the valve operation -- e.g., the valve opening force vs. available actuator force, the seat contact stress, and the valve opening times -- were reviewed. The maximum errors computed for various parameters were added to the results reported by SCE to draw conservative conclusions. Additionally, the differences between the current surveillance tests, which are performed under flowing conditions, and the proposed tests, which will be performed under no-flow conditions, were identified and evaluated from the standpoint of their impact on demonstrating the operability of the SIS valves.

Based on this review, it is concluded that the surveillance tests to date have demonstrated that the design modifications in the SIS valves have been successful in eliminating the root causes of the failure; and the actuator force has sufficient margin over the required force to open the valve under long-term set effects. Also, based on the quantification of the force margins and seat contact stress margins already demonstrated and an evaluation of the differences between the flowing and no-flow tests, the proposed long-term surveillance testing plan is concluded to be adequate to ensure the functional integrity of the SIS valves in the future.

2. SUMMARY OF RESULTS AND CONCLUSIONS

(1) Based on the nonlinearity, hysterisis, effect of temperature or sensitivity of the pressure transducers as well as the accuracy of the recording system, the maximum errors in pressure measurements can be as follows (see Table I):

Accumulator and Manifold Pressures : +/- 75 psi

Upstream Pressure : +/- 31 psi

(2) The calculated valve opening force can have the following possible error magnitudes due to the errors in pressure measurements in the function tests:

Maximum Possible Error in Opening Force: +/- 1,991 lbs.

Root Mean Square Error in Opening Force: +/- 1,352 lbs.

(3) The variation in the valve opening forces reported by SCE shows a reasonable band, consistent with the above estimates of the maximum and RMS errors for a total of ten out of twelve tests performed. The first two test measurements for HV-851A are unreasonably low and inconsistent with available data for the minimum coefficient of friction for the materials used. This is attributed to a possible instrumentation malfunction or error. The reported forces from the remaining tests fall within the following ranges:

For HV-851A : 6,250 +/- 1,490 lbs.

For HV-851B : 5,056 +/- 1,488 lbs.

(4) From the reported opening forces, the coefficient of friction between the discs and seats falls within the 0.15 to 0.25 range after assigning a reasonable amount to the stem packing friction. This falls well within the range of coefficient of friction for Stellite vs. Stellite gate valves and is indicative of a healthy valve operation without any abnormal degradation of the internal parts.

(5) The overall conclusion from the independent review of the six functional tests performed over the last four years under flowing

conditions is that all of the root causes of the previous failure have been eliminated. Specifically,

1) The average seat contact stress has been maintained below 10,000 psi to avoid galling

2) The "double disc drag" condition has been eliminated as concluded from the opening force measurements under the measured differential pressure

3) A large margin (3.4 to 1) is present in the available actuator force vs. the valve opening force required after a long-term set

4) The valves have opened consistently within the three to five seconds requirement each time.

(6) The SCE proposed long-term surveillance testing plan under Mode 5 conditions was independently reviewed to identify and evaluate the differences between the flowing and no-flow test conditions. A detailed discussion is included in Section 4 of this report.

(7) Under the proposed long-term test plan, the valve will be operated under no P and no-flow conditions. Since the interim surveillance testing has clearly demonstrated that the modifications implemented in the safety injection system have successfully eliminated the root causes of the previous failure, the proposed test plan is sufficient to verify the ongoing integrity of the SIS system.

(8) It is very important to explicitly monitor the opening of the solenoid valve used to bleed off the body cavity pressure during the proposed surveillance tests under Mode 5. Procedures should be included in the proposed testing to accomplish this.

Such a step was unnecessary during the previous interim surveillance testing because a malfunction of the solenoid valve operation would have been detected indirectly. A double disc drag would have resulted due to this malfunction, which would show up in the form of a large increase in opening forces. However, since, in the proposed testing, no differential pressures are present, the solenoid valve malfunction can not be indirectly detected.

3. INDEPENDENT EVALUATION OF THE SAFETY INJECTION SYSTEM SURVEILLANCE TEST RESULTS

In order to ensure that the root causes of the failure of the safety injection system valves HV-851 A and B to open had been eliminated by the modifications in the SIS system as documented in Reference 1, a periodic surveillance testing program was undertaken by Southern California Edison (Reference 2). Under this surveillance testing, the integrity of the complete safety injection system was to be confirmed, and the force required to open the SIS valves was to be determined every 92 days of operation. The testing was performed under actual flowing conditions. A total of six such tests have been performed to date.

The results of these tests were provided to Kalsi Engineering, Inc., by SCE (Reference 1) for an independent assessment. The following sections discuss the method used for actuator force determination, an error estimate in the force measurements based on instrumentation accuracy, a review of the actual force test results (including error estimates), and conclusions from the surveillance test results.

3.1. Method Used for Determining the SIS Valve Opening Force

The force required to open the SIS valves HV-851 A and B was determined by making strip chart recordings of the pressures measured on both sides of the actuator piston and the upstream pressure on the valve which also acts on the valve stem area. Appendix A includes a hydraulic and pneumatic schematic of the valve actuator and a sample calculation used to determine the force to open the SIS valves from the pressure measurements recorded on the strip chart.

A more direct method to measure the opening force would have been the use of a load cell in the stem connection or by attaching strain gages to form a Wheatstone bridge directly on the stem. Even though this approach is capable of providing more accurate force measurements, it is more difficult to implement in the actual hardware on these SIS valves. This approach was also considered by SCE and abandoned in favor of the simpler approach of making pressure measurements on both sides of the actuator piston since it did not interfere with the normal operation and required no design modifications in the actuator stem.

Hysterisis friction present in the piston seals as well as the rod seals of the actuator make this method of using pressure measurements less accurate for the valve opening force measurements. However, even though these hysterisis forces reduce the accuracy, they add conservatism in the valve opening forces calculated by this method. This is so because the hysterisis friction forces from the actuator seals are included in the valve opening force calculated by this method. One would expect more scatter in the data; however, the calculated values will be higher than those obtained by a load cell attached to the stem. Therefore, for the surveillance tests, where a conservative valve opening force measurement is required, the method employed is suitable.

3.2. Error Analysis of the Measured Force

The error caused by the hysterisis friction of the actuator piston and rod seals can be ignored as it adds conservatism in the valve opening force calculation. However, the error contributions due to the nonlinearity, hysterisis and effect of temperature on the sensitivity of the pressure transducers, and the accuracy of the recorder has to be accounted for in order to determine the opening force from the pressure traces recorded on the strip chart recorder. From the information available about the accuracy of the pressure transducers and recorders and their full ranges (see Appendix A), we can quantify the error contribution from these sources.

The valve opening force is calculated from three individual components of forces:

(1) Accumulator Force, F_a: obtained by multiplying the measured accumulator pressure, p_a, with the net piston area, A_a, on the accumulator side. $A_a = 11.05$ in^2 for the actuator on HV-851 A and B.

(2) Manifold Force, F_m: obtained by multiplying the measured manifold pressure, p_m, with the net piston area, A_m, on the manifold side. $A_m = 14.19$ in^2 for the actuator on HV-851 A and B.

(3) <u>Stem Force, F_s</u>: This is the stem "blowout" force acting on the stem area (passing through the valve packing gland) due to the pressure in the valve body cavity, p_s. Since the valve body cavity and the upstream side of the valve are connected, this is the same as the measured upstream pressure. The stem area, $A_s = \quad /4 \times 2.0^2 = 3.14\ in^2$ for HV-851 A and B.

These three forces require measurement of three separate pressures: the accumulator pressure, p_a; the manifold pressure, p_m; and the pressure acting on the valve stem, p_s. All of these pressures were measured with strain gage type pressure transducers. Table I summarizes the maximum errors calculated for the measurement and recording of these pressure traces. It can be seen that the combined effect of the nonlinearity, hysterisis, effect of temperature on sensitivity on the pressure transducers and the strip chart recording accuracy is to contribute a maximum possible error of +/- 75 psi in p_a and p_m, and +/- 31.25 psi in p_s measurements.

Based on the above errors in pressure measurements, we can calculate the following errors in three force components used to calculate the valve opening force:

$$\text{Error in Accumulator Force, } F_a = +/- 75 \times 11.05\ in^2$$
$$= +/- 828.75\ lbs$$

Error in Manifold Force, $F_m = +/- 75 \times 14.19 \text{ in}^2$

$= +/- 1,064.25$ lbs.

Error in Stem Blowout Force, $F_s = +/- 31.25 \times 3.14 \text{ in}^2$

$= +/- 98.1$ lbs

Therefore, total maximum error in calculating valve opening force

$$\Delta F_{max} = \pm (828.75 + 1,064.25 + 98.1)$$

$$\therefore \quad \boxed{\Delta F_{max} = \pm 1,991\# \text{ (Maximum Error in Force)}}$$

and, root mean square (RMS) error in valve opening force

$$\Delta F_{rms} = \sqrt{(828.75^2 + 1,064.25^2 + 98.1^2)}$$

$$\boxed{\Delta F_{rms} = \pm 1,352\# \text{ (RMS Error in Force)}}$$

Thus, the valve opening forces measured and provided by SCE from the surveillance tests can have a maximum possible error of +/- 1,991 pounds considering the worst case combination of all error contributing factors; however, the most likely range of error contributions should fall within the +/- 1,352 pounds RMS value.

In reviewing the actual data provided for the six surveillance tests performed to date, the above error bounds will be kept in mind.

Description/Source	Error % of FR	Full Range (FR)	Error
1. <u>Accumulator and Manifold Pressure (P_a, P_m)</u>			
Nonlinearity + Hysterisis	+/- 0.13% FR	6000 psi	+/- 7.80 psi
Sensitivity Shift Due to a t = 40^{o}F	+/- 0.003% FR/^{o}F	6000 psi, 40^{o}F	+/- 7.20 psi
Strip Chart Recorder Accuracy	+/- 1.0% FR	6000 psi	+/- 60.0 psi
			Maximum Error in p_a, p_m = +/- 75.0 psi
2. <u>Upstream Pressure (Acting on Stem) P_s</u>			
Nonlinearity + hysterisis	+/- 0.13% FR	2500 psi	+/- 3.25 psi
Sensitivity Shift Due to a t = 40^{o}F	+/- 0.003% FR/^{o}F	2500 psi, 40^{o}F	+/- 3.00 psi
Strip Chart Recorder Accuracy	+/- 1% FR	2500 psi	+/- 25.0 psi
			Maximum Error in p_s = +/-31.25 psi

<u>TABLE I</u>: SUMMARY OF ERROR ANALYSIS IN PRESSURE MEASUREMENTS

3.3. Evaluation of Functional Test Results

Table II is a summary of the results from the HV-851 A and B SIS valve surveillance tests performed six times during the last full cycle at SONGS I. The table includes the calculated valve opening force (using the method described in Appendix A), the measured pressure differential, the calculated average seat contact stress and the opening times for these valves.

Differential Pressure and Seat Contact Stress:

In the six tests, the upstream pressure, which acts as P across the valve, spans a range from 242 psi to 267 psi for HV-851A and 224 psi to 315 psi for HV-851B. Since the maximum possible errors in the upstream pressure measurement is 31 psi (Table I), the maximum differential across HV-851A was below (267 + 31 =) 298 psi and across HV-851B was below (315 + 32 =) 346 psi considering worst case combination of errors due to nonlinearity, hysterisis, temperature effect and recorder sensitivity. Both of these values are below the 350 psi goal set in the SIS system modification. Also, these are well below 462 psi P allowable which corresponds to an average seat contact stress of 10,000 psi which is permissible for the Stellite vs. Stellite seat and disc sliding surfaces without galling (Reference 3). The maximum seat contact stress for 346 psi p (which includes the worst case accuracy in measurement) is computed to be 7,483 psi, which is well within the permissible limit of 10,000 psi to avoid galling.

		HV-851A				HV-851B			
		Opening Force	P	Calc. Ave. Contact Stress	Opening Time	Opening Force	P	Calc. Ave. Contact Stress	Opening Time
Test No.	Test Date	Lbs.	PSI	PSI	Seconds	Lbs	PSI	PSI	Seconds
1	11-23-81	2,435	260	5,623	N/A	6,545	315	6,812	N/A
2	02-27-82	120	266	5,753	N/A	4,520	284	6,142	N/A
3	11-13-84	4,761	267	5,774	4.5	5,337	270	5,839	4.3
4	02-09-85	7,740	242	5,233	4.5	3,568	224	4,844	4.4
5	05-10-85	6,794	242	5,233	4.5	5,658	242	5,233	4.5
6	08-22-85	7,224	254	5,493	4.6	6,023	260	5,623	4.4

TABLE II: SIS HYDRAULICALLY OPERATED VALVES FUNCTIONAL TEST RESULTS

Valve Opening Force:

The calculated valve opening forces for HV-851A show the first two test results to be unreasonably low. It is suspected that this is due to instrumentation malfunction or error in the measurement or recording of the accumulator and manifold pressures.

In the next four tests, the opening force ranges from a low of 4,761 pounds to a maximum of 7,740 pounds. This variation in the opening force for HV-851A can be expressed as 6,250 +/- 1,490 pounds. Similarly, for HV-815B, the opening force for all the six tests ranged over 5,056 +/- 1,488 pounds. It is interesting to note that the band of variation in the opening force for both the valves is the same. This variation in the openining force is the result of a number of factors already discussed: (1) hysterisis friction from the actuator piston and rod seals, (2) error in measurement and recording of the pressures, (3) variations in the upstream pressure within the normal range of the feedwater pump pressure decay characteristics. This +/- 1,490 pounds variation in calculated valve opening force is well within the +/ 1,991 pounds maximum possible error computed earlier and closer to the +/- 1,352 RMS estimated error based on accuracy of the instruments used. Thus, it is concluded that the forces reported by SCE show a reasonable amount of variation consistent with the measurement method and the accuracy of the instruments employed for ten measurements out of a total of twelve.

By backsubstituting these measured opening forces in the appropriate formulas (Reference 3), the coefficient of friction is found to fall between 0.15 and 0.25 for the gate discs and seats, making certain reasonable assumptions for the packing gland friction. This corresponds to the most frequent range of measurements that have been previously reported for Stellite vs. Stellite gate valves tested in water, with average seat contact stress of 10,000 psi or below (Reference 3). This indicates a healthy valve operation without any abnormal degradation of the valve internals due to cycling.

From the data provided for all the surveillance tests performed to date, a conservative assessment of the maximum opening forces for the valves HV-851 A and B, including the measurement inaccuracies, is given below:

Valve	Test No.	SCE Reported Opening Force	Maximum Error	Max Opening Force Including Error
HV-851A	4	7,740 lbs	+/- 1,991 lbs	9,731 lbs
HV-851B	1	6,545 lbs	+/- 1,991 lbs	8,546 lbs

The available design thrust from the actuator is 33,160 pounds. Thus, the valve opening force on HV-851A did not exceed 29.3 percent and on HV-851B did not exceed 25.8 percent of the available design thrust from the actuator. This represents a very healthy safety margin of 3.4 (= 1/0.293) in the actuator design force in the worst case.

Valve Opening Times:

The valve opening times for both the valves show very little variation in the different tests as shown in Table II. In all of the tests, the opening time varied between 4.3 and 4.6 seconds for both HV-851 A and B valves. The relatively small variation in the opening time for various tests is an indication that the valve internals have not suffered any abnormal degradation.

3.4. <u>Conclusions from the Independent Review of Functional Tests</u>

The six tests performed over the last four years under flowing conditions have clearly demonstrated that all of the root causes of the previous failure have been eliminated. Specifically,

1) The average seat contact stress has been maintained below 10,000 psi to avoid galling
2) The "double disc drag" condition has been eliminated as concluded from the opening force measurements under the measured differential pressure
3) A large margin (3.4 to 1) is present in the available actuator force vs. the valve opening force required after a long-term set
4) The valves have opened consistently within the three to five seconds requirement each time.

The overall conclusion from the surveillance tests performed is that the SIS modifications implemented in October 1981 have successfully eliminated the problems that resulted in the failure of the SIS valves to operate during the September 3, 1981 incident.

4. ASSESSMENT OF THE PROPOSED LONG-TERM SURVEILLANCE TESTS

As described in Reference 1, SCE is proposing to replace the interim surveillance testing plan that has been effective to date with a long-term surveillance plan which eliminates the need to bring the unit to MODE 3 operation. Under the proposed long-term surveillance plan, the SIS valves will be tested under "no flow" conditions instead of the "flowing conditions" currently required. The actuation time under no-flow conditions will be verified to be between three and five seconds.

The valves have already been proven to perform satisfactorily (after the SIS modification) under flowing conditions during the last six surveillance tests. Under no-flow conditions, the following major differences are introduced from the SIS valve operation standpoint:

(1) Lack of differential pressure and gate drag during stem travel

(2) Temperature difference at the valve during no-flow conditions.

These differences, and their impact on surveillance testing is discussed below.

4.1. Effects of No P and No-Flow on SIS Valve Tests

Under the proposed no-flow conditions, no differential pressure is applied across the gate when it travels from fully closed to the open position. Thus, no downstream disc drag will be offered during the stroking of the valve. Due to a reduction in the valve forces resisting the actuator opening force, the valve will be expected to open a little faster than under flowing conditions. However, with the current actuator design and the SIS modifications, the available actuator force has a large margin (3.4 to 1) over the required opening force even under flowing conditions. With such a margin, the valve opening time is dominantly controlled by the viscous resistance to hydraulic flow offered by the orifice restriction on the manifold side. If the orifice restriction is already operating under choked flow conditions when the valve is tested under flowing conditions, then there will be no difference in opening time when the valve is stroked under no-flow conditions. Otherwise, the valve opening time may be a little faster (by a fraction of a second) in the no-flow condition test.

It is recommended that SCE measure this difference in opening time for the no-flow conditions and compare it to the previously measured values for the flowing conditions. This should be done without making any changes in the orifice adjustments. Once this difference in opening times for no-flow vs. flowing conditions is measured, one can use it appropriately in the proposed long-term surveillance tests to ensure that the three to five seconds goal under flowing conditions will not be compromised.

Another difference caused by the lack of differential pressure in the no-flow test is that the gate disc does not have to slide over the seat contact area under high contact stresses. Since the adequacy of the gate disc to slide against the seat under differential pressure conditions without galling has been already established, this is not an area of concern. In fact, sliding without differential pressure will reduce the normal wear at the seat faces and extend the life of the valve internals.

4.2. Effect of Temperature Differences on the Opening Force

Under the proposed long-term surveillance testing, the SIS valves will be tested under no-load conditions (Mode 5) as compared to the current functional tests that are performed during hot standby conditions (Mode 3). The temperature of the valve under current test conditions can vary up to 330°F, whereas in the Mode 5 (no-flow test conditions) it ranges between 60°F and 80°F. The differences in temperatures cause dimensional changes in the valve body and the valve internal moving parts, which in some cases can create significant differences in the operating forces required.

If the gate is in the closed position when it is at the higher temperature, and the temperature is subsequently reduced, there can be a net increase in the seat contact force if the coefficient of thermal expansion of the body is higher than that of the gate. This magnitude of increase in the seat contact force depends upon the change in temperature, the difference in the coefficients of thermal expansion between the body and the gate components, the stiffness of the valve body and the gate. Quantitatively, this increase in seat contact force, F, can be evaluated from the following equation:

$$\Delta F = L_0(\alpha_b - \alpha_g)\Delta T \cdot \frac{K_b \cdot K_g}{(K_b + K_g)} \tag{1}$$

where

L_0 = Distance between the seat faces

α_b = Coefficient of thermal expansion for the body material

α_g = Coefficient of thermal expansion for the gate material

ΔT = Difference in the temperature to which the valve is subjected

K_b = Valve body axial stiffness for a force applied at the seat

K_g = Gate stiffness in response to a force applied at the seat contact area

For the HV-851 A and B valves, the following materials are employed for the valve body and gate:

Body	:	SA351-CF8M
Seat Rings	:	SA182-F316 (with Stellite overlay)
Upper and Lower Wedges	:	SA351-CF8M (with Stellite overlay)
Discs	:	SA182-F316 (with Stellite overlay)

Both of the above materials are classified under (16 Cr - 12 Ni - 2 Mo) material grouping in ASME Boiler and Pressure Vessel Code, Section III.

The coefficient of thermal expansion for both the valve body materials and the gate materials over the temperature range from 70°F to 350°F is:

$$\alpha_b = \alpha_g = 9.11 \times 10^{-6} \text{ in/in/}^\circ\text{F}$$

since $\alpha_b = \alpha_g$, Equation (1) gives

$$\Delta F = 0$$

Therefore, for the valve materials being used in HV-851 A and B, there should be no increase in the valve opening force due to the differences in temperatures at which the tests are performed.

The temperature difference between the current testing plan and the proposed long-term surveillance test plan is therefore not considered a significant factor from the standpoint of SIS valve testing.

4.3. Need for Verification of the Body Relief Solenoid Valve Operation

Under the current surveillance testing plan, there was no need to independently check that the body relief solenoid valve did open during the testing. A failure of the solenoid valve to open would have resulted in a double disc drag condition due to the higher pressure being trapped inside the body cavity. This would have resulted in a significant increase in the valve opening forces, and the malfunction would have been detected.

In the proposed long-term surveillance tests under cold shutdown conditions, since no pressure is used during the testing, this malfunction would not affect the valve opening forces or opening times. Thus, this malfunction, if not explicitly detected, can go unnoticed and can have serious consequences on the operability of the SIS valves during operation.

Therefore, it is very important to explicitly verify the integrity of the solenoid valve operation as part of the testing that is planned in the proposed long-term surveillance testing of the SIS valves.

REFERENCES

1. "Technical Basis for the Proposed Change to Technical Specification 4.2.3 Safety Injection System Hydraulic Valve Testing", SONGS 1, September 30, 1985.

2. SONGS 1 Technical Specification 4.2.3, "Safety Injection System Hydraulic Valve Testing (Surveillance Requirement)."

3. Kalsi Engineering, Inc. report dated December 23, 1981: "Independent Review and Analysis of Operability Failure Problems and Proposed Modifications for the Safety Injection System Valves at San Onofre Nuclear Generating Station, Unit 1."

APPENDIX A

A SAMPLE OPENING FORCE CALCULATION

AND

SIS VALVE TEST INFORMATION*

* Provided by SCE

COPY FOR YOUR INFORMATION

ENGINEERING ANALYSIS AND EVALUATION

DATE COMPLETED 8/22/85 TIME COMPLETED 1130

1.0 TEST RESULTS

1.1 From the strip chart recordings, record the following parameters at the point of initial HV-851A opening. This point corrresponds to the maximum pressure differential accross the actuator piston.

1.1.1	HV-851A accumulator pressure	3150 psi
	Accumulator force = press. x 11.05 in^2	34,807 lb_f
1.1.2	HV-851A manifold pressure	2000 psi
	Manifold force = press. x 14.19 in^2	28,380 lb_f
1.1.3	Upstream press. x 3.14 in^2 = stem force	797 lb_f

Sta. Engr. / Date 8-22-85

1.2 Force to open HV-851A = Accumulator force - manifold force + stem force — 7,224 lb_f

Sta. Engr. / Date 8-22-85

1.3 From the strip chart recordings, record the following parameters at the point of initial HV-851B valve opening. This point corresponds to the maximum pressure differential across the actuator piston.

1.3.1	HV-851B accumulator pressure	3200 psi
	Accumulator force = press. x 11.05 in^2	35,360 lb_f
1.3.2	HV-851B manifold pressure	2125 psi
	Manifold force = press. x 14.19 in^2	30,153 lb_f

FOR YOUR INFORMATION

1.0 TEST RESULTS (Continued)

1.3.3 Upstream press x 3.14 in^2 = stem force

816 lb_f

/ 8-22-85

Sta. Engr. Date

1.4 Force to open HV-851B = Accumulator force - manifold force + stem force

6,023 lb_f

/ 8-22-85

Sta. Engr. Date

2.0 ACCEPTANCE CRITERIA

2.1 If the measured opening actuator thrust for each of the HV-851A & B valves (1.2 and 1.4) is less than 10,000 lb_f, then the test is acceptable.

2.2 If the measured actuator thrust of either HV-851A or B is between 10,000 and 22,000 lb_f, then the test will be repeated.

2.2.1 Use the results of this test and those of the previous surveillance tests to determine the next surveillance time according to the following formula (Tech. Spec. 4.2.3).

NOTE: For the first surveillance test, the value of F shall be the average actuator force of HV-851 A&B valves from pre-operation testing (3135 lb_f). All subsequent surveillance testing shall assume the F_2 value from the previous surveillance test for each valve. If an F_2 was not required during the previous surveillance test, the F_1 value for each valve shall be assumed.

$$T = \frac{(22{,}000 - F_2)}{(F_1 - F) / T_L}$$

T = Time in days prior to which the next surveillance test must be performed

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2.0 ACCEPTANCE CRITERIA (Continued)

2.2.1 (Continued)

where F_1 = measured actuator force from the first Hot SIS test during the current surveillance test (lb_f)

F_2 = measured actuator force from the second Hot SIS test during the current surveillance test (lb_f)

T_L = time (in days) since the last surveillance testing

F = the actuator force from the previous surveillance test (lb_f)

NOT REQUIRED

Calculations PERFORMED BY: [signature] / 8-22-85
Sta. Engr. Date

2.2.2 If the calculated value of T does not exceed 92 days, the next surveillance test must be performed before T days had elapsed.

2.3 If the measured actuator thrust of either HV-851A or B is greater than 22,000 lb_f, then the valves must be declared inoperable. NRC approval must be obtained before returning to power.

2.4 Determine the margin to available acutator force (Objective 1.2). (Baseline Data)

Margin for HV-851A = 33,160 lb_f
- acc. force + man. force = 26,733 lb_f

Margin for HV-851B = 33,160 lb_f
- acc. force + man. force = 27,953 lb_f

VERIFIED BY: [signature] / 8-22-85
Sta. Engr. Date

2.5 Complete Attachment 3, "Summary of Test Results."

2.6 Deliver this Attachment to the SRO Operations Supervisor upon completion of calculation of force required to open HV-851A and B as required for their Acceptance Criteria.

[signature] / 8-22-85
Sta. Engr. Date

FOR YOUR INFORMATION

3.0 RESTORATION

3.1 Request I&C and Electrical Test disconnect wiring used in connection with the strip chart recorders. Enclose an initialed SO(123) 335 on the test records.

/ 8-22-85
Sta. Engr. Date

4.0 TEST EVALUATION

4.0 The results of the test have been reviewed and determined to be acceptable.

Vandenbrook 8-22-85

/ 8-22-85
Sta. Engineer Date

/ 8/22/85
Supv. Engineer Date

RESPONSES TO ADDITIONAL QUESTIONS ON
PROPOSED SAFETY INJECTION VALVE TESTING

1. Should pressure in cavity of MOV's 850 A, B and C be relieved also?

   No, MOV's 850 A, B and C are 4" flexible wedge gate valves. Their design is different from the HV's which use a self-aligning twin-disc design. The average seat contact stresses, and the required operating force under a maximum differential pressure of 1735 psi across the gate (RCS pressure at point of SI signal) were evaluated following the September 1981 event and found to be satisfactory.

   The average seat face contact stresses for these valves was calculated to be approximately 10,320 psi. This value is well below the threshold of galling for stellite vs. stellite surfaces which has been calculated to be approximately 47 kpsi.

   The actuator opening force required to open these valves against the maximum pressure differential of 1735 psi was calculated to be approximately 12,338 lbs. (includes the use of a high coefficient of static friction to account for the "long-term" set effects). This value is below the "breakaway" thrust of 22500 lbs. provided by the valve motor operators.

   Additionally, as a result of compliance with IE Bulletin 85-03, complete MOVATS testing is planned for these valves.

2. Should HV 853 A and B be in T.S. also? What is required stroke time?

   No, failure of the HV-851 valves was found to be the result of:
   1) excessive average contact stresses between valve discs and seats, for a sliding contact, resulting in galling during valve operation;
   2) insufficient margin in actuator sizing considering that the effect of "long-term" set is to increase static coefficient of friction; and
   3) trapping higher pressure fluid in the valve body cavity than either the upstream or downstream pressures thus causing "double disc" drag.
   For the HV-853 valves the average contact stresses were calculated to be approximately 9,050 psi under a design differential pressure of 355 psid. This value provides adequate margin from galling. Pressure differential across HV-853 during actual normal plant operation is approximately 300 psid. This value is too low to cause the "long-term" set effect of an increased coefficient of friction.

   In addition, cavity relief of HV-853 to the upstream condensate pump discharge also assures further pressure decay as the condensate pumps coastdown.

   The time assumed in the safety injection accident analysis for the opening of the HV-853's is 3 to 6 seconds (from actuation signal to full valve opening).

The HV-853 valves are part of the IST program, and therefore, they are full stroke and position indication tested during cold shutdown (Mode 5) and reactor refueling (Mode 6) plant operation. This testing provides adequate assurance of valve operability.

3. How would starting of feed pumps with MOV 850 and HV 851 valves open cause pump runout (T.S. SER, p. 8)?

   This statement is made by the NRC in their safety evaluation report which granted Amendment 57 (SIS Modifications). SCE's position was:

   > "The delayed opening of MOV-850 A, B and C will mitigate the effects of back pressure on HV-851 A and B which potentially could exist due to a leak in the reactor coolant boundary check valves (downstream of 850's) and allow the pumps to start against a higher system resistance."

   The concern was not with pump runout, rather it was a desire to minimize the differential pressure against the HV 851 valves.

4. Why doesn't 700 psi CV lift during SI (SI is 1200 psi)?

   The relief valve does lift under SI conditions, however, flow through this valve is choked due to: 1) line size of 3/4" and 2) a downstream orifice (RO-899). This bypass was originally designed to relieve volume expansion in the safety injection lines and the CV setpoint was originally set at 900 psi.

5. Where do HV 851 reliefs connect to (11/21/85 submittal in error?)?

   The equalization (relief) lines of the HV-851's are connected to the upstream piping to equalize pressure between the valve body cavities and the feedwater pump discharge pressures during pump coastdown.

   A solenoid valve is provided in each equalizing line to maintain required containment isolation capability in conjunction with the upstream disc of the HV-851's. This solenoid valve is normally de-energized closed and is energized open on SIS or SISLOP.

6. How is hydraulic actuator force measured?

   Maximum actuator force is taken as the point of maximum pressure differential across the actuator piston, i.e., point of maximum force exertion by the stored energy of the accumulator. Total force required for valve opening is the maximum actuator force plus the valve stem force (upstream pressure acting on the unbalance area of the valve).

   Note that actuator operating parameters (charging system pressure and accumulator gas pressure) which are out of range are alarmed in the control room.

7. Is hydraulic fluid source of constant pressure? Is it safety grade?

The HV operators are, in effect, hydraulic cylinders coupled directly to nitrogen accumulators and are not a source of constant pressure. The accumulator stores the energy required for opening the valve in the form of compressed nitrogen gas. Upon command (by energizing a solenoid valve), the stored energy is converted into a stroke of the main shaft at a uniform velocity and at the required dynamic thrust to actuate the valve. The hydraulic fluid is safety grade.

8. Can the fluid flow be increased in order to decrease stroke time?

Yes, the HV operators actuate at a controlled rate which is set by the adjustment of two separate pressure compensated flow control valves in each operator.

9. What is the effect of a water hammer increasing the differential pressure during stroking? Have the valves been tested since the 11/21/85 water hammer?

A water hammer would only increase the differential pressure across the valve in the highly unlikely event of initiating valve opening at the precise moment that the maximum pressure wave reaches the upstream disc of the valve. This momentary increase in pressure differential is of minimum duration. Secondary pressure waves would most likely aid the valve initial opening and help the actuator.

The valves have not been tested since the 11/21/85 water hammer event; however, all HV's will be full stroke exercise and position indication tested during the next Mode 5 plant operation.

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