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Omaha, Nebraska 68102-2247
402/636-2000

September 3, 1992
LIC-92-278R

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Station P1-137
Washington, DC 20555

Reference:
1. Docket No. 50-285
2. Letter from OPPD (W. G. Gates) to NRC (Document Control Desk) Dated October 8, 1990 (LIC-90-0756)
3. Letter From NRC (J. T. Larkins) to OPPD (W. G. Gates) Dated May 5, 1992

Gentlemen:

SUBJECT: Response to Request for Additional Information Concerning the Fort Calhoun Station (FCS) Inservice Testing (IST) Program Relief Requests (TAC No. M75282)

In Reference 3, the NRC requested Omaha Public Power District (OPPD) to supply additional information concerning the FCS IST Program relief requests. The following attachments contain the items that the NRC requested.

Attachment 1 is a document that describes the methodology for flow testing the Safety Injection Tank (SIT) discharge check valves. This document also contains the results from the most recent surveillance test concluded in February 1992 for the SIT discharge check valves.

Attachment 2 is a copy of the latest revision of the surveillance test (SS-ST-SI-3015) for the SIT discharge check valves. SS-ST-SI-3015 was most recently performed on February 22-23, 1992, according to the FCS Inservice Inspection (ISI) Program Plan, using Code exception E19 as detailed in Reference 3. The attached procedure revision employs the same methodology as the revision performed in February, 1992.

Attachment 3 is a copy of the calculation to analyze the test methodology and determine the flow testing acceptance criteria for the SIT discharge check valves.

Attachment 4, the FCS IST Philosophy, is a description of the process used in developing the IST Program. Most of this document was extracted from information contained in the FCS ISI Program Basis Document.

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If you should have any questions, please contact me.

Sincerely,

W. G. Gates
Division Manager
Nuclear Operations

WGG/grc

Attachments (4)

c: LeBoeuf, Lamb, Leiby & MacRae (w/o attachments)
J. L. Milhoan, NRC Regional Administrator, Region IV (w/o attachments)
R. P. Mullikin, NRC Senior Resident Inspector (w/o attachments)
S. D. Bloom, NRC Acting Project Manager (with attachments)

Attachment
LIC-92-278R

ATTACHMENT 1

Methodology for Flow Testing Safety Injection Tank Check Valves

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Methodology for Flow Testing Safety Injection Tank Check Valves

ABSTRACT

This paper presents the evolution that led to the use of a reduced pressure Safety Injection Tank (SIT) dump as the preferred test method for full stroke testing the SIT check valves at Fort Calhoun Station. This discussion includes the following:

1. An interpretation of the Code requirements for full stroke testing of check valves.
2. Problems encountered with various test methods.
3. The analysis technique used to relate the reduced pressure flow test results to safety analysis flow requirements.
4. A description of the test method and results to date.

Fort Calhoun Station found that a reduced pressure SIT dump was the most cost effective method of SIT check valve testing that would yield credible test results.

NOMENCLATURE

A	=	Cross sectional area of pipe (square feet)
C_v	=	Flow coefficient (gallons per minute with 1.0 psi pressure drop)
K	=	Resistance coefficient (dimensionless)
ΔP	=	Differential pressure (pounds per square inch)
Q	=	Rate of flow (gallons per minute)
d	=	Internal diameter of pipe (inches)
ρ	=	Weight density of fluid (pounds per cubic foot)

INTRODUCTION

Fort Calhoun Station (FCS) is a 485 MW PWR located on the Missouri River about 17 miles north of Omaha, Nebraska. FCS has four Safety Injection Tanks (SIT) that each have one Motor Operated Valve (MOV) and two check valves in 12" nominal diameter piping separating the SIT from the Reactor Coolant Loops. The eight check valves are identified in the FCS Inservice Inspection (ISI) Program as Category C valves requiring full stroke testing under Paragraph IWV-3520 of ASME Boiler and Pressure Vessel Code, Section XI (80W80). These check valves are 12", 1500#, weld end, Duo-Chek check valves manufactured by Mission Manufacturing Company.

Due to the difficulty of verifying full stroke open operability of these valves, FCS obtained relief from the Nuclear Regulatory Commission (NRC) in 1988 to perform a sample disassembly of two valves at Refueling Frequency to satisfy IWV-3520. Due to valve design and the inaccessible location, the sample disassembly of these valves proved to be so difficult and time consuming that an alternative method of full flow testing was pursued. This led to a trial performance of a reduced pressure SIT dump test in the Spring of 1990 that proved to be practical to perform, and that yielded credible test results.

In January 1991, FCS received interim approval from the NRC on an ISI Program that adopted the reduced pressure SIT dump test for full flow testing of the SIT check valves. In February 1992, the test was performed with acceptable results on all four SITs.

PROBLEM STATEMENT

The ISI Coordinator at FCS interpreted Paragraph IWV-3522 and NRC Generic Letter 89-04 to say that the full flow requirement for a check valve could be verified in three ways:

1. By verifying that the design flow rate would pass through the valve when the design differential pressure was imposed across the valve in the flow direction, or

2. By verifying that the valve disc will move to its full open position when a force of the appropriate magnitude is applied to the disc, or

3. By sample disassembly to verify the condition of valves that cannot practically be tested by 1 or 2, above.

Performing a test to pass the design flow rate through the SIT check valves at the design differential pressure proved to be impractical for the following reasons (see Figure 1, Plant Layout, and Figure 2, SIT Dump Schematic):

- The 12" motor operated gate valve takes about 54 seconds to fully open.

- At the design differential pressure (~240 psig) and level (~60% or 6,000 gallons), the SIT will be empty well before the MOV is completely open, and the design flow rate (~15,000 GPM) will never be achieved.

- If the SIT is dumped at refueling through the open reactor vessel (RV), expansion of the SIT nitrogen (N_2) blanket bubble under design conditions will result in releasing the N_2 to the containment atmosphere through the RV in a violent manner that would cause substantial airborne contamination.

The mechanical exercising of the SIT check valve disc requires disassembly of the check valve, because the valve is constructed so that no non-intrusive mechanism is available to move or observe the valve disc position. Relief was obtained from the NRC to satisfy the SIT check valve full flow test requirement by sample disassembly in 1988. Disassembly was performed *in situ* by removing an access port that was sealed with a silver plated, soft iron seal.

Sample disassembly and exercising of the SIT check valves were performed for the first time at FCS in the Fall of 1988. The valve was found to be in excellent condition, but a great deal of craft resources was expended in providing access to the valve and in getting the inspection port to seal after the disassembly. The access port was slightly out-of-round, and required machining before it would reseal. The disassembly of these valves is performed while the reactor coolant level is at mid-loop, so the potential for critical path delays is high. The same difficulties were encountered on the valves disassembled for inspection during the 1990 Refueling Outage. The resources expended in performing the disassembly and inspection of two SIT check valves include:

- $4,000 in materials
- 800 hours of craft/engineering time
- 6.5 manrem of radiation exposure
- Radwaste from 155 containment entries

Thus, the per-operating-cycle cost of performing the SIT check valve sample disassembly is very high both in dollars and from n ALARA standpoint.

In 1990, FCS performed a reduced pressure SIT dump (Pilot Test) in an effort to qualify the procedure's capability to satisfy the requirements of IWV-3520 for the SIT check valves. The dump test was performed on the SIT that dumped through valves that had just been disassembled and inspected. Thus, as the valves were known to be in good condition, the test would provide credible baseline data.

CONCEPTUAL BASIS FOR REDUCED PRESSURE DUMP TEST

Using the reduced pressure SIT dump test to verify full flow capability of the SIT check valves is based on the concept that flow rate (Q) through a piping system is proportional to the square root of the differential pressure (ΔP) across the piping system.

(1) $$Q \propto \sqrt{\Delta P}$$

In Crane "Flow of Fluids" 1985, Equation 2.7, the same concept is stated:

(2) $$Q = C_v \sqrt{\Delta P(62.4/\rho)}$$

where ρ = fluid density and C_v is a flow coefficient that is dependent only on the mechanical configuration of the flow path. For the purpose of the SIT dump, ρ is assumed to equal 62.4 lb/ft^3, which reduces Equation B to:

(3) $Q = C_v \sqrt{\Delta P}$

With this concept in mind, the goal of the SIT dump test is to establish a C_v that is adequate to satisfy the safety analysis SIT flow requirement, and then to perform a dump test to measure the C_v using manageable test parameters. If the measured C_v is equal to or greater than the safety analysis C_v, the SIT check valves have fulfilled the full flow test requirement.

TEST SETUP/DEFINITION

The SIT dump is performed by establishing adequate initial conditions of water level and nitrogen pressure in the SIT while the MOV in the SIT discharge piping is closed. Any initial conditions that will fully open the check valve and not inject nitrogen into the reactor coolant piping when the MOV is opened is considered adequate. Then SIT pressure and level versus time are recorded as the MOV is opened to release the water to the refueling cavity through the SIT check valves.

The most practical test setup for FCS was to [illegible] the SITs to the reactor vessel (RV) when the vessel head was removed, the co[illegible]as offloaded and about 20 feet of water was in the refueling cavity. Figure 2 shows a schematic of the test arrangement.

The initial conditions in the SIT (i.e., water level and nitrogen blanket pressure) were determined based on the desire to have the equilibrium water level in the SIT of 0% after an isothermal expansion of the nitrogen blanket expelled the water from the SIT to the refueling cavity. This is desirable to prevent nitrogen from being injected into the reactor coolant loop. The increase in water level in the refueling cavity (~5 inches) as the SIT dumps was neglected. The initial conditions chosen for the test included an SIT level of 90% and an SIT pressure of 104 psig. These compare to normal values of 60% and 240 psig, respectively.

The test was performed by recording the SIT level and pressure on a strip chart recorder while the motor operated block valve was opened fully and then closed. The flow (Q) and differential pressure (ΔP) were calculated from the rate of change of the SIT level and the SIT pressure adjusted by the fluid level. The ΔP and Q were then used to calculate C_v in accordance with Equation (3).

In order to register the maximum C_v from the test, the flow rate after the MOV is fully opened (54 seconds after test initiation) must still be high enough (about 3,500 GPM if the valves are in new condition) to fully open the SIT Check Valves.

TEST RESULTS/CALCULATIONS

The Pilot Test to qualify the SIT dump procedure was performed on one SIT in the Spring of 1990. Figure 3 shows plots of some of the critical test parameters versus time. The calculated flow rate through the check valves at the point when the MOV was 100% open was 4,462 GPM. This is above the 3,500 GPM (as stated by the manufacturer) required to fully open the check valves. The ΔP calculated at this point was 12.58 psig.

(4) $$\therefore \qquad C_v(MEAS.) = \frac{Q}{\sqrt{\Delta P}} = \frac{4462}{\sqrt{12.58}} = 1{,}258$$

An uncertainty analysis was performed based on instrument accuracy that indicated the calculated C_v has an uncertainty ± 3.4%. This conservatively indicates that measured C_v = 1,215.

The acceptance criteria for this test [C_v (LOCA)] was determined by using the Nuclear Steam Supply System (NSSS) Vendor's Loss of Coolant Accident (LOCA) Analysis. The NSSS Vendor developed flow resistance coefficients (K) and effective flow area (A) that can be used in Crane "Flow of Fluids" 1985 Equation 2.6.

(5) $$C_v = \frac{29.9\ d^2}{\sqrt{K}}$$

When the NSSS Vendor's values of K = 7.34 (for piping from SIT SI-6C) and A = .5592 ft² for the piping from the tank being dumped are inserted into Equation (5) the acceptable C_v is obtained.

(6) $$d^2 = \frac{4A}{\pi} = \frac{4}{\pi}(.5592\ ft^2)\ (144\ in^2/ft^2) = 102.5\ in^2$$

(7) $$C_v = \frac{29.9\ x\ 102.5}{\sqrt{7.34}} = 1131$$

The acceptance value C_v(LOCA) = 1,131 (SI-6C) is the reference value that must be exceeded to verify the NSSS Vendor's calculations. The Pilot Test showed a C_v margin of 7.3%, demonstrating acceptability of the tested SIT check valves and the Pilot Test methodology.

Although the acceptance criteria was based on the NSSS Vendor's LOCA Analysis, it should be remembered that the intent of the ASME Section XI Pump and Valve Program is to detect component degradation. The baseline data for valves tested in the Pilot Test is C_v = 1258. This baseline value of C_v is a credible indicator of valve condition regardless of how it compares to the LOCA Analysis, because the check valves were disassembled and verified to be in satisfactory condition prior to performing the flow test.

A cost estimate on the effort requi ed to perform the Pilot Test was developed to project the cost of dumping all four SITs to test the eight SIT check valves. The performance of this test is expected to cost about $2,500 with negligible impact on outage radiation exposure. It is planned to dump all four SITs for this test each refueling outage.

All four SITs were dumped for the first time during a Refueling Outage in February 1992. The test results showed that all of the SIT check valves satisfied their respective acceptance criteria (see test result summary table below):

SIT DUMP TEST RESULTS SUMMARY

TANK (VALVES)	ACCEPTANCE CRITERIA (C_v)	1990 PILOT RESULTS FLOW	1990 PILOT RESULTS C_v	1992 TEST RESULTS FLOW	1992 TEST RESULTS C_v
SI-6A (SI-219 & 220)	1189	----	----	3563 GPM	1206
SI-6B (SI-215 & 216)	1164	----	----	4126 GPM	1201
SI-6C (SI-211 & 212)	1131	4424 GPM	1258	3897 GPM	1184
SI-6D (SI-207 & 208)	1159	----	----	4241 GPM	1229

There are some interesting observations that may be drawn from the test results:

- The C_v values obtained from the test indicate that the test technique is dependable and capable of producing consistent results.
- The N_2 bubble in the SIT approximated an isothermal expansion as the water was dumped from the SIT.
- The apparent discrepancy between the C_v values obtained for SI-6C in 1990 versus 1992 appears to be the result of different initial conditions rather than a negative performance trend, but since both results meet the acceptance criteria, further investigation will be postponed until the next SIT dump.

The test is considered successful in that it demonstrated the viability of the test technique, it established credible baseline information that may be used to evaluate future test results (performance trending), and it demonstrated that the check valves performed as predicted by the NSSS designer within a reasonable tolerance.

SUMMARY

The test method described in this paper for full flow test verification of the SIT check valves by dumping the SIT has been demonstrated to be a viable, cost-effective alternative to sample disassembly. The estimated cost for testing all eight SIT Check Valves by dumping the four SITs is less than 3% of the estimated cost for sample disassembly of two valves each refueling outage.

FCS has received interim approval from the NRC for the reduced pressure SIT dump methodology and plans to continue to satisfy the full flow test requirement for the SIT Check Valves by performing the reduced pressure SIT dump test. All eight valves will be tested by this mechanism each refueling outage.

REFERENCES

1. ASME Boiler and Pressure Vessel Code, Section XI, 1980 Edition, Winter 1980 Addendum, Subsection IWV

2. Nuclear Regulatory Commission Generic Letter 89-04 "Guidance on Developing Acceptable Inservice Testing Programs", Attachment 1, Item 1, "Full Flow Testing of Check Valves"

3. Omaha Public Power District Special Procedure SP-SI-7, "Safety Injection Tank SI-6C Dump Test", Performed April 2, 1990

4. Crane "Flow of Fluids Through Valves, Fittings, and Pipe", 1985 Edition

5. Omaha Public Power District Calculation #FC-05428 "Valves SI-207/208 Full Open Stroke Data Analysis for SP-SI-7 April 1990 Performance"

6. Combustion Engineering Report 0-PD-113 "LPSI Pump, HPSI Pump and Safety Injection Tank Data for New ECCS Evaluation Model", Dated March 15, 1974

7. Omaha Public Power District Surveillance Test Procedure SS-ST-SI-3015, "Safety Injection Tank Discharge Check Valve Test", Performed February 22, 1992

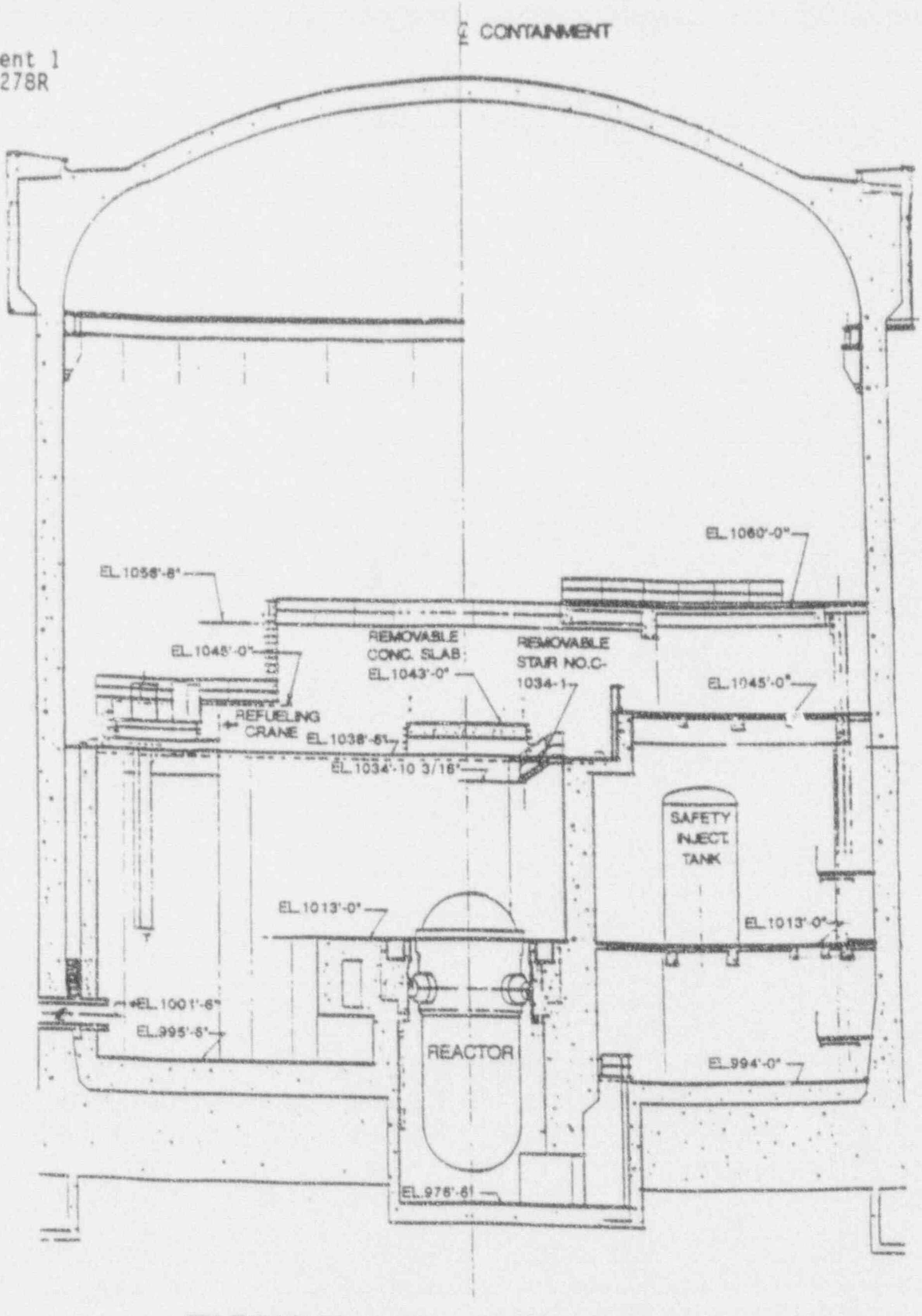

FIGURE 1-PLANT LAYOUT

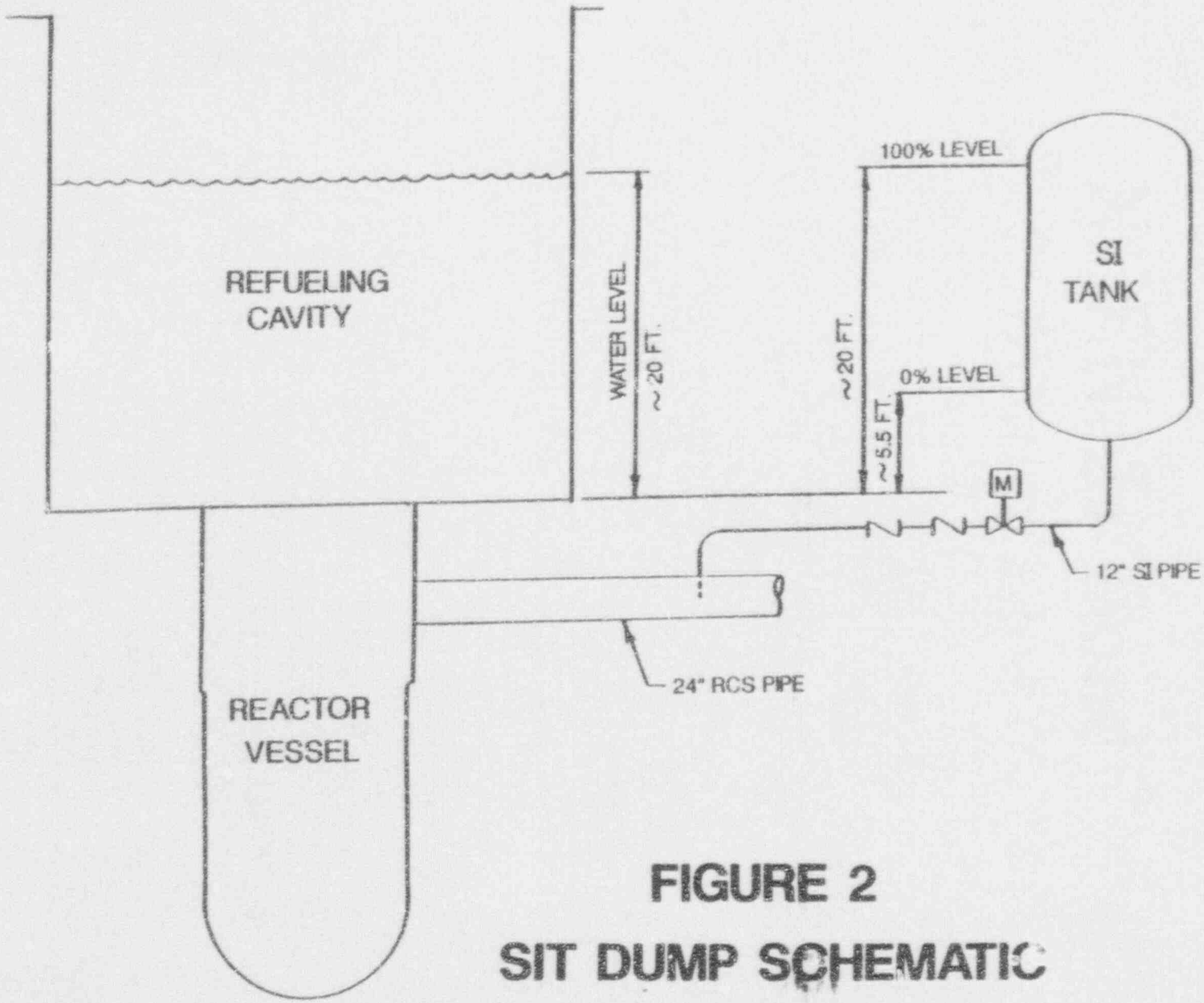

FIGURE 2

SIT DUMP SCHEMATIC

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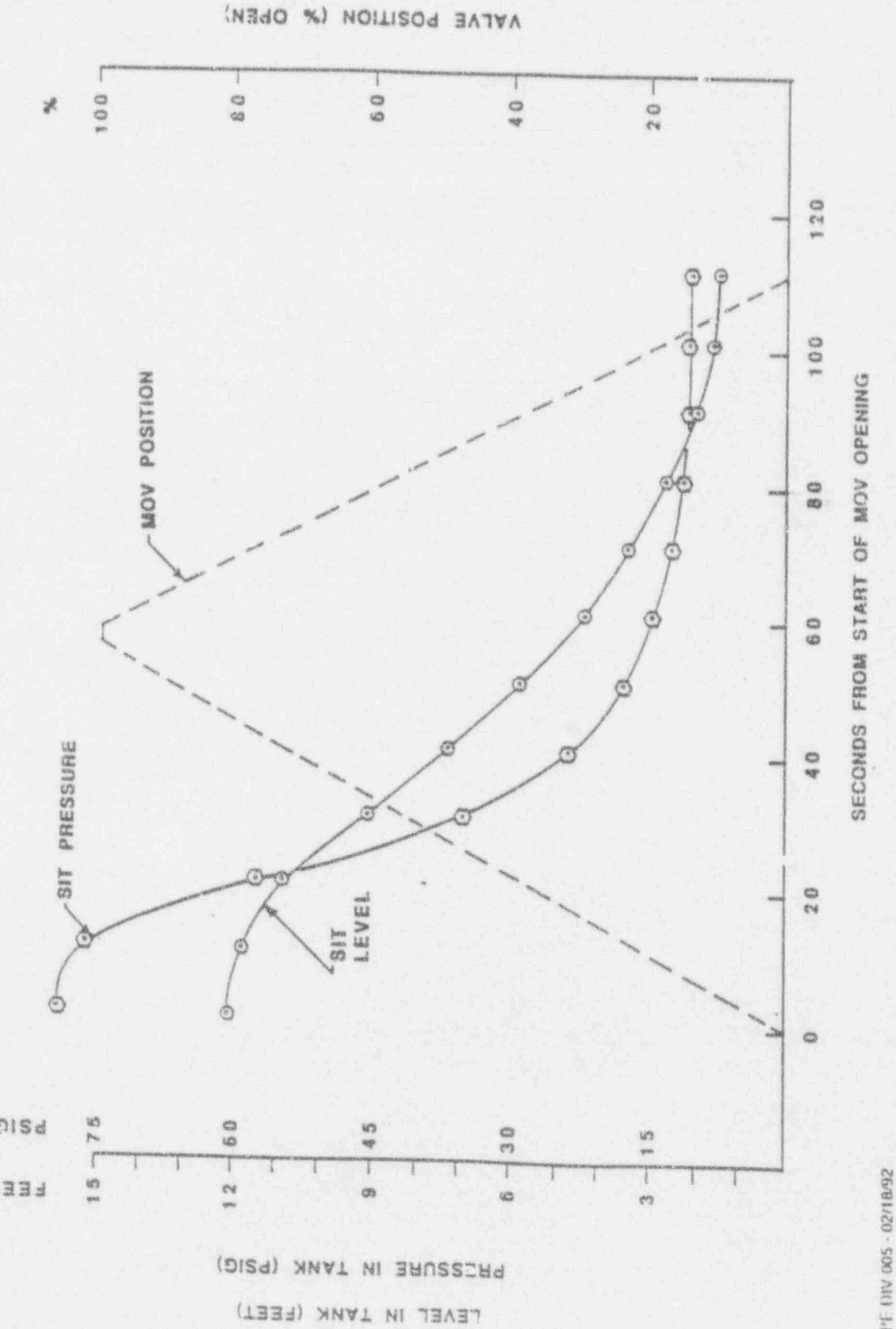

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FIGURE 3 RESULTS OF PILOT TEST

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ATTACHMENT 2

Safety Injection Tank Discharge Check Valves Test

Surveillance Test (SS-ST-SI-3015)