Sandia National Laboratories
Albuquerque, New Mexico 87185
Allan S. Benjamin

50-280
50-281

July 17, 1985

Ms. Jocelyn Mitchell
U. S. Nuclear Regulatory Commission
Accident Source Term Project Office
7915 Eastern Avenue, MS 1130SS
Willste Building
Silver Spring, Maryland 20910

Dear Jocelyn:

This letter responds to your request for an estimate of the probability that a break outside containment during a V sequence at Surry will be submerged.

The question posed is difficult to answer without a systematic thermalhydraulic/structural analysis of the situation pertaining during the postulated accident. No such analysis exists. Further, I am not a structural engineer and do not claim any expertise in this area. Therefore, I relied upon the opinions of others more expert than I to formulate a more-or-less subjective estimate of the required probability. Toward this end, I specifically talked with the following people:

James E. Metcalf, Stone and Webster Company
Walter A. von Riesemann, Sandia National Laboratories
Peter R. Davis, Intermountain Technology Company
Robert L. Ritzman, Electric Power Research Institute

The Surry V sequence involves the failure of a check valve in one of the 6-inch cold leg emergency core cooling system injection lines following a preexisting condition in the same line where the other check valve was stuck open following a test/maintenance operation (See Figure 1). Water from the reactor coolant system at operating pressure and temperature (2250 psi, 550 F) rapidly flows through a locked-open motor-operated valve at the outside containment boundary, whereupon it enters a 10-inch diameter ASME class 2 pipe of lower pressure capacity (600 psi design pressure for temperatures under 200 F). The low pressure piping is postulated to break, causing a loss of coolant accident outside containment.

The four people I talked with all expressed uncertainty as to whether the low pressure piping will in fact rupture. If the pipe does not rupture, the path of flow would be through a 1-inch diameter relief valve to a liquid waste collection tank. This would comprise a significantly less severe accident than the one postulated to occur, since there are emergency procedures which the operator could implement to provide continued core cooling.

A double-ended guillotine break of the 10-inch line outside containment would cause the contents of the refueling water storage tank and primary system inventory to discharge into the safeguards building. The discharge would rapidly fill the pump shafts and flood the floor of the safeguards building up to the level of the pipe blockout (Figure 2), where it would spill over to the auxiliary building.

The location of the pipe break determines the depth of submergence. Messrs. Metcalf, Davis, and Ritzman, who have examined the piping at the site and have reviewed the drawings in detail, claim that about 80% of the piping run in the safeguards building is within 2 feet of the floor and would be covered by 2 to 3 feet of water. The remaining 20% is at least 2 feet higher in elevation and so would be covered by less than 1/2 foot of water.

Mr. Metcalf of Stone and Webster, the architect engineering company for the Surry plant, indicated in our conversations that the most likely point of rupture would be at the first elbow following the transition to low pressure piping (see Figures 2 and 3). His rationale was that (a) this elbow would be the first to see high stress levels and (b) the elbow is restrained by an integral attachment, which would increase the stress levels. The elbow in question is within the area of piping that would be submerged by 2 to 3 feet. Based on these observations, Mr. Metcalf stated that he would attribute a 90% probability to the break being submerged.

Mr. von Riesemann, supervisor of the Containment Integrity Division at Sandia, corroborated Mr. Metcalf's observations qualitatively but felt that the 90% probability of submergence might be on the high side. Without any structural analyses, Mr. von Riesemann could offer no quantitative estimate of the probability of submergence.

In a follow-up letter (Attachment A), Mr. Metcalf added that Stone and Webster had earlier performed an analysis of normal operating stresses for the system in question (i.e., the stresses occurring following a design-basis loss of coolant accident in containment). The situation analyzed is quite different from the V sequence, in that the direction, velocity, and thermodynamic conditions of the flow are different. However, the results can provide limited insights into the likely locations of high stress.

In that analysis, the elbow in question was the location of second highest stress. Maximum stress occurred at an elbow which was similarly restrained by an integral attachment and which would similarly be submerged by 2 to 3 feet. This led Mr. Metcalf to conjecture that the probability that the break would be submerged was "at least" 90%.

Most of Stone and Webster's views on the V sequence are summarized in a paper presented to the American Nuclear Society,[1] for which Mr. Metcalf is a co-author (see Attachment B). I reviewed this paper as well.

Mr. Davis of Intermountain Technology performed his own assessment of the Surry V sequence, based on a plant visit, review of drawings, and discussions with personnel at Virginia Electric Power Company and Stone and Webster. In my conversation with Mr. Davis, he indicated general agreement with the idea that the break occurring during a V sequence would likely be submerged. Asked for his own subjective estimate of the probability that the break would be submerged, he tentatively took a figure of 80%.

Mr. Ritzman of E.P.R.I. analyzed the Surry V sequence while at Science Applications International Corporation under a contract with E.P.R.I. The results of this analysis are now part of an E.P.R.I. report[2] for which he is the principal author. In my discussion with him, he indicated that he and the other authors of the report could not justify any conclusions about where the break would be located. Based on piping lengths alone, however, he felt that there would be at least an 80% probability that the break, if one occurred, would be in a location where it would be submerged.

A key question among the authors and the reviewers of the E.P.R.I. report, he indicated, was what he termed the morphology of the break. If a 10-inch diameter double-ended guillotine break were to occur at a submergence depth of 2 to 3 feet, there would be a real question as to whether bubble breakup could occur rapidly enough, at the gas velocities involved, to assure any significant amount of scrubbing of the fission products. Data from General Electric Company, he noted, indicates that a rise height of

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1 A. Drozd, F. A. Elia, Jr., and J. E. Metcalf, "The V Sequence: An Engineering Viewpoint," presented at ANS Topical Meeting on Fission Product Behavior and Source Term Research, Snowbird, Utah, July 15-19, 1984.

2 R. L. Ritzman, et al., "Surry Source Term and Consequence Analysis," EPRI NP-4096, June 1985.

one to two pipe diameters is required for a gas discharge to break up into a swarm of bubbles. Based on this, he and the other authors had concluded that it was "unlikely" that one would get classic pool scrubbing.

He felt that the confined nature of the safeguards building made it more likely that one would get scrubbing as a result of two-phase mixing and turbulence, a situation for which there are no applicable fission product scrubbing models. Based on his own judgment, he felt that it was "fairly probable" that a large fraction of the fission products would end up in the water as a result of this confined turbulence. On further questioning, he indicated that "fairly probable" meant about equally likely as not and "large fraction of fission products" meant a decontamination factor of 10.

Considering deposition on the walls as well as in the water, he felt that it was "highly likely" that the overall fraction of fission products remaining in the safeguards building would be large.

Let me return now to the original question. Based on piping lengths and the assessment of likely rupture locations, I would estimate the probability of the break being at least 2 feet below the overflow level (i.e., the pipe blockout) to be at least 80% and probably more like 90%. However, a possibility not examined in previous analyses is whether the operator might take action to isolate the refueling water storage tank within the 10 minutes or so that it takes to flood the safeguards building. (The valves between the refueling water storage tank and the reactor coolant system injection points are normally open.) Further, there may not be an adequate water head above the rupture to assure breakup of the gas bubble if the rupture is the full size of the pipe diameter. I therefore redefined the question to ask whether the rupture location is sufficiently submerged to assure significant fission product scrubbing. For this question, I felt that the best-estimate probability lies between 50% and 90%; therefore, I subjectively took a more-or-less average value of 75%.

Sincerely,

A. S. Benjamin, Supervisor
Reactor Safety Technology
Division 6411

ASB:6411:cg
Enclosures

Copy to:

NRC	J. C. Glynn
NRC	D. Pyatt
NRC	M. Ernst
BCL	R. Denning
BNL	T. Pratt
6410	J. W. Hickman
6412	A. L. Camp
6415	F. E. Haskin
6449	D. C. Williams

FIGURE 1

LOW PRESSURE SAFETY INJECTION FLOW PATH
SURRY 1 & 2

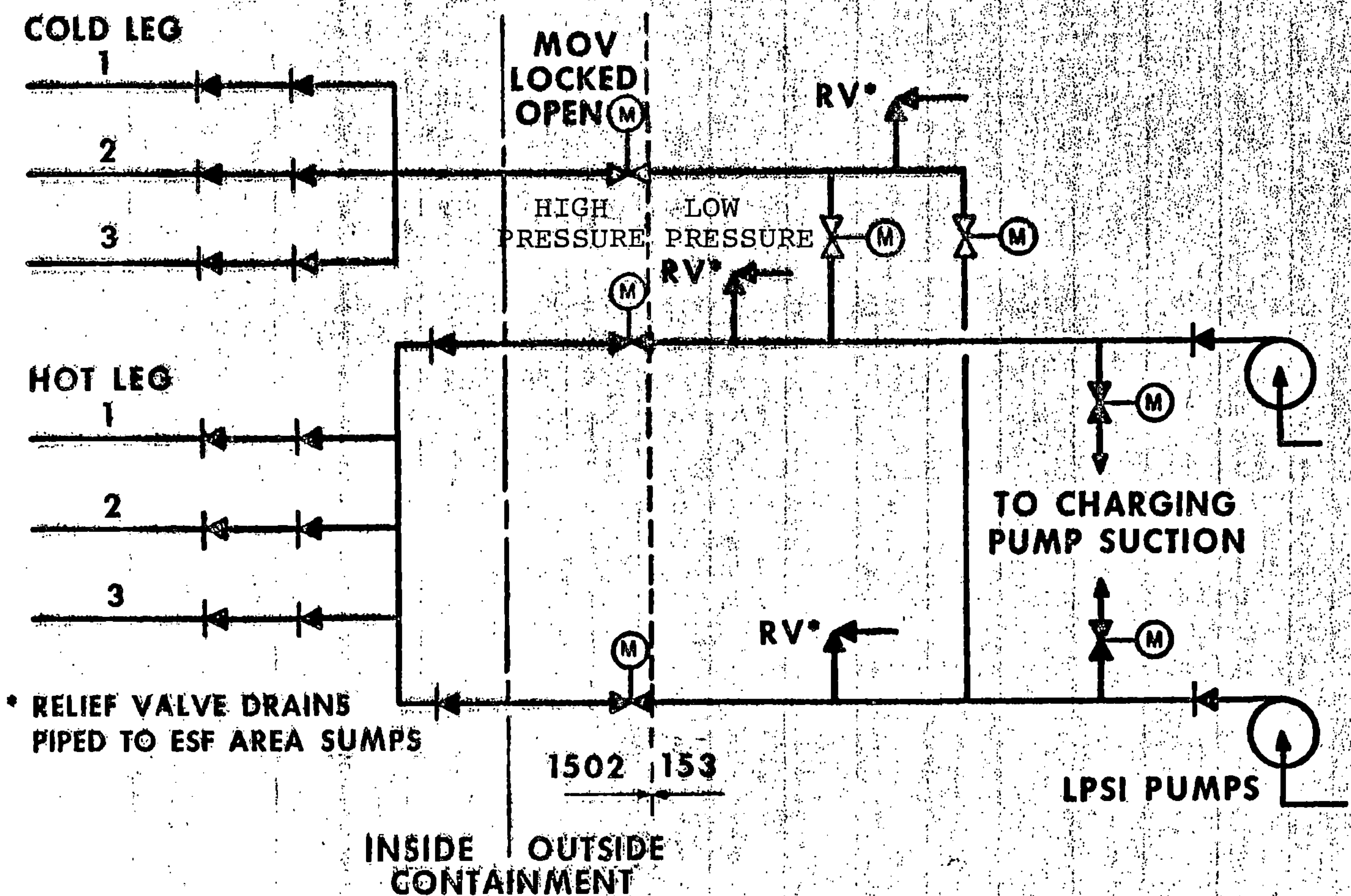
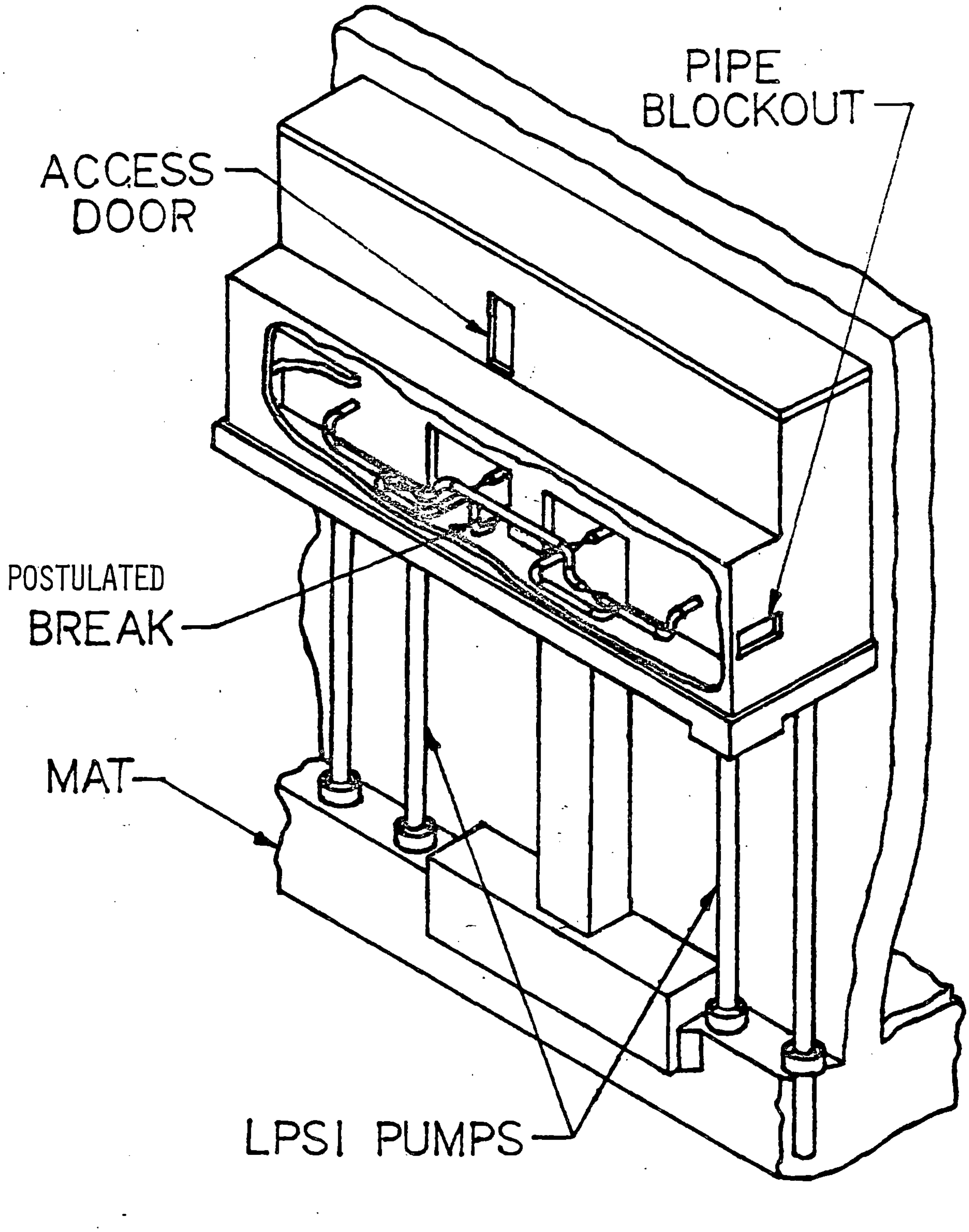
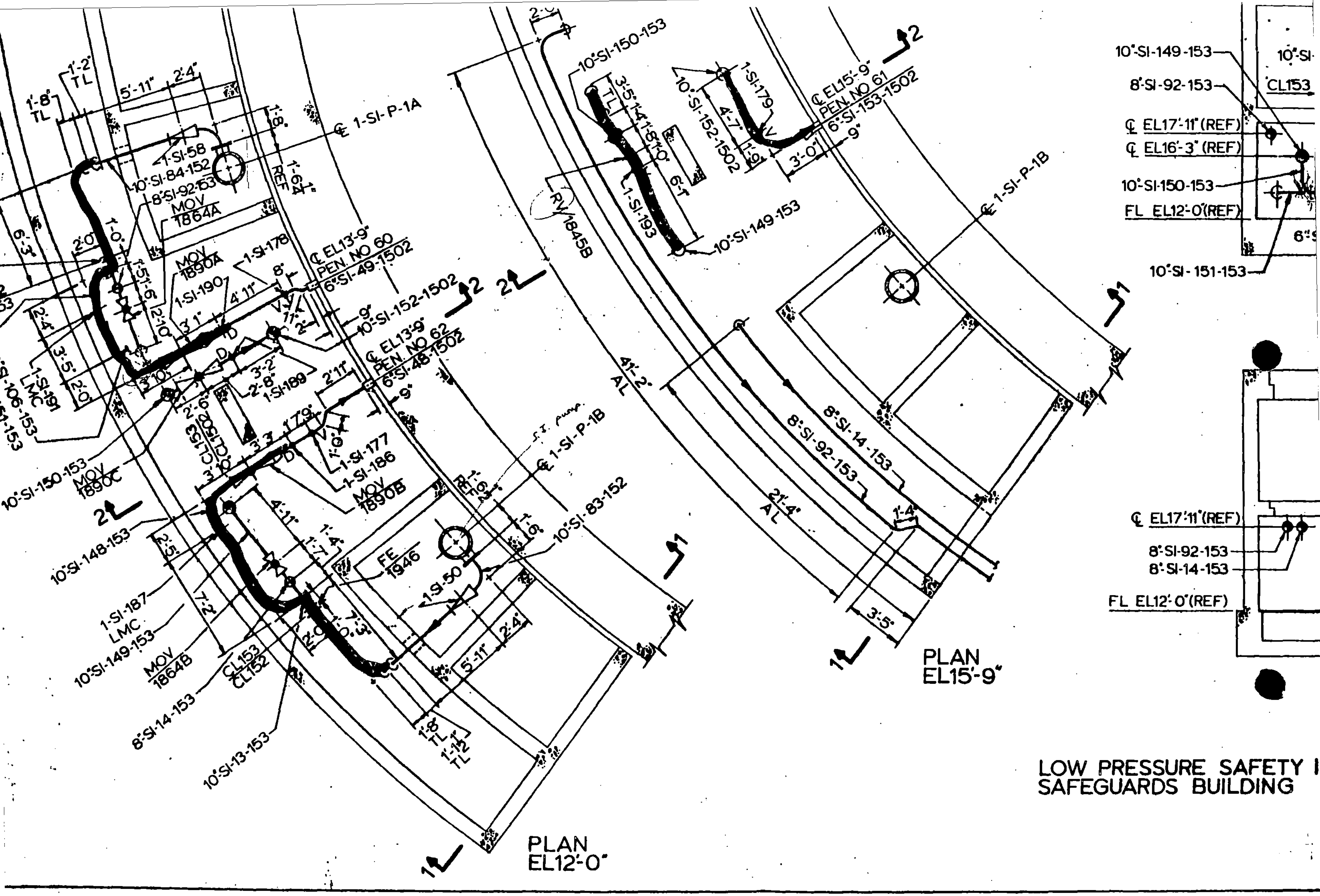


FIGURE 2



SG BLDG DETAILS



PLAN
EL12'-0"
PLAN
EL15'-9"
LOW PRESSURE SAFETY I
SAFEGUARDS BUILDING
℄ 1-SI-P-1A
℄ 1-SI-P-1B
℄ EL13'-9"
PEN. NO 60
6"-SI-49-1502
℄ EL13'-9"
PEN. NO 62
6"-SI-48-1502
℄ EL15'-9"
PEN. NO 61
6"-SI-153-1502
MOV
1864A
MOV
1890A
MOV
1890C
MOV
1890B
MOV
1864B
FE
1946
RV/1845B
1-SI-58
10"-SI-84-152
8"-SI-92-153
1-SI-178
1-SI-190
1-SI-189
1-SI-177
1-SI-186
1-SI-187
LMC
1-SI-191
LMC
1-SI-50
10"-SI-152-1502
10"-SI-150-153
10"-SI-148-153
10"-SI-149-153
8"-SI-14-153
10"-SI-13-153
10"-SI-83-152
1-SI-179
1-SI-193
10"-SI-152-1502
8"-SI-14-153
8"-SI-92-153
CL153
CL152
41'-2"
AL
21'-4"
AL
10"-SI-149-153
8"-SI-92-153
℄ EL17'-11" (REF)
℄ EL16'-3" (REF)
10"-SI-150-153
FL EL12'-0" (REF)
10"-SI-151-153
℄ EL17'-11" (REF)
8"-SI-92-153
8"-SI-14-153
FL EL12'-0" (REF)

FIGURE 3

ATTACHMENT A

STONE & WEBSTER ENGINEERING CORPORATION

245 SUMMER STREET, BOSTON, MASSACHUSETTS

ADDRESS ALL CORRESPONDENCE TO P.O. BOX 2325, BOSTON, MASS. 02107

W. U. TELEX: 94-0001
94-0977

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DESIGN
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EXAMINATIONS
CONSULTING
ENGINEERING

Dr. Allan Benjamin
Sandia National Laboratories
1515 Eubank SE
Albuquerque, NM 87125

May 22, 1985

BREAK LOCATION FOR SURRY V SEQUENCE

As a followup to your visit to our Boston office on May 21, 1985 to discuss details of our analysis of the V sequence for the Surry plant, this letter transmits the results of our investigation of the normal operating stresses in the portion of the low pressure safety injection system piping exposed to RCS pressure. Although the accident induced stresses would be different from the normal operating stresses, the latter are an indication of relative stress intensities at various points of interest throughout the system.

The findings of our review are as follows:

(1) Maximum normal operating stress between MOV1890C and RV1845B (that portion of piping exposed to high temperature flow through the relief valve) is confirmed to be at the currently postulated break location (90° elbow with hanger #127C2.11).

(2) Maximum normal operating system stress occurs at the 90° elbow where the piping turns upward towards the pump discharge at a 45° angle to the floor. An integral attachment is also placed on this elbow (hanger #127C2.13). A break at this location would be submerged to the same depth as the currently postulated break location.

(3) Normal operating stresses in the 8" line running above the flooded water level were found to be a minimum factor of three below the maximum normal operating system stress.

(4) Normal operating stresses in the portion of the 10" line running slightly below the flooded water level were found to be a minimum factor of two below the maximum normal operating system stress.

We conclude that the currently postulated break location remains the most likely. The alternative break location is also a 90° elbow with integral attachment, located at the same elevation with respect to the flooded water level as the currently postulated break location. Breaks slightly below, at, or above the flooded water level are extremely unlikely, estimated to be at least a factor of ten less likely than either the currently postulated break location or the alternate location discussed above.

Very truly yours,

James E. Metcalf

James E. Metcalf
Lead Engineer
Source Term Project