(7-77)

LICENSEE EVENT REPORT

Original Submittal - 12-20-79

CONTROL BLOCK: | | | | | | | (1) (PLEASE PRINT OR TYPE ALL REQUIRED INFORMATION)

0	1	N C B E P 1 (2)	0 0 - 0 0 0 0 0 - 0 0 (3)	4 1 1 1 1 (4)	(5)
7	8	9 LICENSEE CODE 14	15 LICENSE NUMBER 25	26 LICENSE TYPE 30	57 CAT 58

CON'T

0	1	REPORT SOURCE L (6)	0 5 0 - 0 3 2 5 (7)	1 2 1 2 7 9 (8)	0 1 1 4 8 0 (9)
7	8	60	61 DOCKET NUMBER 68	69 EVENT DATE 74	75 REPORT DATE 80

EVENT DESCRIPTION AND PROBABLE CONSEQUENCES (10)

0 2 While performing PT 19.6.0.1, Visual Inspection of Inaccessible Snubbers, the follow-

0 3 ing snubbers were found on the safety relief valve F013H tailpipe: 1) B21-34SS296,

0 4 elongated hole in rodeye; 2) B21-34SS297, reservoir missing, broken shaft, two bent

0 5 rodeyes, bent extension; 3) B21-34SS298, clamp moved; 4) B21-34SS299, broken shaft,

0 6 bent rodeye, clamp moved; 5) B21-34SS300, cracked weld on I-beam, clamp moved; 6) B21-

0 7 34SS336, bent extension, clamp moved, valve body damaged, broken springs; 7) B21-

0 8 34SS337, broken shaft, clamp rotated, extended end springs jammed into valve (cont'd.)

	SYSTEM CODE	CAUSE CODE	CAUSE SUBCODE	COMPONENT CODE	COMP. SUBCODE	VALVE SUBCODE
0 9	C C (11)	E (12)	B (13)	S U P O R T (14)	D (15)	Z (16)
7 8	9 10	11	12	13 18	19	20

(17) LER/RO REPORT NUMBER

EVENT YEAR		SEQUENTIAL REPORT NO.		OCCURRENCE CODE	REPORT TYPE		REVISION NO.
7 9	—	1 0 7	/	0 1	T	—	1
21 22	23	24 26	27	28 29	30	31	32

ACTION TAKEN	FUTURE ACTION	EFFECT ON PLANT	SHUTDOWN METHOD	HOURS (22)	ATTACHMENT SUBMITTED	NPRD-4 FORM SUB.	PRIME COMP. SUPPLIER	COMPONENT MANUFACTURER
X (18)	X (19)	Z (20)	Z (21)	0 0 0 0	Y (23)	Y (24)	A (25)	B 2 0 9 (26)
33	34	35	36	37 40	41	42	43	44 47

CAUSE DESCRIPTION AND CORRECTIVE ACTIONS (27)

1 0 It is believed that this damage occurred following a reactor scram on November 20, 1979,

1 1 when safety relief valves F013F, G, and H automatically lifted. Corrective actions are

1 2 described on the attached pages under the following headings: I. Repairs, II. Inspec-

1 3 tions and Tests, III. Commitments, IV. Analysis of Actual Event, and V. Piping

1 4 Integrity Analysis. (See attached pages).

	FACILITY STATUS	% POWER	OTHER STATUS (30)	METHOD OF DISCOVERY	DISCOVERY DESCRIPTION (32)
1 5	G (28)	0 0 0 (29)	N/A	B (31)	Periodic Test
7 8	9	10 12	13 44	45	46 80

	ACTIVITY RELEASED	CONTENT OF RELEASE	AMOUNT OF ACTIVITY (35)	LOCATION OF RELEASE (36)
1 6	Z (33)	Z (34)	N/A	N/A
7 8	9	10	11 44	45 80

PERSONNEL EXPOSURES

	NUMBER	TYPE	DESCRIPTION (39)
1 7	0 0 0 (37)	Z (38)	N/A
7 8	9 11	12	13 80

PERSONNEL INJURIES

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	NUMBER	DESCRIPTION (41)
1 8	0 0 0 (40)	N/A
7 8	9 11	12 80

LOSS OF OR DAMAGE TO FACILITY (43)

8001170486

	TYPE	DESCRIPTION
1 9	Z (42)	N/A
7 8	9	10 80

PUBLICITY

	ISSUED	DESCRIPTION (45)	NRC USE ONLY
2 0	N (44)	N/A	
7 8	9	10 68	69 80

NAME OF PREPARER A. C. Tollison, Jr. PHONE: 919-457-9521

GPO 917-326

Facility: BSEP Unit No. 1

Event Description and Probable Consequences (cont'd.)

body; 8) B21-34SS338, valve body damaged by poppet spring; 9) B21-34SS339, rodeye bent, clamp moved; 10) B21-34SS340, bent rodeye, clamp moved.

Technical Specification 6.9.1.8i

Cause Description and Corrective Actions (cont'd.)

I. Repairs

1. All damaged snubbers were rebuilt and functionally tested successfully.

2. All rodeyes, extensions, clamps, and I-beams were repaired or rebuilt, depending upon the extent of the damage.

II. Inspections and Tests

1. All other safety relief valves and associated piping were checked for damage, with none found.

2. All relief line vacuum breakers were inspected and tested satisfactorily.

3. The testing and rebuild history of the snubbers on the F013H tailpipe were reviewed. There were no significant findings

4. The F013H valve operating history was reviewed. There were no significant findings.

5. The following inspections were done for F013H:

   a. A visual inspection by engineering of all piping and supports in the drywell and torus.

   b. A magnetic particle or liquid penetrant inspection by QA of all pipe to elbow welds in the drywell and the SRV F013H to pipe welds.

   c. A 5X visual inspection by QA of the high-stress weld on each pipe support in the drywell.

   d. A visual inspection of all drywell piping and supports after opening the SRV's at ∿ 250 psig. (See II.6 below).

e. A visual inspection of all drywell piping and supports after opening the SRV's at ∿ 920 psig. (See II.6 below).

6. SRV's F013F and F013H share the same discharge header. In order to obtain more information, the following tests were performed after repairs had been completed. After each test, visual inspections of the pipes and supports were performed.

   a. At 250# reactor pressure, each SRV was opened sequentially.

   b. At 920# reactor pressure, SRV F013F was opened; and one second later, F013H was opened. SRV F013H was then closed three seconds later, and then F013F closed two seconds later.

   Inspections following each of the tests disclosed no damage.

III. Commitments

As a result of this event, CP&L has made the following commitments:

1. Until a permanent resolution is determined, if any pair of safety relief valves which share the same exhaust header lift, the affected unit will be shut down at once and the piping and supports inspected for damage. All snubbers on the affected line will be functionally tested.

2. Torus modification already planned will eliminate the potential for the recurrence of this event since each SRV discharge line will have a separate T-quencher. These modifications will be installed on both Brunswick units in 1980.

IV. Analysis of the Actual Event

Analyses were performed in December by United Engineers and Constructors in an attempt to identify a specific cause for the event. These analyses consisted of two parts. The first was an examination of the line for a normal SRV discharge, and the second was an estimation of the effects of a realistic water slug.

1. The study of the normal SRV discharge was performed using the General Electric Code RVFOR04 to generate a force-time history of each pipe segment using realistic system parameters. The results were then incorporated into a "Nupipe IIL" analysis of the line and its restraints. The results of this analysis showed that the loadings on all restraining elements were within their rated capacity, and all stresses were acceptable.

Further analyses were performed, selectively removing two, three, and four hydraulic snubbers from the system, which found the system loads still acceptable. From these analyses, it was concluded that a normal SRV discharge would not cause the observed damage, even with a substantial number of initially inoperable snubbers.

2. The second part of the analysis was a qualitative look at the potential forces associated with the existence of a water slug in the line of F013H due to the discharge of F013F. Once again, an analysis assuming that all snubbers are initially functional and realistic estimates of system parameters indicates that no loss of structural integrity is likely to occur. However, in the event that selected snubbers were nonfunctional when the event occurred, the resulting loads would be capable of producing the observed damage.

V. Piping Integrity Analysis

As a result of concerns expressed by members of the ONRR staff on January 4 1980, an analysis was performed to demonstrate the integrity of the SRV discharge line segment inside the torus but above the water line. That analysis is attached as Appendix A. The results of that analysis confirm that the structural integrity of the line is maintained even with extremely conservative calculational assumptions.

CAROLINA POWER & LIGHT COMPANY
BRUNSWICK STEAM ELECTRIC PLANT
S/RV DISCHARGE LINE INTEGRITY ANALYSIS

Abstract

This report documents the results of the analysis which shows that the S/RV discharge line in the torus can withstand the loads associated with the discharge of a water slug at the time of an S/RV actuation. Therefore, the occurrence of a line rupture in the torus above the water level with a stuck-open relief valve is not a credible event, and no further analysis for this occurrence is warranted.

Introduction

The safety/relief system for the General Electric Mark I boiling water reactor at the Brunswick Steam Electric Plant consists of eleven 3-stage Target Rock safety relief valves attached to the main steam lines. The discharge piping is routed through the containment (drywell) such that two lines are routed through five different vent pipes and one through a sixth vent pipe. See Figure 1. The discharge lines run through the vent pipe to the ring vent header where they penetrate the header in a vertical orientation. The discharge lines run approximately 89" vertically downward to a submergency of approximately 64". See Figure 2. For the design of the two lines in the same vent pipe, the discharge is through a common horizontal header, called the "double-T." See Figure 3. The single line discharges through a "single-T."

It has been postulated that a recent sequence of S/RV openings resulted in damage to snubbers on a discharge line in the drywell (Reference LER 1-79-107). The postulated scenario is that, following a reactor scram, reactor pressure increased to the point that an S/RV opened. As a result of the S/RV opening, the manifold pressure increased causing the water initially in the adjacent discharge line sharing the same exhaust header to be pushed up into the S/RV line. This safety relief valve was then actuated. The expulsion of this water slug from the discharge line caused high loads which resulted in damage to the snubbers. This damage was detected during a routine snubber inspection and was reported in LER 1-79-107.

In reviewing the LER, the ONRR staff raised questions about the possible existence of an unreviewed safety question. The issue concerns whether the loads from such an event could cause a pipe rupture in the S/RV discharge piping inside the torus but above the water level. A break in any other location is clearly within the bounds of LOCA cases already analyzed. For this event to have significance, an additional failure in the form of a stuck-open S/RV is also required.

This analysis examined the S/RV discharge line in the torus between the ring vent header and the torus water level which is a 2-foot section of the 100-foot discharge line. An analysis has been performed to show that this section of pipe can withstand the loads associated with the discharge of the water slug. Thus, a failure at this location cannot occur as the pipe maintains structural integrity. A description of the analysis and the result follow in this report.

Analysis

The analysis of the safety/relief system and the mechanism of failure revealed that the load imposed can be defined in terms of velocity of the water slug. The analysis was restricted to the pipe segment in the torus between the vent header and the water level. The analysis consisted of the following three parts:

1. Determination of the location with the highest potential for failure.

2. Determination of the velocity for the actual water slug discharge.

3. Comparison of the actual velocity with the allowable velocity at the point with the highest potential for failure.

For this analysis, assumptions had to be made to allow the use of available computer codes. In all cases, the assumptions resulted in conservative results for selecting the point of failure and allowable velocity and for determining the slug velocity. These conservatisms are discussed later in this report.

1. Location of Failure

   The segment of line under investigation is a vertical run of pipe from the penetration of the vent header to the water level in the torus as shown in Figure 3. A break above this penetration allows the discharge of the steam through the normal pressure suppression mode through the vent header downcomers. A break below the water level will still retain pressure suppression by condensation as designed.

   The S/RV discharge line is a 10-inch diameter, schedule 80, A106 Grade B carbon steel pipe. The design of the penetration at the vent header is shown on Figure 4. The discharge line is attached to the vent header by a 3/4-inch full penetration weld. This area around the weld, as well as the normal pipe section, were selected for analysis to determine the location with the lowest allowable load at structural integrity, hence the location with the highest potential for failure.

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a. For Section 1.a of Figure 4, the welded area at the penetration, it was assumed that the load carrying capability was limited by shear in the weld (i.e., fault occurring in the weld heat affected zone propagating into the base metal of the pipe). The maximum load capability in this area is defined as:

$$F_{\substack{1a\\cap}} = 2\,\pi\, r\, t_w\, \tau_{all}$$

where r = OD pipe radius (5.375 inches)
t_w = effective weld shear thickness (assumed conservatively as same thickness as vent header thickness - 0.75 inches)

τ_{all} = allowable shear ($0.65\sigma_y$ where σ_y = 36,000 psi)

$$F_{\substack{1a\\cap}} = 2\,\pi\,(5.375)\,(0.75)\,(0.65)\,(36{,}000)$$

$$= 592{,}700 \text{ pounds}$$

b. For Section 1.b of Figure 4, normal pipe section, the maximum load carrying capability was limited by a tension failure in the base metal. The maximum load capability before structural integrity is defined as:

$$F_{1.b} = A_p\, \sigma_{all}$$

where A_p = cross section area of pipe material

σ all = 36,000 psi

$$F_{\substack{1.b\\cap}} = \pi/4\,(10.75^2 - 9.564^2)\,(36{,}000)$$

$$= 681{,}120 \text{ pounds}$$

Therefore, it is concluded that the location having the highest highest potential for failure for the given load condition for the segment of pipe investigated is at the weld of the discharge line to the vent header.

2. Water Slug Velocity Calculation

A computer analysis was made to determine the maximum velocity of the water slug being expelled from the discharge line. Using the relationship $F = \rho A v^2$, the allowable load can be equated to an allowable velocity for comparison to the calculated velocity.

The S/RV discharge line was taken as 103 feet in length (same as the line where the problem existed). The water colum… in the discharge l·ne under no flow conditions is the same height as th… …oun… of submergence. It was, therefore, assumed that the …ater slug length was equal to the submergen…e, 64", and that the S/RV line above the water …s at atm… …heric pressure, 14.7 psi. It has been calculated th… … discharge line pressure in the "double-… exhaust h… …uer is approximately 60 psi for one S/RV discharge. If the water slug is assumed to stay intact and is pushed up the S/RV line until pressures on opposing sides equalize, the water slug will travel approximately 70 feet up the line. A parametric study was done for various conditions to determine the maximum expected velocity of the water slug at the pipe segment in question. Several assumptions had to be made to make the analysis compatible with available equations. The conservative nature of the assumptions are discussed later in this report. Basically, the line was considered a straight line with additional loss factors added equivalent to the number of elbows in the line. The water slug was assumed to stay intact, no breaking up or two-phase flow. The S/RV opens and drives the water slug out of the line, until, at the exit, the velocity reaches 554 feet per second.

3. Actual vs. Allowable Comparison

The fluid-induced loads for this postulated event van be defined as:

$$F = DLF\ \rho A V^2$$

where DLF = dynamic load factor, which was conservatively assumed to equal 2

ρ = mass density of the water, 1.938 slug per foot^3

A = cross sectional area of the pipe

v = water slug velocity

$$F = 2(1.938)\frac{\pi}{4}(9.564)^2 v^2$$

$$= 1.9\ v^2$$

$$v = \sqrt{F/1.9}$$

The load for structural integrity at the point of highest probability of failure (weld at the penetration of vent header) was calculated to be 592,700 pounds. Therefore, the maximum allowable velocity without exceeding structural integrity of the pipe is:

$$v_{all} = \sqrt{592,700/1.9}$$

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v_{all} = 558 ft/sec

The allowable velocity (588 feet/second) is greater than the computed velocity of 554 feet/second; and, hence the pipe will maintain structural integrity and no pipe failure will occur. To reiterate, this analysis is considered conservative because of the assumptions made as discussed below.

Analysis Conservatisms

The following discussions are presented concerning the assumptions used in the analyses and their selection to make the analysis conservative.

1. The water slug stays intact

   This assumption had to be made for analytical purposes, as no code exists which allows the slug to break up. However, fluid dynamics indicates that the many changes of direction in the S/RV line through the drywell will tend to break up the water slugs so that the high loads and associated damage would not occur.

2. Water slug rises to the maximum height possible

   This assumption was made to give the highest velocity at the exit following an S/RV opening. The water slug is accelerating throughout the discharge and the longer the pipe, the higher the velocity.

3. The S/RV line is a straight line

   This assumption was also made for analytical purposes and tends to give higher velocities than would be expected for the line with multiple elbows. This results in higher calculated loads as velocity and load are directly related.

4. Pipe failure mechanism simplication

   The pipe was assumed to fail in the shear of the weld at the penetration of the vent header. It is assumed that the load causing the weld to shear also allows a break to propagate across the base metal and rupture the pipe. In addition, the effective thickness of the weld was considered as only that of the vent header and does not consider any increase due to the throat of the weld.

5. Dynamic load factor

   The dynamic load factor utilized in the equation for determining allowable load, and hence allowable velocity,

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was taken as two, which is the maximum factor for this configuration and load condition.

6. Selected stress allowable for structural integrity contains significant margin to failure ($0.65\ \sigma_y$).

Seismic Analysis

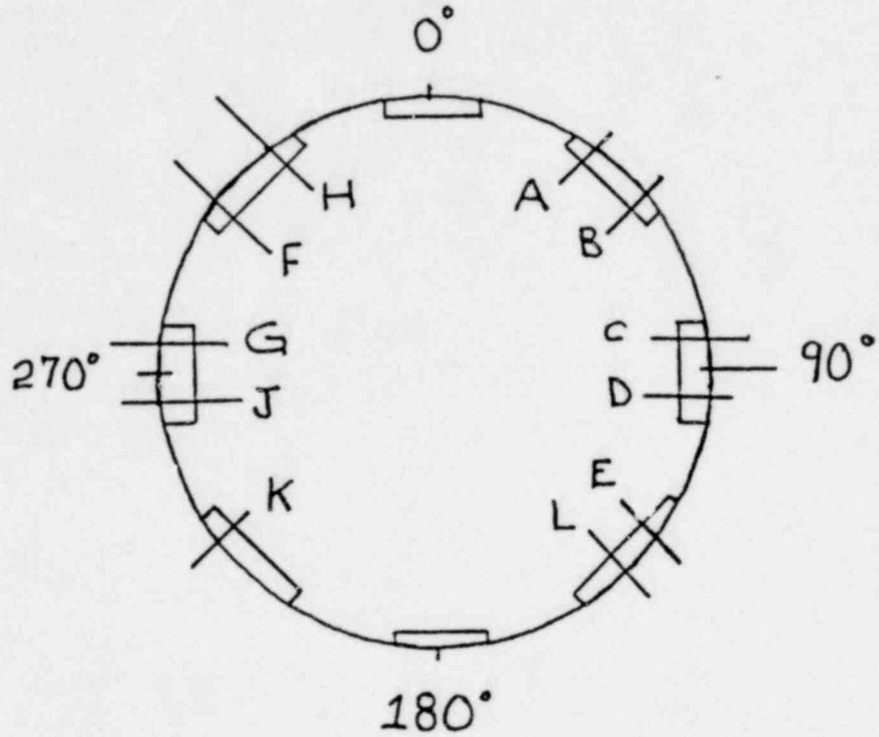
A conservative evaluation was done to determine the seismic stress component for the segment of the S/RV line in the torus being analyzed. Since the first natural frequency of this S/RV line section is in the rigid range, the seismic response was assumed to be the same as the maximum of the vent header. Upperbound seismic stresses were calculated to be less than 1,000 psi. Therefore, the seismic component will not add significantly to the stresses in this pipe for the event being analyzed.

Conclusions

The design of the safety relief system and potential operating loads were reviewed. It can be postulated that an S/RV which shares a common exhaust header with another S/RV could be opened while containing the water slug. Although the set pressures are different for the valves, the allowable $\pm$ 1% margin on set pressure could cause the event that was postulated to have caused the damage to the snubbers at Brunswick. An exacting analysis of the system under postulated conditions cannot be made due to the limitation of existing computer codes and the lack of knowledge of the exact values of contributing parameters for the event. Therefore, a simplified analysis was made for the event where the assumptions required were made in a conservative direction. The conclusion of the analysis is that, while the loads are high for an SRV discharge with a water slug in the line, the load carrying capability of the line will not be compromised as pipe will maintain structural integrity.

FIGURE 1:

SRV DISCHARGE PIPE LOCATION & SRV SET POINTS



VALVE NO.		SET PRESSURE		
		1105	1115	1125
RVFO 13	A	X		
	B			X
	C	X		
	D		X	
	E		X	
	L			X
	K		X	
	G	X		
	J			X
	F	X		
	H		X	

FIGURE 2:

SRV DISCHARGE PIPE SECTION IN VENT PIPE & TORUS

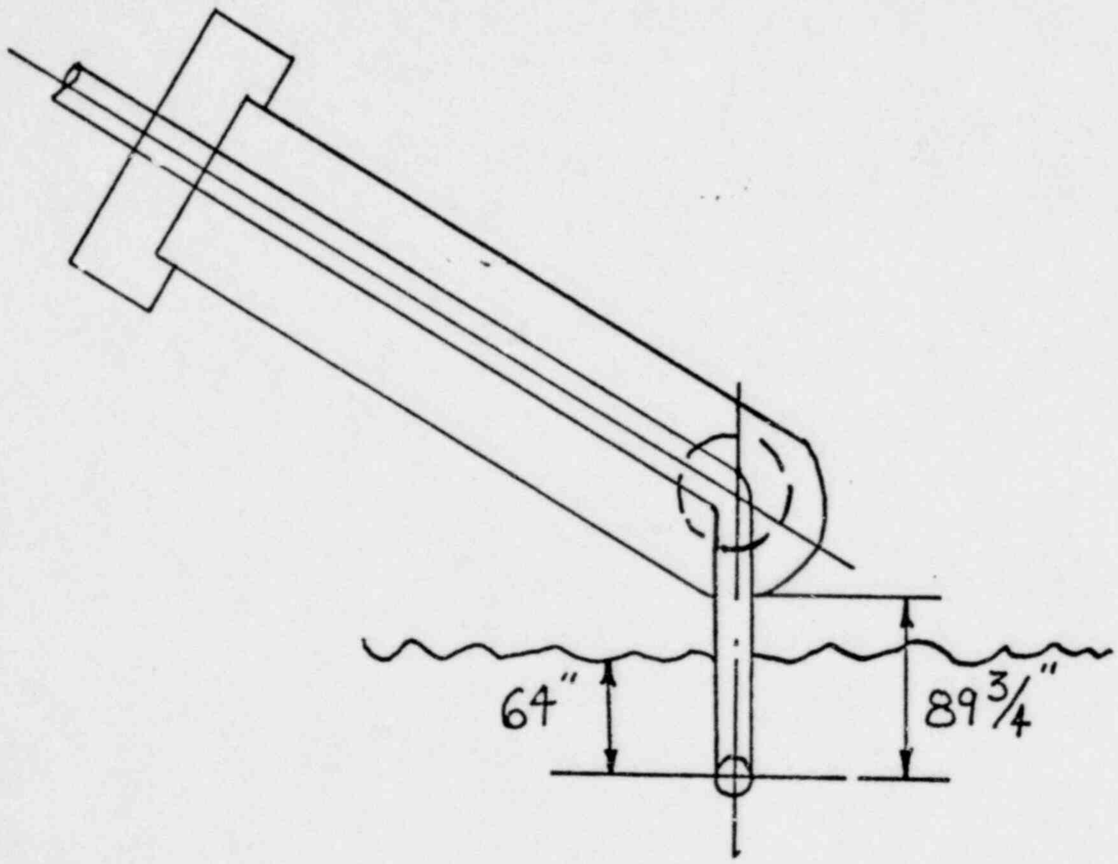


FIGURE 3:

SRV "DOUBLE T" ARRANGEMENT

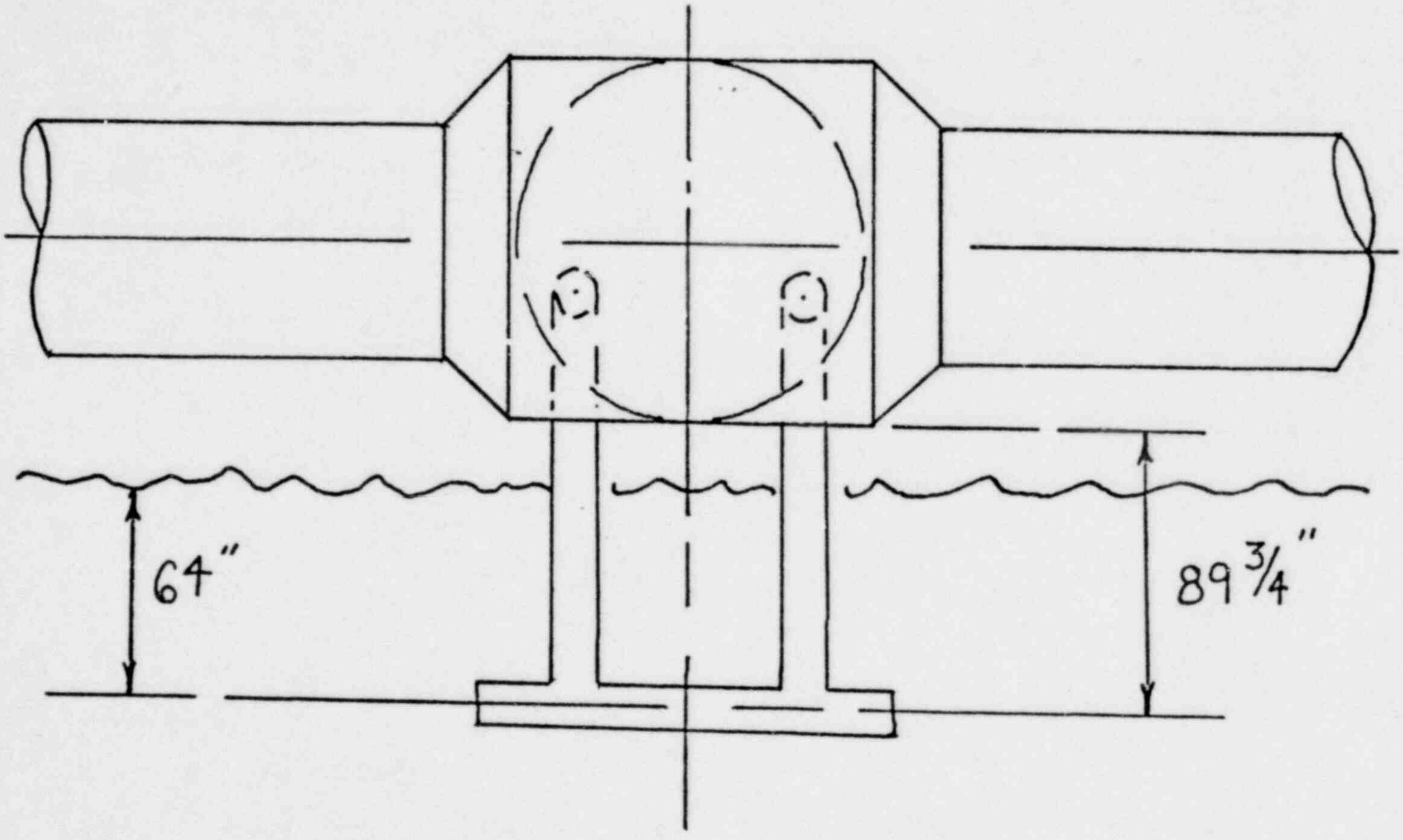
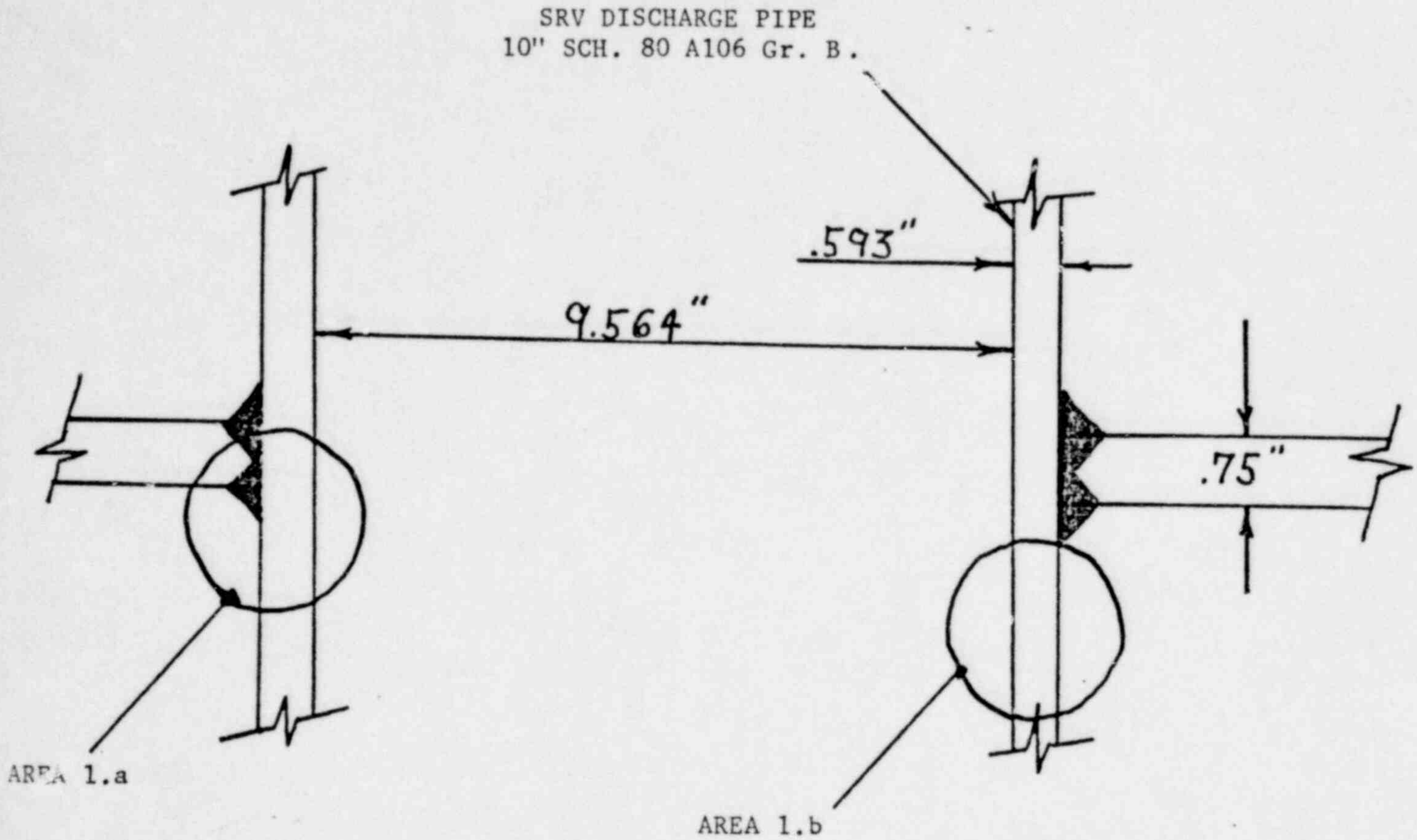


FIGURE 4:



SECTION OF SRV PIPE PENETRATION AT RING HEADER CONNECTION