GPU Nuclear

GPU Nuclear Corporation
Post Office Box 480
Route 441 South
Middletown, Pennsylvania 17057-0191
717 944-7621
TELEX 84-2386
Writer's Direct Dial Number:

June 15, 1984

5211-84-2134

Office of Nuclear Reactor Regulation
J. F. Stolz, Chief
Operating Reactors Branch No. 4
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Stolz:

Three Mile Island Nuclear Station, Unit I (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
Asymmetric LOCA Loads (ALL)

As discussed with Mr. Owen Thompson of your staff, we are transmitting a copy of the back-up calculations showing that the TMI-1 hot leg restraint is adequate under ALL conditions. This information should resolve items 2.4.1, 2.4.4, 2.4.8, 3.3.1 and 3.3.2 of your letter dated March 27, 1984. The attached information also supplements GPUN letter dated June 25, 1982 (5211-82-151), B&W 1621 and its supplement. The attached information provides the appropriate calculations demonstrating the acceptability of the existing TMI-1 hot leg restraints without additional modification.

Sincerely,

H. D. Hukill
H. D. Hukill,
Director, TMI-1

HDH/PGD/CWS/mle

Attachment: B&W Letter, B. J. Short to D. G. Slear
dated July 29, 1982 (ESC-393)

cc: R. Conte
J. Van Vliet

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AUG 0 4 1982 PGD

Babcock & Wilcox

a McDermott company

Nuclear Power Generation Division

3315 Old Forest Road
P.O. Box 1260
Lynchburg, Virginia 24505-1260
(804) 385-2000

July 29, 1982
ESC-393
582-7086/T1.2

TMI - 1
AUG 2 1982
RESTART
9.30.114

Mr. D. G. Slear, TMI-1 Engineering Project Manager
GPU Nuclear Corporation
100 Interpace Parkway
Parsippany, New Jersey 07054

Attention: Mr. J. A. Mahn

Subject: GPU Nuclear Corporation (TMI-1)
Master Services Contract, Effective date: June 1, 1977
Reference Nos.: B&W 582-7105, GPU M77120
Task 202 - Analysis of Hot Leg Support for Asymmetric LOCA Loads

Attachment: GPU Nuclear Vendor Transmittal Form, P.O. No. M77120, transmitting B&W Document Number 32-1135359-00 (5 copies)

Dear Mr. Slear:

The results from evaluating the Asymmetric LOCA Loads for TMI-1 (Task 86) showed that the hot leg restraint was overstressed. Many discussions between your Mr. Steve Leshnoff and several engineers at B&W concluded that a less conservative calculation could be performed and a positive margin could be calculated.

The attached document shows a calculated safety factor of 1.002 and completes the subject Task 202.

If you need any further assistance, or have any questions, please call me at 804-385-2083.

Very truly yours,

B. J. Short

B. J. Short, Senior Product Manager
Engineering Product Management

BJS/bgd

cc: S. Leshnoff - GPUN
W. D. Maxham - B&W
L. J. Stanek - B&W

GPU Nuclear **Vendor Transmittal Form**

To: D. G. SLEAR — P.O. No. M77120

Address: 100 Interpace Parkway — WO/SO 5520/60270 — B/A 412095

Parsippany, NJ 07054 — Spec. No. NA — Base 5522

Subject: Analysis of Hot Leg Support for Asymmetric LOCA Loads — Engr. J. A. Mahn

From: Babcock + Wilcox

Address: P.O. Box 1260
Lynchburg, Va. 24505

Sub. By: B. J. Short

Title: Sr. Product Manager

No. Reprod. ______ No. Prints 5

Submitted For:

- ☐ Waiver
- ☐ Review
- ☐ Dist.
- ☐ Info

Sub. No. ______

Action Codes			
A	Drawing Reviewed	Without comments	1
		With comments as noted	2
		Not required	3
		No comments and no print returned	4
B	Vendor Action	No further reproducible is required	5
		Resubmit revised reproducible	6
		Resubmit certified mylar reproducible	7
		Do not proceed with fabrication resubmit revised reproducible	8

GPUN No.	Vendor Doc. No.	Rev.	Title	Act.
	32-1135359-00		Review of GPUN Calculation for TMI Restraint Bracket Design	

Waiver/Comment

Instruction/Comment

Approval ______
Supervisor — Date

cc:

A0000361
11-81

CALCULATION DATA/TRANSMITTAL SHEET

DOCUMENT IDENTIFIER

CALC. 32 - 1135359 - 00

TRANS. 86 - -

TYPE: ___RESEARCH & DEVELOPMENT ___SAFETY ANALYSIS REPORT ___NUC. SERV. INPUT ___DESIGN RQMT. ___DESIGN VERIF. ___OTHER

TITLE Review of GPUN Calculation For TMI Restraint Bracket Design

PREPARED BY C. C. Lin *CC Lin* REVIEWED BY *William D. Moxham*

TITLE Principal Engineer DATE 7/28/82 TITLE *Manager SSU* DATE *29 Jul 82*

PURPOSE:

To review GPUN design calculation for TMI Hot Leg Restraint Bracket

SUMMARY OF RESULTS (INCLUDE DOC. ID'S OF PREVIOUS TRANSMITTALS & SOURCE CALCULATIONAL PACKAGES FOR THIS TRANSMITTAL)

See summary of this document.

DISTRIBUTION

I. INTRODUCTION

This report presents our view on GPUN calculation No. 1101X-322C-A41[1], design qualification for TMI Hot Leg Restraint Bracket attachment. It is not intended to qualify the use of the results.

II. DESIGN REQUIREMENT

References 2 and 3 are used as the guideline for this review. Bracket design should meet the following requirements:

II-a. $\phi \cdot F \geq \gamma \cdot L$ ------(1)

Where F = Shear strength of the bracket

$$F = 1.4 \cdot (\ell - D_1/2) \cdot t \cdot \sigma_u^P \cdots (2)$$

L = Design Load

ϕ = Strength Reduction Factor

γ = Load Factor

II-b. $\ell / D \geq 1.7 \cdot \sigma_b / \sigma_u^P$ -------------(3)

Where ℓ = Length of Bracket Free-End Zone

D = Diameter of Pin

$\sigma_b = \gamma \cdot L /$ Projected Area of Pin

$\sigma_u^P = 1.05 \cdot \sigma_u$ (σ_u = Ultimate Strength of bracket material)

The bracket has structural parameters as follows:

ℓ = 7 in.

D = 4 in.

t = 3 in.

σ_u = 58 ksi

D_1 = 4.03125 in.

III. REVIEW OF GPUN CALCULATION

Design load, L, of 1271.7 Kips is obtained from BAW-1621, the asymmetric LOCA loads analysis. Shear strength of the bracket, F, calculated from EQ.(2), is 1274.9 Kips.

III-1 To meet EQ.(1)

EQ. (1) Can be rewritten as

$$F/L \geq \gamma/\phi \text{ -------(4)}$$

It should be noted that F/L is also termed as safety factor (SF).

Therefore, the bracket is designed with $SF = F/L = \frac{1274.9}{1271.7} = 1.002$ --- (5)

If $\phi = .85$ is applied to the design, then EQ.(1) can be met only with using a load factor of .852 (<1.).

Hence, it can be concluded that the design has a SF of 1.002, and a load factor of .852 if strength reduction factor of .85 is used in design calculation. In case a load factor of 1. is to be used, this design provides no margin for strength reduction.

III-2 To meet EQ.(3)

EQ.(3) is derived with a safety factor of 2. To provide a SF of 1.002, EQ.(3) can be modified into

$$\ell/D \geq .852 \cdot \frac{\tau_b}{\tau_u} \rho \text{ ---(6)}$$

with $\ell/D = \frac{7}{4} = 1.75$ and

$$.852 \cdot \frac{\tau_b}{\tau_u} \rho = .852 \; \frac{\frac{1271.7}{3*4}}{60.9} = 1.5$$

Therefore, EQ.(6) is met if SF of 1.002 is used in design.

IV. SUMMARY

The design of TMI Hot Leg Restraint Bracket has a safety factor of 1.002, and allows no margin for strength reduction if a LOAD factor of 1. is used.

V. REFERENCES

1. GPUN calculation no. 1101X-322C-A41 (Attached)
2. AISC Code, 1978
3. Fisher, J.W., and Struk, J.H.A., "Guide to Design Criteria For Bolted and Rivets Joints," Wiley, 1974.

SUBJECT EVALUATION OF TMI-1 HOT LEG RESTRAINT AFTER POSTULATED GUILLOTINE BREAK AT ELBOW

32-1135359-00

1.1 STATEMENT OF THE PROBLEM

The asymmetric LOCA loads (ALL) analysis (BAW-1621) identified the bracket attachment to the primary wall embedment portion of the hot leg restraint as a possible point of failure subsequent to a guillotine break at the elbow. This is, in fact, not an asymmetric LOCA load but was considered as part of the ALL evaluation.

Due to a maximum load of 1271.7 KIPS, the bracket attachment is said to fail by a shear-out failure due to high bearing loads. If true, a reportable situation exists due to a structural deficiency from a loading that is part of the plant design basis.

2.0 KEY RESULTS

A technical logic exists which can be used to demonstrate that the hot leg restraint bracket attachment will not fail at the postulated load. The technical logic employs:

1. NRC Standard Review Plan (SRP) 3.6.2 to incorporate strain rate effects (10% increase on yield strength and a permissable strain of one-half the uniform ultimate strain).
2. AISC Sec. 1.5.2.2 to incorporate a 35% increase in yield when considering bearing stress.
3. A B & W Owners Group position on material property variability to increase both yield strength and ultimate strength by 5%.
4. Design guidelines from the experimental work of, Fisher, J. W., and Striuk, J. H. A., Guide to Design Criteria for Bolted and Riveted Joints, Wiley, 1974.

The results below are supported by calculation

1. The maximum overload to be taken in bearing is 1271.7 KIPS. It can be shown that the maximum allowable load is 1274.9 KIPS.
2. The net section tension stress is 42.53 KSI while the maximum net section tension strength is found to be 42.77 KSI.

Attached Reference

These results are conservative because the following load reduci mechanisms are not invoked:

1. A plastic hinge develops in the hot leg piping between the restraint and the OTSG inlet which will permit the large rotation required for the pipe to contact more than the 4 U-bars of the 7 that are impacted.

2. These results ignore the energy absorbing circumferential deformation of the hot leg pipe as it bears against the U-ba The pipe is treated as infinitely stiff with respect to loca deformations.

3.0 CONCLUSIONS

A reportable situation does not exist. There is margin in the present structure, without modification, to withstand a maximum load of 1271.7 KIPS as a result of a guillotine break at the hot leg elbow. Structural integrity is demonstrated using NRC SRP 3.6.2, AISC code, and the technical literature.

4.0 REFERENCES

1. BAW-1621, B&W 177-FA OWNERS GROUP, EFFECTS OF ASYMMETRIC LOCA LOADS, PHASE 2 ANALYSIS, JULY '80.

2. FISHER, J.W., & STRUIK, J.H.A., GUIDE TO DESIGN CRITERIA FOR BOLTED AND RIVETED JOINTS, WILEY, 1974.

3. AISC MANUAL OF STEEL CONSTRUCTION, SEVENTH EDITION.

4. NRC STANDARD REVIEW PLAN (SRP) 3.6.2.

5.0 ASSUMPTIONS AND BASIC DATA.

1. LOADS
THE ELBOW BREAK LOADS ARE IDENTIFIED ON THE FOLLOWING TABLE (TABLE 1). ONLY THE PEAK LOAD AT BAR #1 IS CONSIDERED.

2. GEOMETRY
App. B. CONTAINS A SKETCH OF THE AREA.

SUBJECT EVALUATION OF TMI-1 HOT LEG RESTRAINT AFTER POSTULATED GUILLOTINE BREAK AT E...

Summary of Pipe Whip Restraint Loads for TMI-1 — As-Built[a]

Break type	Restraint (see Figure B-2)		Peak load, lb		Load description
Hot leg guill. at RV	No. 1,	bar 1	2,533,810		Tension
		bar 2	2,513,110		Tension
		bar 3	2,275,870		Tension
		bar 4	868,406		Tension
		bar 5	NI		--
		bar 6	NI		--
		bar 7	NI		--
		Sum	8,161,230		Tension
		Collar	NI		--
	No. 2		NI		--
Hot leg guill. at elbow	No. 1,	bar 1	2,543,340	*	Tension
		bar 2	2,519,150		Tension
		bar 3	2,261,450		Tension
		bar 4	544,007		Tension
		bar 5	NI		--
		bar 6	NI		--
		bar 7	NI		--
		Sum	7,718,890		Tension
		Collar	NI		--
	No. 2		NI		--

* DESIGN LOAD

Note: NI: not impacted.

TABLE 1

PEAK DESIGN LOAD FOR ELBOW BREAK

1271.6
= 2547301

Attached Reference

SUBJECT TMI-1 HOT LEG RESTRAINT, BRACKET ATTACHMENT EVALUATION AFTER ELBOW BREAK.

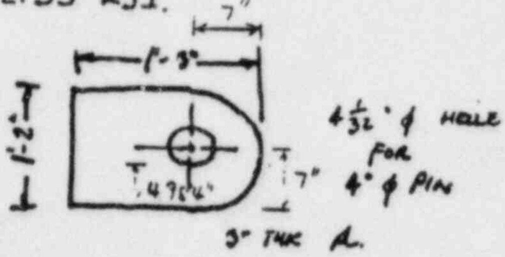
6.0 CALCULATIONS.

BRACKET STRESSES

MAX AXIAL LOAD: 1271.7 KIPS.

6.1 TENSION

$$\sigma_t = \frac{1271.7 \text{ KIPS}}{4.984 \times 3 \times 2} = 42.53 \text{ KSI.}$$



THIS STRESS IS ACCEPTABLE USING EITHER OF TWO CRITERIA.

1. USING NRC SRP 3.6.2, THE MAX. STRAIN FOR RESTRAINTS SHOULD NOT EXCEED ONE-HALF THE UNIFORM ULTIMATE STRAIN, $\frac{1}{2}\epsilon_{un}$. THE STRESS ASSOCIATED WITH THIS STRAIN IS S_a = 51.15 KSI. (FIG. 1)

$$\sigma_t < S_a.$$

2. IN FISHER & STRUIK, REF. ABOVE IT IS NOTED THAT IT IS USUALLY CONSIDERED DESIRABLE FOR A PINNED JOINT TO HAVE THE CAPACITY FOR DISTORTION OR GEOMETRICAL ADJUSTMENT BEFORE FAILURE BY FRACTURE. THIS MEANS THAT THE CONNECTION SHOULD PERMIT YIELDING TO OCCUR IN THE GROSS CROSS-SECTION MEMBER BEFORE THE JOINT FAILS THROUGH THE NET SECTION. THIS REQUIREMENT IS SATISFIED IF:

$$\frac{A_n}{A_g} \geq \frac{\sigma_y}{\sigma_u}. \qquad \text{EQ. 5.10 IN FISHER \& STRUIK.}$$

Attached Reference

GPU Nuclear

CALC. NO. 1101X-322C-A01
SHEET NO. 5 OF 7
DATE 7/16/81
COMP. BY/DATE 7/28/81
CHK'D. BY/DATE 7/31

SUBJECT A. L. L. HOT LEG RESTRAINT, BRACKET ATTACHMENT EVALUATION AFTER ELBOW BREAK

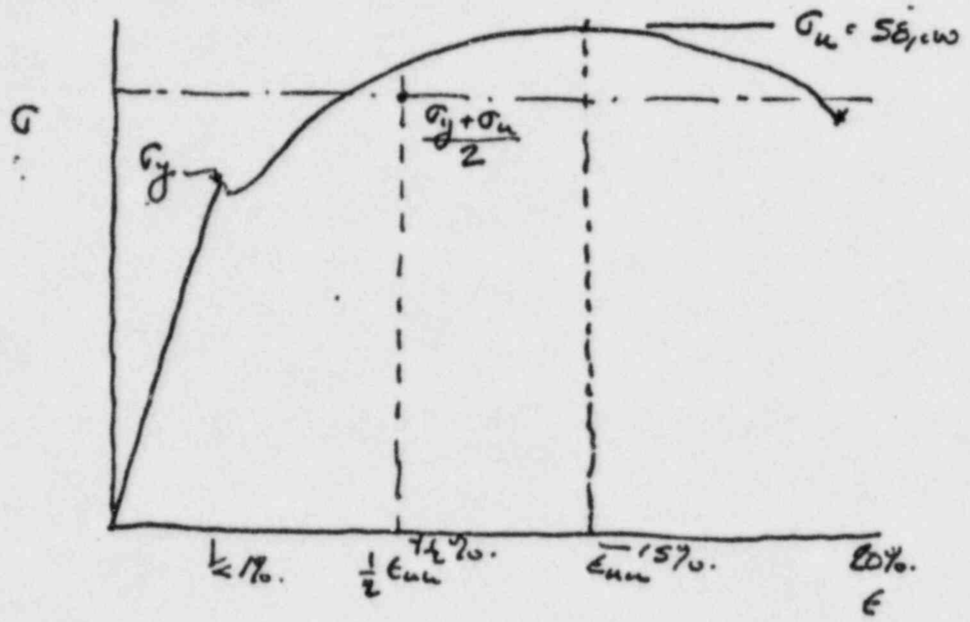


FIG. 1

STRESS — STRAIN CURVE FOR STRUCTURAL STEEL.

Attached Reference

BY REARRANGEMENT,

$$A_n \sigma_u \geq A_g \sigma_y$$

SOLVING FOR THE NET SECTION ALLOWABLE, REMEMBERING THAT σ_u PERTAINS TO THE NET SECTION AND σ_y TO THE GROSS SECTION,

$$A_n (\sigma_n)_{ALLOW.} = A_g (\sigma_g)_{ALLOW.}$$

$$(\sigma_n)_{ALLOW.} = \frac{A_g}{A_n} (\sigma_g)_{ALLOW.} = \frac{(\sigma_g)_{ALLOW.}}{A_n/A_g}$$

NOW,

$$\frac{A_n}{A_g} = \frac{2 \times 4.984 \times 3}{2 \times 7.00 \times 3} = 0.712$$

$$\& \quad (\sigma_g)_{ALLOW} = .5\sigma_u \quad \text{(AISC SECT. 1.5.1.1)}$$

SUBSTITUTING,

$$(\sigma_n)_{ALLOW.} = \frac{30.45}{.712} = 42.77 \text{ KSI} > \sigma_t$$

IT IS USEFUL TO NOTE THAT:

$$A_n \sigma_{u_3} \geq A_g \sigma_y$$

$$(2 \times 4.984 \times 3)(1.05 \times 58) \geq (2 \times 7.00 \times 3)(1.1 \times 1.05 \times 36)$$

$$(29.904)(60.9) \geq (42) \times (41.58)$$

$$1821.2 \geq 1746.4$$

THE GROSS SECTION REACHES YIELD BEFORE THE NET SECTION FRACTURES.

FISHER AND STRUIK RECOMMEND A FACTOR, ϕ, EQUAL TO 0.85.

$$\frac{A_n}{A_g} \geq \frac{\sigma_y}{\phi \sigma_u}$$

IN THIS APPLICATION, THE FACTOR IS .96 AND IS JUSTIFIED BY VIRTUE OF INFREQUENT LOADING.

Attached Reference

SUBJECT TMI-1 HOT LEG RESTRAINT, BRACKET ATTACHMENT EVALUATION AFTER ELBOW BREAK.

BRACKET STRESSES

MAX AXIAL LOAD : 1271.7 KIPS.

6.2 BEARING

USE OF σ_u FOR BEARING ALLOWABLE

AISC 1.5.2.2	MAT'L PROP. VARIABILITY	$\dot{\epsilon}$ (SRP 3.6.2)	AISC 1.5.6 FOR INFREQUENT LOAD

$$F_p = 1.35 F_y \times 1.05 \times 1.10 \times 1.33$$

$$= 2.07 F_y = 74.66 \text{ KSI} > \sigma_u$$

USE σ_u.

FROM FISHER & STRUIK, USING LOAD FACTOR DESIGN,

$$F = (2t)\left(L - \frac{d}{2}\right)(0.7\,\sigma_u^{\,P})$$ EQ. 5.35 IN FISHER & STRUIK.

$$F = (1.4)\left(7 - \frac{4.03125}{2}\right)(3)(60.9)$$

$$F = 1274.9 \text{ KIPS.}$$

$$F > F_{APPLIED} \; ; \; F_{APPLIED} = 1271.7 \text{ KIPS.}$$

THE LIMITING LOAD CAPACITY IS GREATER THAN THE APPLIED LOAD

THE ULTIMATE TENSILE STRENGTH IS

$$\sigma_u = \underset{\text{(FOR MAT'L PROP. VARIABILITY)}}{1.05} \times \underset{\text{MIN. ULT.}}{(\sigma_u)_{MIN}}$$

$$= (1.05)(58) = 60.9 \text{ KSI.}$$

Attached Reference

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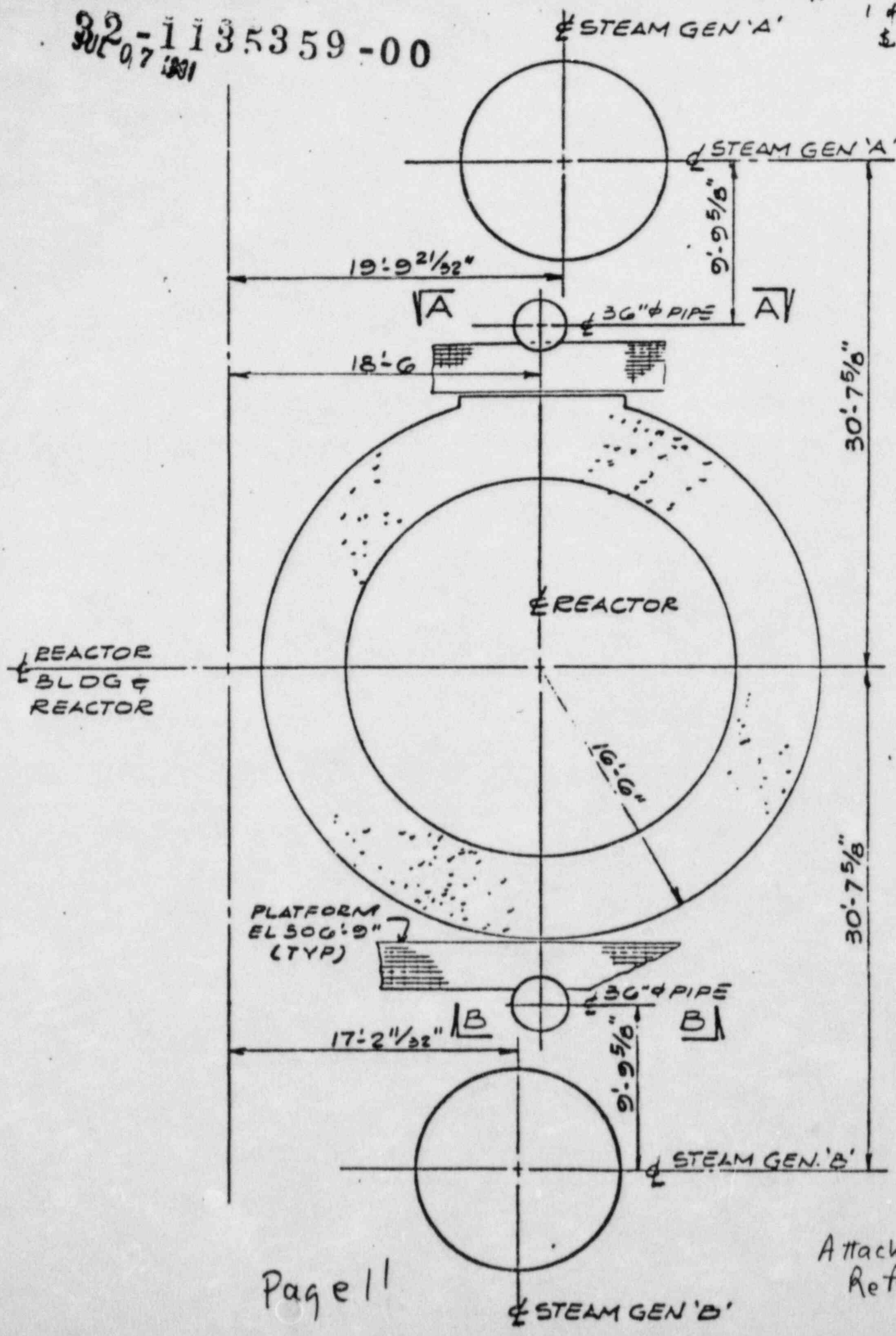

Page 11

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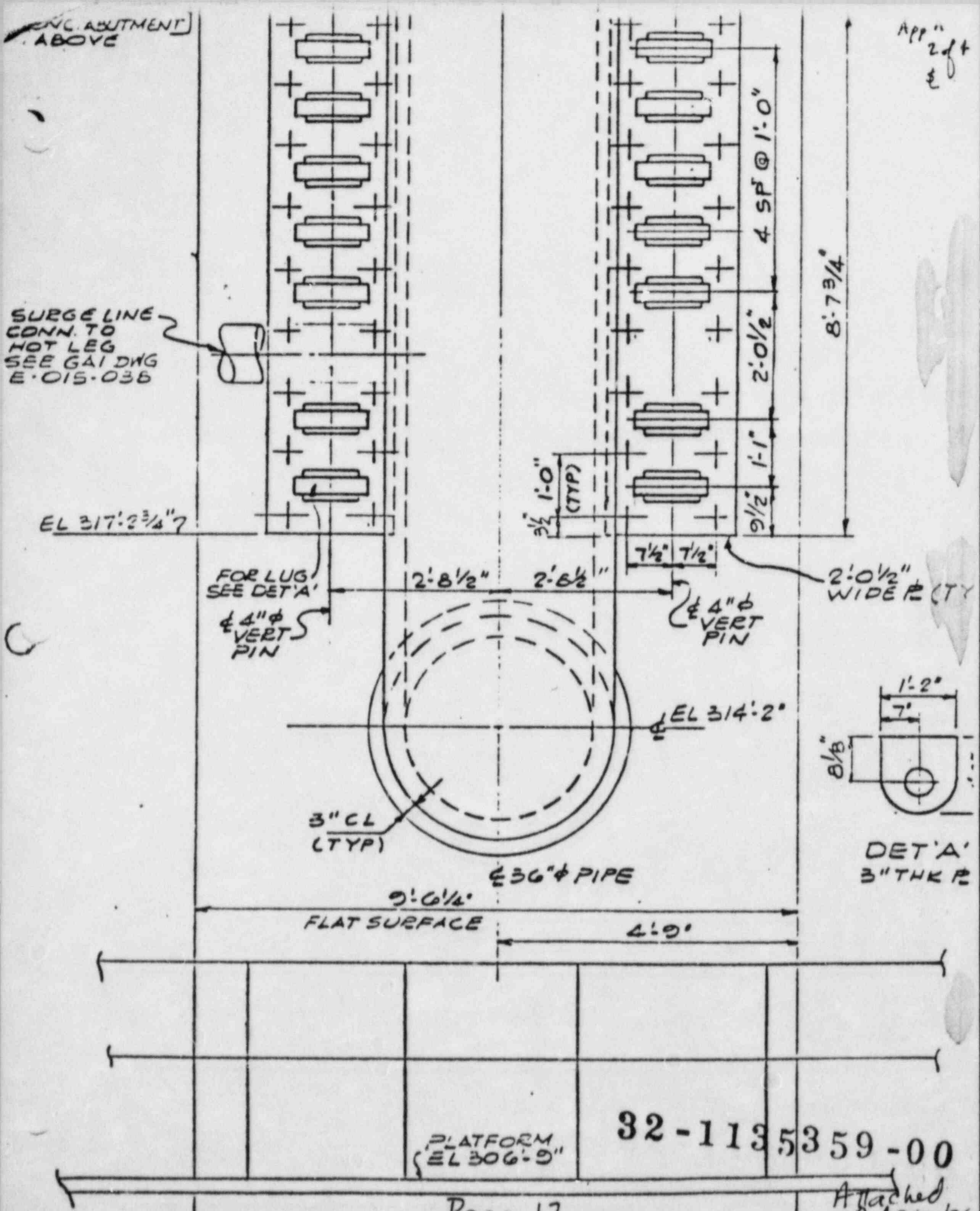


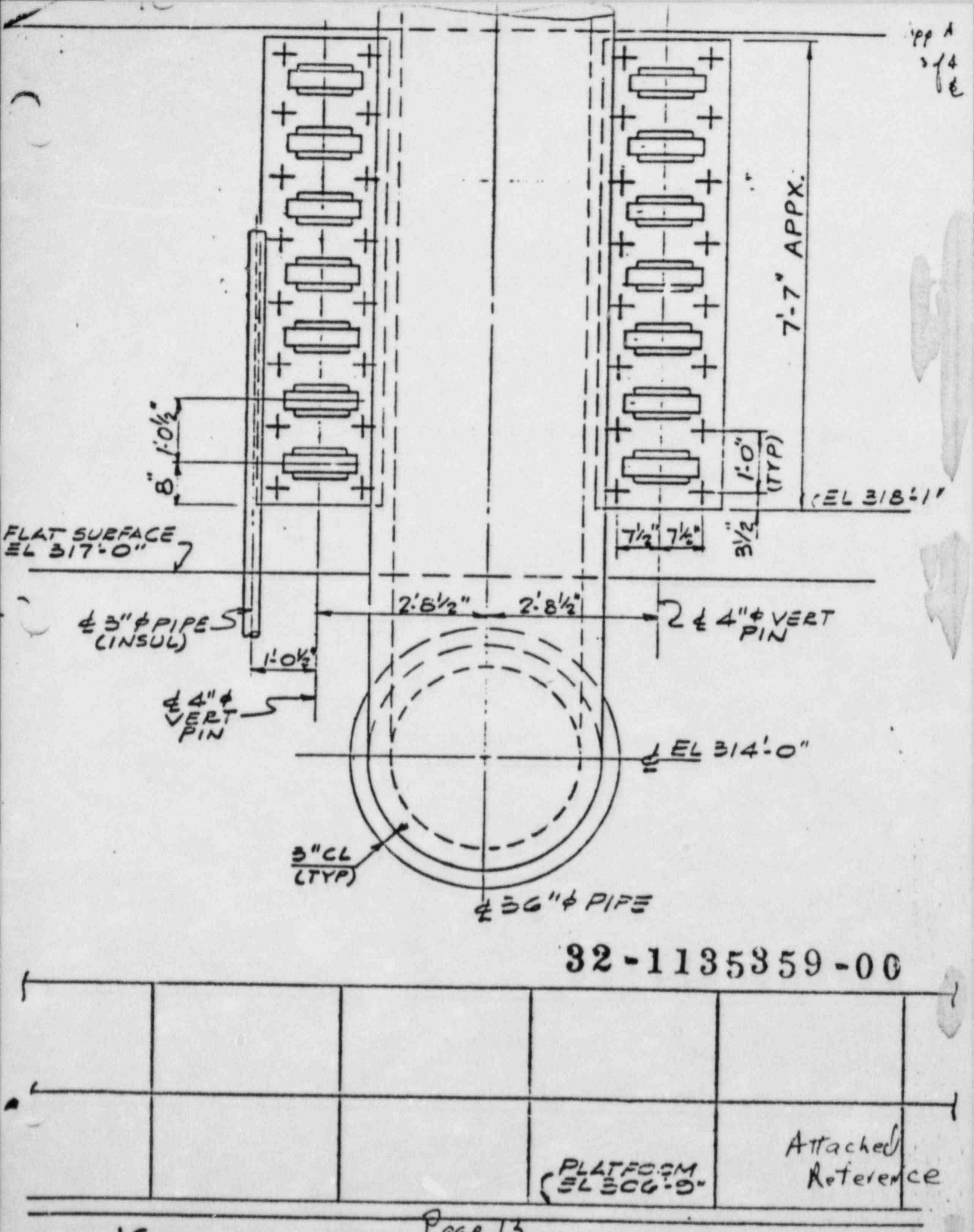
SECT A

App " 2 of 4

32-1135359-00

Page 12

Attached Reference SH 2 OF 4



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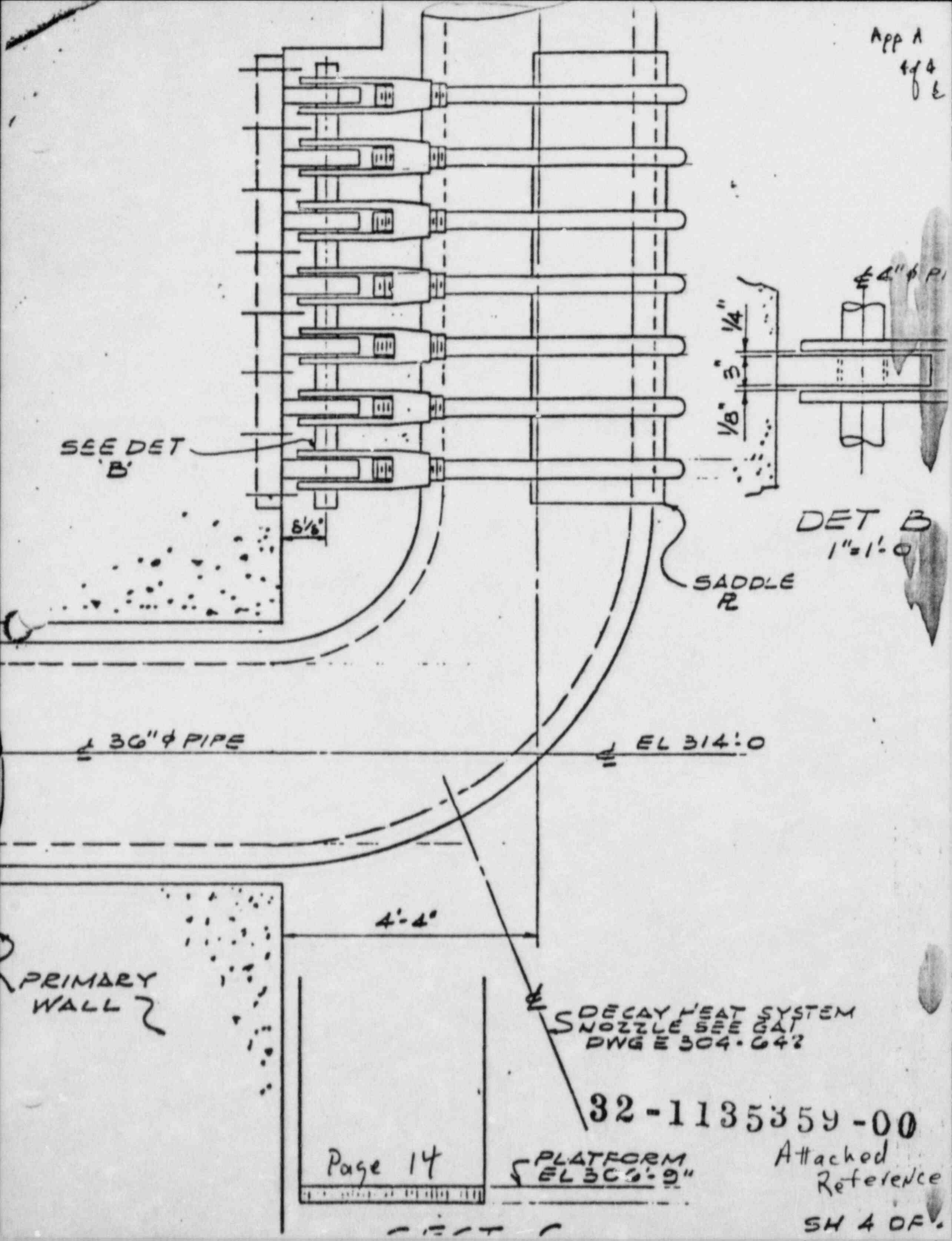
1C

App A 4 of 4



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Page 14

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SH 4 OF