DESIGN CALCULATION COVER SHEET

PART 1: DESIGN CALCULATION IDENTIFICATION

A) Design Calculation Number DC-5882	B) Volume Number Vol. I
C) Revision ϕ / D) FIS Number U2200	E) QA Level ☒ Non-Q ☐ 1 ☐ 1M
F) ASME Code Classification ☒ NA	G) Certification Required ☐ Yes ☒ No
	I) Incorporation Code W
H) Lead Discipline Mechanical / Civil	

J) Title Verification of Turbine Building East side Overhead Crane Girder G2

K) Design Change Documents Incorporated (Number and Revision)

N/A

L) Design Calculations Superseded (Number and Revision)

N/A

M) Revision Summary

Original Issue

PART 2: PREPARATION, REVIEW, AND APPROVAL

A) Prepared By R. C. HSU	Sign [signature]	Date 1-13-94
B) Checked By G. I. ABDALLAH	Sign [signature]	Date 1-14-94
C) Verified By G I ABDALLAH	Sign [signature]	Date 1-14-94
D) Approved By	Sign [signature]	Date 1/21/94

Form NEP-CM1-20 ATT 1 P1/1 070693 DTC TDF MEC DSN DC-5882 File 1801

Not decommissioning related Date 1-21-94 Rev 0 Recipient ______

9410260118 941019
PDR ADOCK 05000341
P PDR

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PURPOSE

The purpose of this calculation is to verify the structural integrity of Turbine Building east side overhead Crane Girder G2 subjected to a suspected missile impact. The area of the damage is located along column line N and about 4'-10" south of column line 4. Attachment A shows the walk down sketches of the damage.

SCOPE

Since the effect of the web plate due to a suspected missile impact produces only a local damage. Therefore, the scope of this DC covers only the structural integrity of Girder G2.

METHOD

1. Calculate the maximum shear force for Girder G2 based on the Crane Wheel Loading Diagram as shown on Drawing 6C721-2100.
2. Calculate average shear stress for the complete section and the damaged section.
3. Find the allowable shear stress of the web plate using Tables 1-36 and 2-36 of Ref. 1 (AISC Manual of Steel Construction, 9th Edition).
4. Calculate ultimate shear strength of web plate for reference.
5. Ignore bending stress of girder since the damage location is far away from the mid-span of the girder which produces the maximum bending stress.

ASSUMPTIONS

None

RESULTS AND CONCLUSIONS

1. Bending stress (maximum at the bottom flange) at the damaged cross section increases only 4.9 %. It is insignificant since the damage location is far away from the girder mid-span which produces the maximum bending stress.
2. Shear stress web plate at the damaged cross section = 8.11 ksi
   Allowable shear stress of the web plate = 14.5 ksi   O.K.

It is concluded that Girder G2 is structurally adequate after the damage due to the suspected missile impact. Any repair or modification of Girder G2 is not required.

REFERENCES

1 AISC Manual of Steel Construction, 9th Edition

2 Omer W Blodgett, "Design of Welded Structures", The James F Lincoln Arc Welding Foundation, 1971 Edition

3 William McGuire, "Steel Structures", Prentice-Hall, Inc , 1968 Edition

4 Charles G Salmon & John E Johnson, "Steel Structures", Harper & Row, Publishers, 1971 Edition

5 DECO Drawing 6C721-2100 Rev G

6 DC-4877 titled "Turbine House & Radwaste Bldg Low Roof"
Note DC-4877 includes the original design calculation of Girder G2

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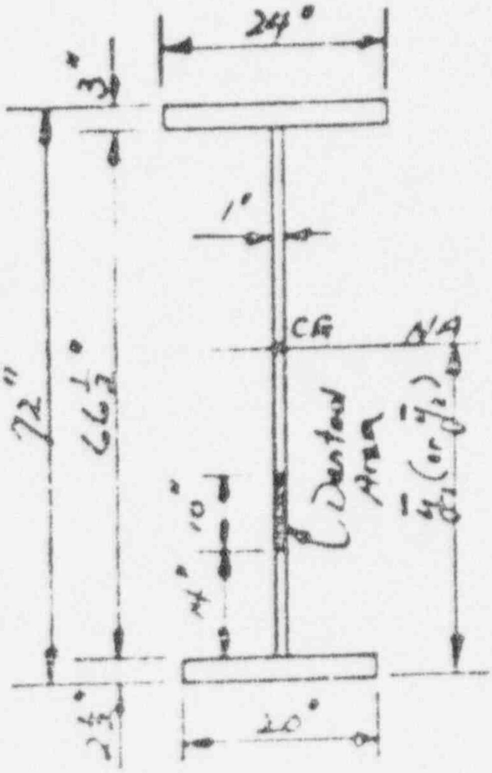
Verification of TB Overhead Crane Girder with Web plate Damage Due to missile impact

Section Properties of Girder G2:
(See Attachment A and Ref. 5)



(A) Complete Section:

$A_1 = 24\times3 + 20\times2.5 + 66.5\times1.0$
$= 72 + 50 + 66.5 = 188.5\ in^2$

$\bar{y}_1 = \frac{1}{188.5}(72\times71.5 + 50\times1.25 + 66.5\times35.75)$
$= 39.87''$

$I_1 = \frac{24(3)^3}{12} + 72(70.5 - 39.87)^2$
$+ \frac{20(2.5)^3}{12} + 50(39.87 - 1.25)^2$
$+ \frac{1(66.5)^3}{12} + 66.5(39.87 - 2.5 - 33.25)^2$
$= 67604 + 74601 + 25635$
$= 167{,}840\ in^4$

$S_1 = I/39.87 = 4210$ (Max. f_{b1} at the bottom flange)

$Q_1 = 72(70.5 - 39.87) + \frac{1.0}{2}(72 - 39.87 - 3)^2$
$= 2629.64\ in^3$ (Max. τ_1 at the C.G. location)

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(B) Section Without Dented Area:

$A_2 = 72 + 50 + 56.5 \times 1.0 = 178.5 \text{ in}^2$

$\bar{y}_2 = \frac{1}{178.5}(72 \times 70.5 + 50 \times 1.25 + 66.5 \times 35.75 - 10 \times 21.5)$

$= 40.90"$

$I_2 = \frac{24(3)^3}{12} + 72(70.5 - 40.90)^2 + \frac{20(2.5)^3}{12} + 50(40.9 - 1.25)^2$

$+ \frac{1(66.5)^3}{12} + 66.5(40.90 - 2.5 - 33.25)^2 - \frac{1(10)^3}{12}$

$- 10(40.9 - 2.5 - 19)^2$

$= 63130 + 78632 + 26270 - 3847$

$= 164{,}193 \text{ in}^4$

$S_2 = I/40.9 = 4015 \text{ in}^3$ (Max. f_{b2} at the bottom flange)

$Q_2 = 72(70.5 - 40.90) + \frac{1.0}{2}(72 - 40.9 - 3)^2$

$= 2526.01 \text{ in}^3$ (Max τ_2 at the C.G. location)

<u>Stress Comparison:</u>

Stress ratios are used for the comparison since the applied loads of the crane girder are not available.

$\frac{f_{b2}}{f_{b1}} = \frac{S_1}{S_2} = \frac{4210}{4015} = 1.049$

$\frac{\tau_2}{\tau_1} = \frac{Q_2/I_2}{Q_1/I_1} = \frac{Q_2 I_1}{Q_1 I_2} = \frac{2526.01 \times 167840}{2629.64 \times 164193} = 0.982 \approx 1.0$

Bending stress increases only 4.9% which is insignificant since the damage spot is far away from the mid-span of the girder which produces the max. bending stress. Investigation of shear stress is covered in the following pages.

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$Q' = 20 \times 2.5 \times 39.65 + 14 \times 1.0 \times 31.4 = 1982.5 \ in^3$

$f_{v2}' = \dfrac{450 \times 1982.5}{16493 \times 1.0} = 5.43 \ Ksi$

Stiffener Spacing, $a \approx \dfrac{32 \times 12 - 34}{3} = 117''$ Say $120''$

$h/t = 66.5/1.0 = 66.5$

$a/h = 120/66.5 = 1.80$

From Table 1-36 of Ref. 1 (Not include tension field action):

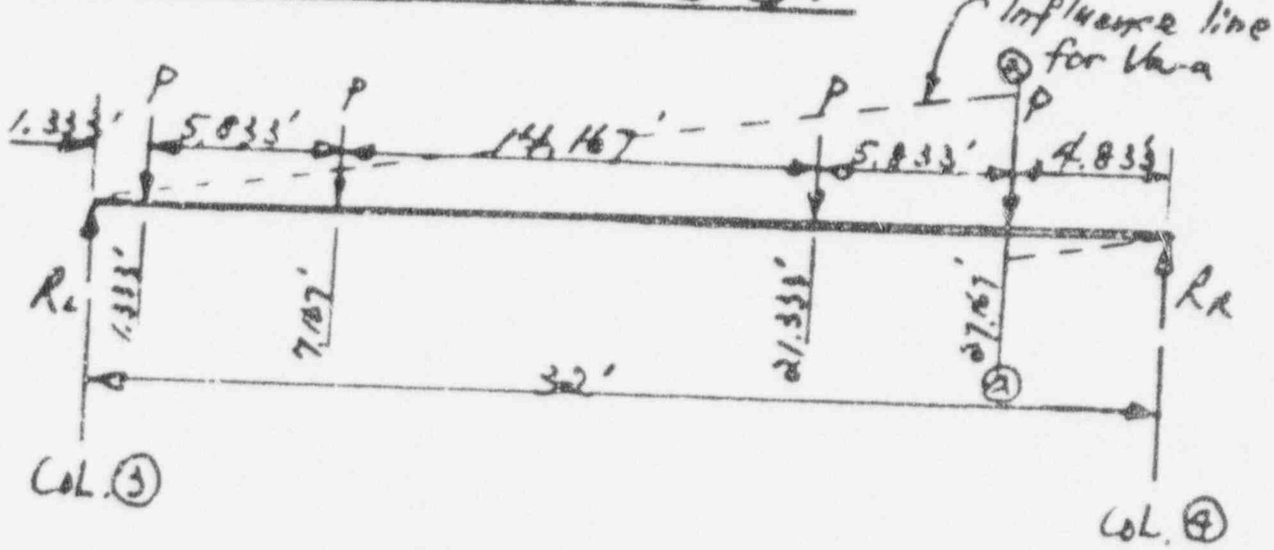
$F_v = 14.5 \ Ksi$

From Table 2-36 of Ref. 1 (Include tension field action):

$F_v = 14.5 \ Ksi$

Tension field action is not active for web plate of Girder G2 since allowable shear stress is the same for both cases.

Max. shear force at Section ⓐ-ⓐ:



Reference: Crane Wheel Loading Diagram from Ref. 5 (Dwg. 60721-2100)

$P = 218^K$

Crane Weight, $\omega = \frac{168.5}{444} \times 0.49 + \text{Stiff } \approx 0.70 \ ^K/_{ft}$

$$R_R = \frac{P}{32}(1.333 + 7.167 + 21.333 + 27.167) + 16\omega$$

$$= \frac{57 \times 218}{32} + 16 \times 0.7 = 399.5^K$$

$V_{a-a} = 399.5 - 4.833 \times 0.7 = 396^K$ use 450 Kips

Check Shear Stress of Web:

Ave. Shear Stress (Complete Section), $f_{v1} = \frac{450}{66.5 \times 1} = 6.77 \text{ ksi}$

Ave. Shear Stress (without Denton Section), $f_{v2} = \frac{450}{55.5 \times 1} = 8.11 \text{ ksi}$

Shear Stress at the Denton Location, $f_{v2}' = \frac{V_{a-a} Q'}{I_2 t}$
(More accurate)

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Ultimate Shear Strength of Web:

A more detailed study of web shear strength is needed since the damage is on the web plate. See Page 5-49 of Ref 1 and Pages 537-557 of Ref. 4

$C_v = \frac{\tau_{cr}}{\tau_y}$ by definition

$C_v = \frac{45000 k_v}{F_y (h/t_w)^2}$ when $C_v < 0.8$

$= \frac{190}{h/t_w}\sqrt{\frac{k_v}{F_y}}$ when $C_v > 0.8$

$a \simeq (32\times12 - 34)/3 = 117"$ say $120"$

$h = 66.5$ in

$k_v = 5.34 + \frac{4.00}{(120/66.5)^2} = 6.568$

$C_v = \frac{45000\times6.568}{36\,(66.5/1.0)^2} = 1.857 > 0.8$ N.G.

$C_v = \frac{190}{66.5/1.0}\sqrt{\frac{6.568}{36}} = 1.22$

Elastic buckling of web plate will not occur for Girder G 2 since $C_v = 1.22 > 1.0$

Let $C_v = 1.0$ or $\tau_{cr} = \tau_y$

$V_{cr} = \tau_{cr} A_w = \tau_y A_w = \frac{36}{\sqrt{3}} \times 66.5 \times 1.0 = 1382$ Kips

$\sigma_t = F_y (1 - C_v) = 0$ ...... Eq (11.6.21) of Ref. 4

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Tension field action,

$$V_{tf} = \sigma_t \frac{h}{t_w}\left[1 + \frac{1}{\sqrt{1+(a/h)}}\right] = 0$$ ---- Eq. (11.6.18) of Ref. 4

Therefore, the ultimate shear strength is

$$V_u = V_{cr} + V_{tf} = 1382 + 0 = 1382 \text{ Kips}$$

The max reaction for Girder G2 = 1150 Kips ... Ref. 5

Let the ultimate shear strength for the section without including dented area is

$$\frac{\tau_2}{\tau_1} V_u = .982 \times 1382 = 1357 \text{ Kips}$$

Max shear force along section ⓐ-ⓐ = $450^K < 1357^K$

O.K.

Turbine Bldg Overhead Crane Walkdown [signature]

The Turbine Building Overhead Crane east girder, was found to have a web plate damage due to an impact from a suspected missile. The location of the damaged web and the details are shown on the walkdown sketch.

The damaged area was bowed in 3/4" deep, with no visual indication of any cracks on the surfaces. (Both front and back)

The walkdown team did not observe any other missile damage on the east girder. The visual inspection of the west crane girder from the east walkway did not indicate any structural damage on the west girder.

In addition, the east girder connection to column N4 (nearest support to the missile hit location) was inspected. Girder to column connection bolts, which were painted, did not indicate that the impact had caused any movement at the connection. There was no indication of any overall girder displacement.

Conclusion: The walkdown team observations conclude that the missile impact was absorbed by the plastic deformation of the web plate which has acted as a diaphragm without any detrimental effect to the overall integrity of the crane girder structure. It was issued to perform an evaluation (design calculation) by neglecting the damaged web area (1ft dia circle) and determine if any restrictions

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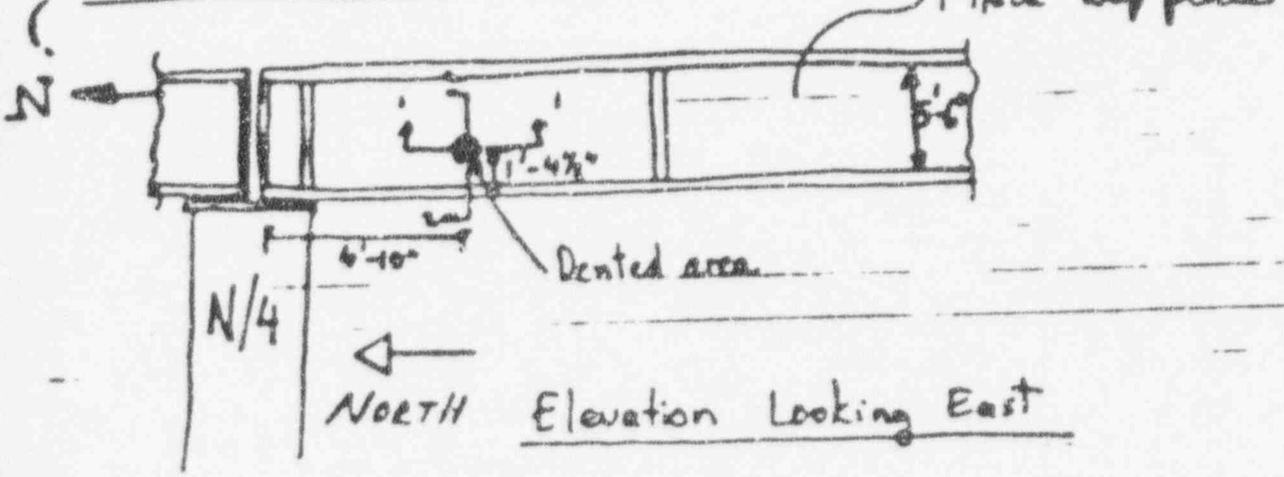
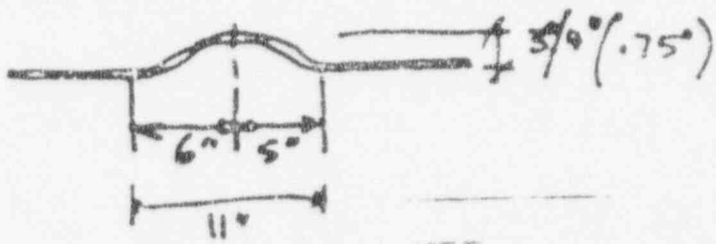
are needed for crane use. If the calculation results show that the crane girder is adequate as-is, no immediate or future repair work are required from structural point of view. During the walkdown, the crane rails were not inspected as they were not accessible.

DC-5862 Vol. I Attachment A

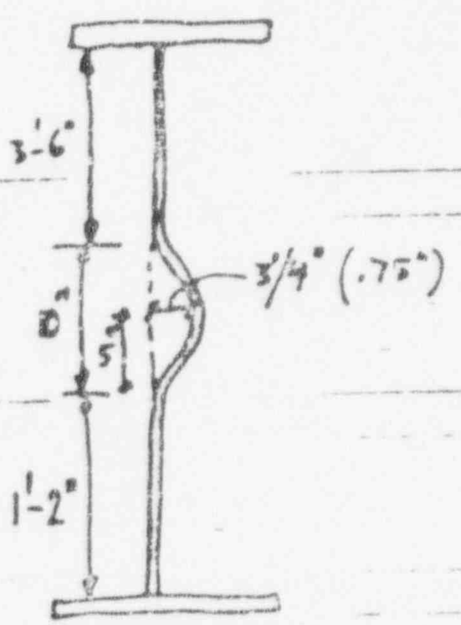
Walkdown Sketch 1/7/94



Elevation Looking East



Sect. 1-1



Sect. 2-2

TB Crane beam
East side
S. of N/4

TECHNICAL SERVICE REQUEST COVER SHEET

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PART 1: IDENTIFICATION/DESCRIPTION (Initiator)

A) Title (Subject): TURBINE BEARING BEAM REPAIRS

B) System PIS Number(s) N3000
[ ] Continuation Sheet

C) Reference Document(s) EDISON ID T1-637, T1-641, T1-642 & T1-3686 T4-27
[ ] Continuation Sheet |A

D) Description of Problem/Proposed Solution
SEE CONTINUATION SHEET
[ ] Continuation Sheet

E) Initiated By
Print Name H. SAHINER Extension 61797
Group/Organization MECH/CIVIL - PE Date 8/25/94

PART 2: CLASSIFICATION

A) QA Level [ ] I [ ] 1M [X] Non-Q	B) Seismic Category [ ] I [ ] II/I [X] None	C) Piping Groups [ ] A [ ] B [ ] C [ ] D [ ] D+ [X] NA
D) ISI Component [ ] Yes [X] No	E) EQ Component [ ] Yes [X] No	F) Technical Specification Component [ ] Yes [X] No
G) Preliminary Evaluation [X] Yes [ ] No		H) Human Factors Applicability [ ] Yes [X] No
I) Simulator Impact [ ] Yes [X] No	J) Training Impact [ ] Yes [X] No	K) Spare Parts Impact [ ] Yes [X] No

L) Required Action
- [ ] Equivalent Part Identification
- [ ] Equivalent Part Installation
- [ ] Type I Modification
- [ ] Type II Modification
- [X] TSR Modification
- [ ] Setpoint Change
- [ ] Configuration Control
- [ ] Engineering Evaluation

[ ] NA Work Request Number 000Z942484

PART 3: DISPOSITION

A) Prepared by
Print H. SAHINER Sign [signature] Extension 61797
Date 8/25/94

[X] NA PART 4: PLANT MANAGER APPROVAL /CLASSIFICATION

[ ] Approved-At-Risk [ ] Approved/5 Year Plan [ ] Approved for Estimate
[ ] Approved to Proceed [ ] Disapproved

Sign Date Sign Date

[X] NA PART 5: OSRO APPROVAL

Print Sign Date

ARMS - INFORMATION MANAGEMENT
DSN 26565 Rev A DECOM Related: [ ] Yes [X] No Date 8-29-94
DTC [ ] TDTSR [X] TCTSR File 1801.03 Recipient 3[illegible]

PART 3: DISPOSITION

Part 1D) Description of Problem/Proposed Solution:

Low pressure turbine bearing beams were inspected after the December 1993 turbine accident. The overall bearing beam structures were found in good condition, with no visual distortion or warpage on the steel plates forming the large box beam sections. However, there were cracks in four bearing beams, mainly between stiffener plates and T sections. The locations and detailed descriptions of these findings are described in Sargent & Lundy Report SLAM-029. (DECo File No. T1-3686)

Proposed Disposition:

This TSR is prepared for the repair of these cracks. Follow the repair procedure as described in the disposition of this TSR. Rev. A of this TSR is prepared to document the final, repaired beam configuration. No additional work is needed in the field. | A

Disposition:

This TSR modification is prepared for the repair of cracks found in the bearing beams, as described in DECo File No. T1-3686. Additional reinforcement was also performed as described in this Rev. A of TSR-26565. | A

TSR Modification:

Cracked fillet weld repair and cracked base metal repair will be performed as described in this TSR-26565. For additional information not detailed in this TSR, follow Fermi Welding Manual.

Apart from the repair of cracks, a weld design change will be made during the repair. This weld design change will eliminate the wrap around welds between T section and 2 1/2" thick rib plates. The walkdown data indicates that this weld was completed as a fillet weld and indications point to this location as the starting point of the propagating cracks. This design change will be repeated at four locations per bearing beam, in total of 16 places. The revised drawings in this TSR, reflect these weld changes. Reinforcement plates used in this repair process are detailed in Rev. A of this TSR. | A

Repair Process:

The repair steps are described for fillet weld cracks and base metal cracks.

Fillet weld cracks:

1) Crack Removal
   - o Remove the defects by air carbon arc gouging. The original joint gap or interface should be exposed at the wrap around weld location.
   - o Verify complete crack removal by magnetic particle (MT) testing.

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PART 3: DISPOSITION

Base Metal Cracks:

1) Crack Removal:

Remove the cracks by grinding. Prepare a double V groove. See Attachment 4 - Sketches, Figure 2, View A-A. If the other side of the base metal is not accessible, such as the vertical plate nearest generator, the base metal should be ground out to a single V-groove, similar to Figure 2 as described above. A ramp, or slope of 45° maximum should be provided at the ends of cavity. If needed, a backing plate may be used. The complete base metal crack removal shall be verified by magnetic particle testing (MT)

Welding Instructions:

These are applicable both for fillet weld and groove weld (base metal) repairs.

After successful MT, preheat the weld area to 200° F minimum.

Use E7018 welding electrodes, Size 1/8" or 5/32" diameter. For fillet weld restoration/repair maximum weld size per pass is 5/16". For base metal/groove welds, maximum 1/4" weld deposit thickness. Reduce the number of weld passes and stay within the maximum weld bead sizes to minimize the distortion and shrinkage stresses. Also balance these stresses by performing weld passes alternately, from either sides of plates.

As a minimum, perform visual examination after each weld pass. Perform MT after the final pass. No linear indications to be present. Use Fermi Welding Manual for additional information if not specified in this TSR.

Work Request 000Z944456 was prepared to take samples for fracture surface analysis. To this date, the samples were sent for examination ~~but results not received.~~ The metallurgical evaluation determined the cracks were caused by high stress during Dec. 25, 1993 turbine failure (Ref. T4-27) For bearing beam crack repairs work request 000Z942484 is prepared. | A

The following TSR pages include the details of each crack found, from DECo File No. T1-3686, Attachments 1 through 4. These cracks shall be repaired as described in this TSR modification as fillet weld repair or base metal/groove weld repair, whichever applicable. In addition, reinforcement and cover plates will be used as detailed. | A

DCAT:

Magnetic particle testing (MT) and visual inspections as described in this TSR Modification are the only DCAT requirements. No linear indications are acceptable. (Ref. Fermi Welding Manual)

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PART 3: DISPOSITION

References:

1. Fermi Welding Manual
2. DECo File No. T1-3686. Sargent & Lundy Report SLAM-029
3. Work Request #000Z944456
4. Work Request #000Z942484
5. DECO File No. T4-27, Technical & Engineering Services Report 94V70 20 | 1A

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PART 3: DISPOSITION

B) Solution Description:

Rev. A of this TSR does not impact the original P.E. performed for Rev. Ø. The preliminary evaluation (P.E.) prepared for Rev. Ø of this TSR, is valid for Rev. A. | Rev. A

[ ] Continuation Sheet

C) Affected BCDDs: [ ] NA

ARMS DTC	ARMS DSN	ARMS Rev	Document Description	Remarks
DDVEND	R205A1919	K	LP Frame Generator End Bearing Beam	Edison ID T1-637 Page 1 of 2
DDVEND	R205A1926	J	LP Frame Steam End Bearing Beam	Edison ID T1-641 Page 3 of 3
DDVEND	R205A1929	J	LP Frame Center Bearing Beam	Edison ID T1-642 Page 3 of 3

[ ] Continuation Sheet

D) Checked by [ ] NA Extension 6-1843

Print RON BUCK Sign R Buck

Date 26 Aug 94

Form FIP-CM1-01 ATT 3 1/1 082793 File: 1801.03

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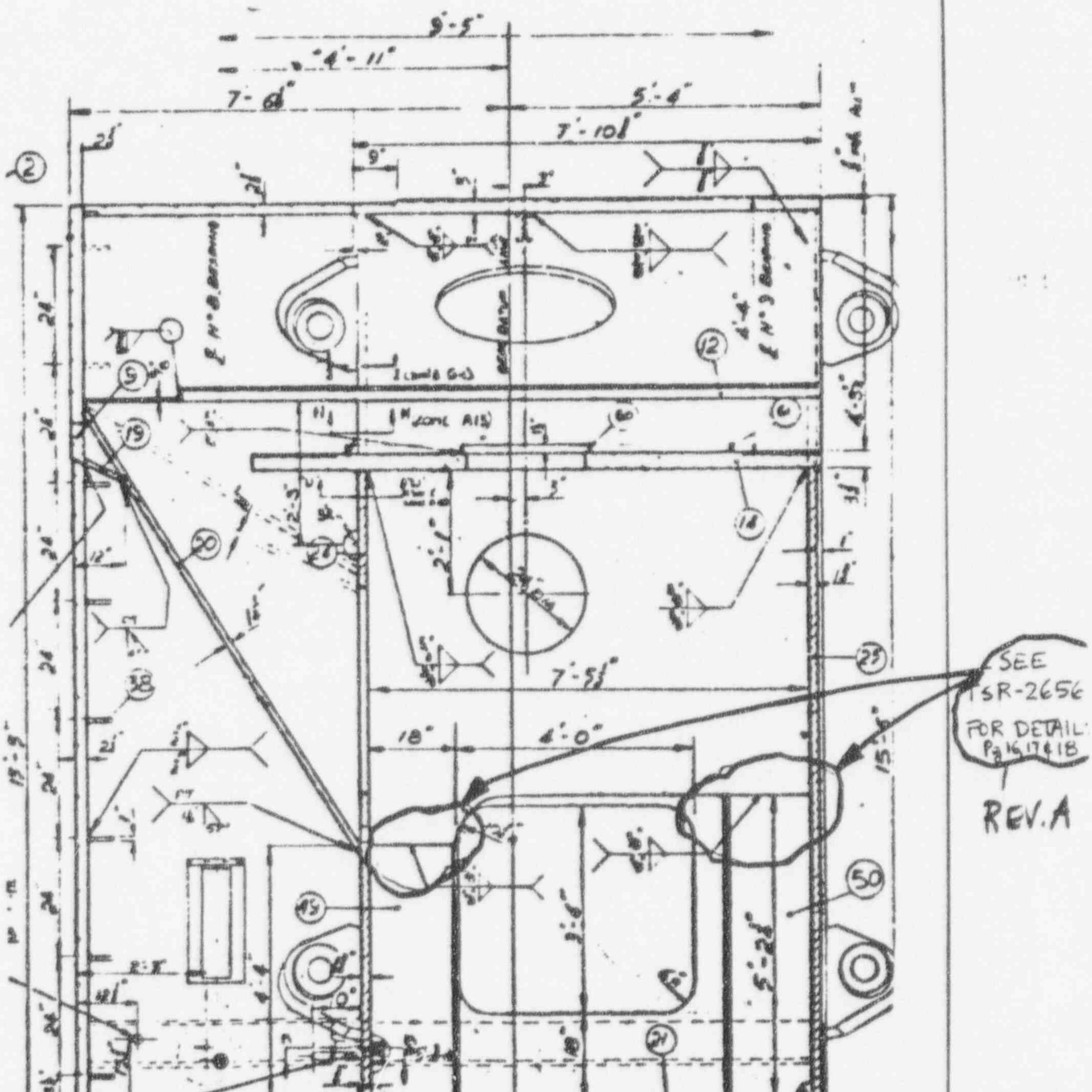
PART 3: DISPOSITION

DOCUMENT TO BE REVISED
DTC: DDVEND DSN: R205A1919 Rev. K
DECo. FILE No. T1-637 PAGE 1 of 2
ZONE: G 11

BEARING BEAM #5 — Rev. A



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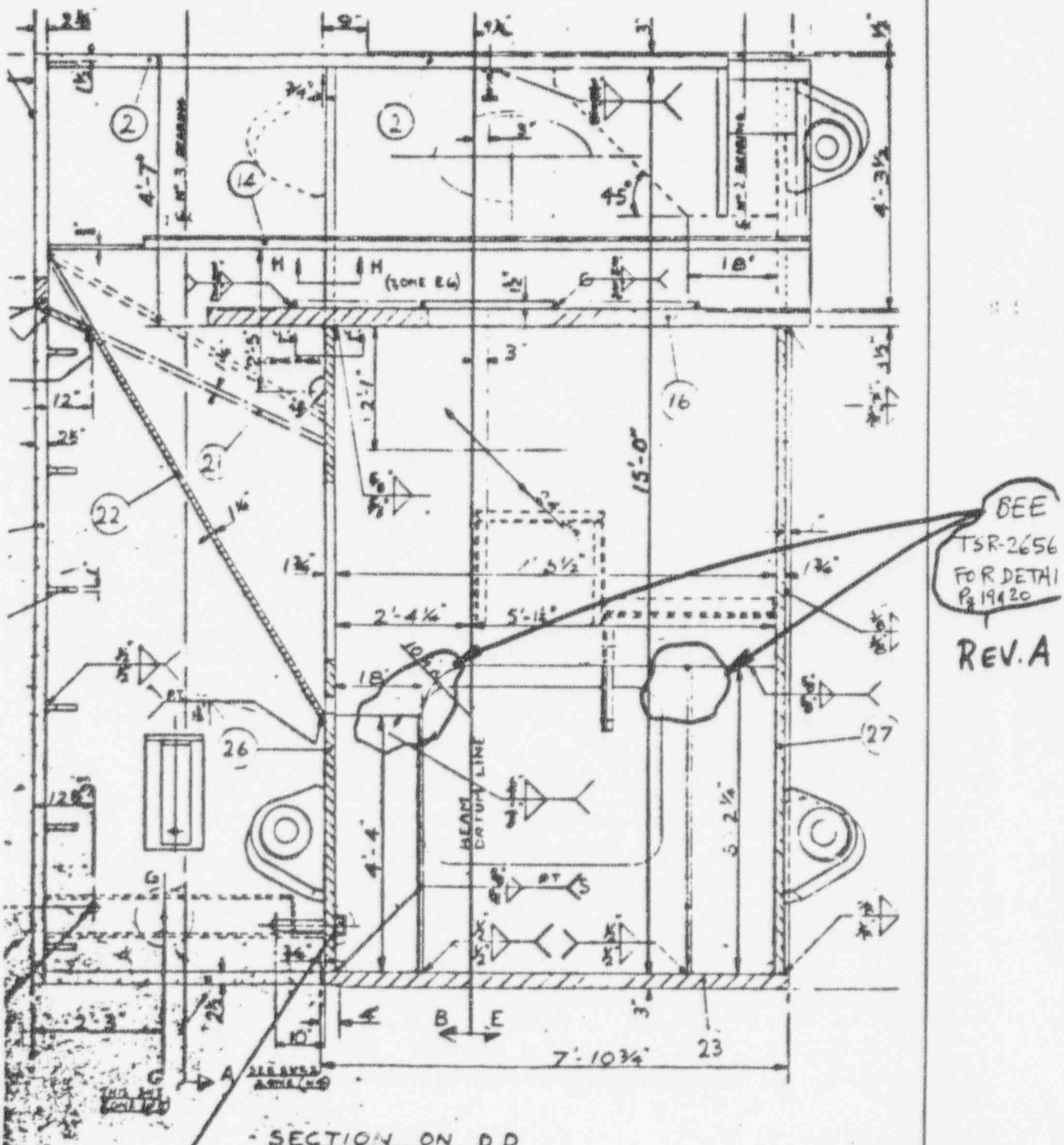
DOCUMENT TO BE REVISED
DTC: DDVEND DSN: R205A1926 REV. J
DE.CO. FILE NO. T1-641 PAGE 3 OF 3
ZONE: D4

Bearing Beam #2 — REV. A



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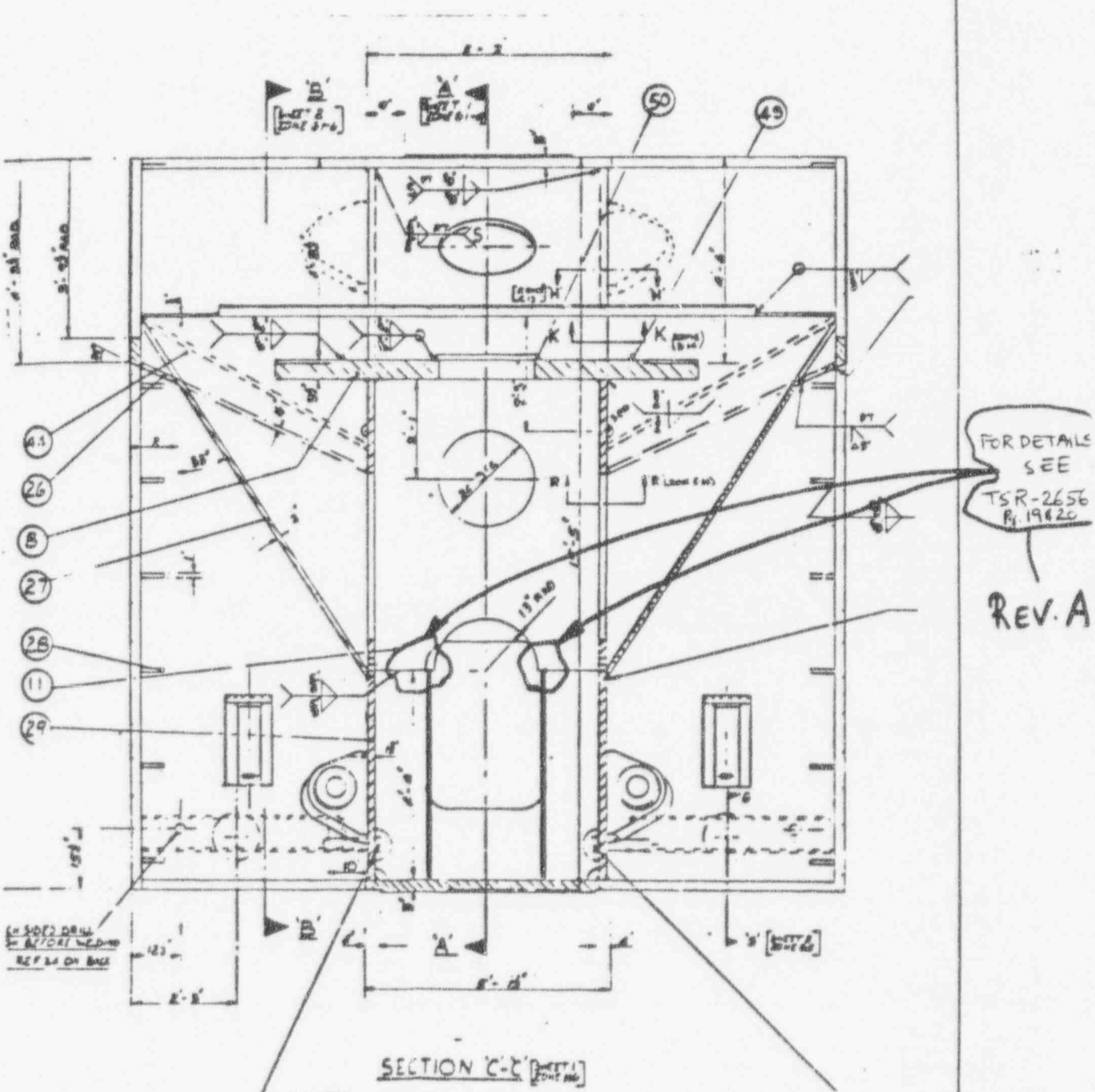
PART 3: DISPOSITION

DOCUMENT TO BE REVISED
DTC: DDVEND DSN: R205A1929 REV. J
DE.CO. FILE NO. T1-642 PAGE 3 OF 3
ZONE: C 10

Bearing Beam #3 & #4 — Rev. A



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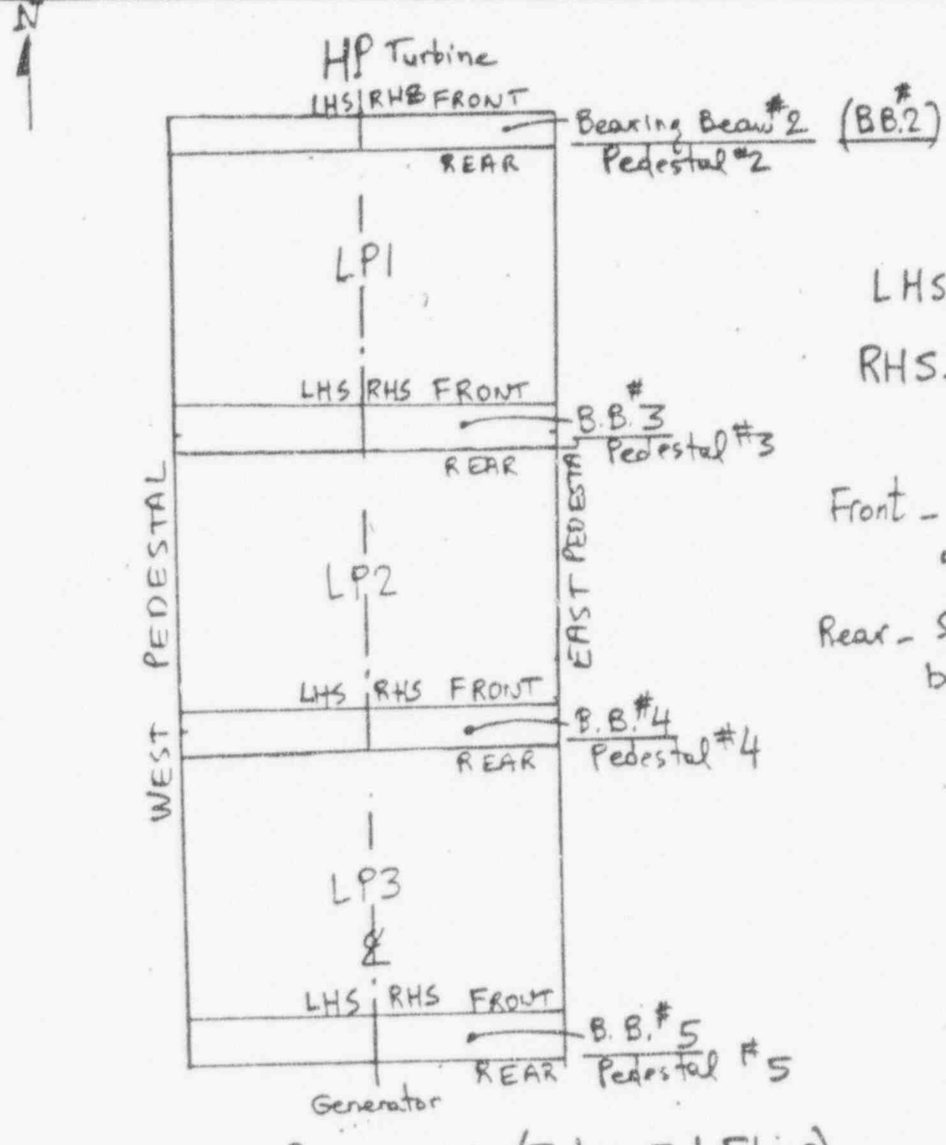
PART 3: DISPOSITION



LHS - Left Hand Side

RHS - Right Hand side

Front - North side of bearing beam

Rear - South side of bearing beam

PLAN VIEW - (Turbine 3rd. Floor)

SCHEMATIC PRESENTATION OF BEARING BEAM LOCATIONS AND IDENTIFICATION OF NOMENCLATURE USED IN THIS TSR and Sargent & Lundy Report SLAM-029. (Deco File # 11-3686.)

Attachment 1 - Steam End Bearing Beam (#2 Pedestal)

Location	Fillet Weld Cracking Found
Rear, RHS	Cracking across T flange weld and about 6" into web weld I/B and O/B sides
Front RHS	Cracking across T flange weld and about 2" into web weld I/B side
Rear, LHS	Cracking across T flange weld and about 1 1/2" into web weld on O/B side and about 4" on I/B side
Front, LHS	Cracking across T flange weld and about 2 1/2" into web weld I/B and O/B sides

NOTES

Rear = side toward generator (south)

Front = north side

RHS = right hand side (east)

LHS = west

I/B = in-board (facing towards the center)

O/B = away from center

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Attachment 2 - Center Bearing Beams (#3 & #4 Pedestals)

A. Pedestal #3

Location	Fillet Weld Cracking Found
Rear, RHS	Cracking across T flange weld and about 1" into web weld on I/B side and about 2" on O/B side
Front RHS	Cracking across T flange weld and about 3" into web weld on I/B side and about 1" on O/B side
Rear, LHS	Cracking across T flange weld and about 1" into web weld on I/B and about 4" on O/B side
Front, LHS	Cracking across T flange weld and about 1" into web weld both sides I/B and O/B

B. Pedestal #4

Location	Fillet Weld Cracking Found
Rear, RHS	Cracking across T flange
Front, RHS	Same as above
Rear, LHS	Cracking across T flange weld and about 1" into web weld on O/B side
Front, LHS	Same as above

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Attachment 3 - Generator End Bearing Beam (#5 Pedestal)

Location	Weld and Base Metal Cracking Found
Front, LHS	Cracking across T flange fillet weld and about 3" into web fillet weld then branching into base metal of web for about 8" on I/B and O/B sides
Front RHS	Cracking across T flange fillet weld and about 3" into web fillet weld then branching into web base metal for about 10" on I/B and O/B sides
Rear, LHS	Cracking across T flange fillet weld and about 6" into web fillet weld on I/B and O/B sides
Rear, RHS	Same as above
Vertical Plate Nearest Generator (adjacent to the above item)	In the southwest upper corner cracking about 2" at toe of weld branching into plate base metal for about 2"

Paint crack only. Base plate and weld were found without indications. | Rev. A

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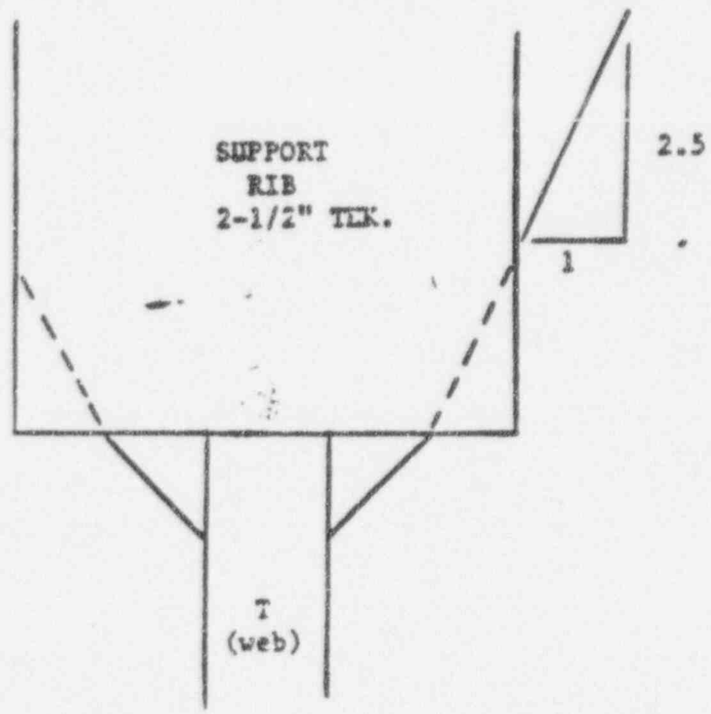


FIGURE 1 - Support Rib to T web Transition

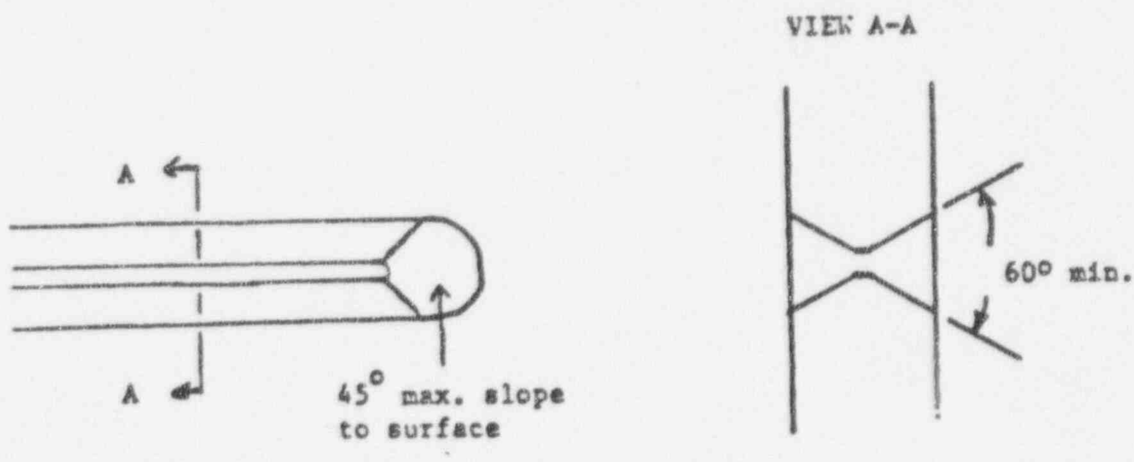


FIGURE 2 - Cavity Configuration on T-web Base Metal

PRELIMINARY EVALUATION

PART 1: DESCRIPTION OF CHANGE (Preparer)

A) Document Identification	B) Revision If Approved	C) PIS Number
TSR-26565	0	*N3000*

D) Description of Change

Low pressure turbine bearing beams are repaired to re-establish their original structural strength. In addition, a typical wrap around weld is eliminated. This weld is believed to have been the starting point of the existing cracks. The majority of the repairs are at the same detail location, four per bearing beam, with four bearing beams involved, for a total of 16 similar repairs. **(continued on page 2)**

PART 2: PRELIMINARY EVALUATION (Preparer, Approver)

A) Review of Commitments

[X] No commitments
[ ] Commitments Exist (Identify in accordance with 6.1.4.5) ______

[ ] Commitments Met - none negated
[ ] Commitments need changing - Describe and justify commitment changes on continuation sheet
[ ] Safety Engineering and/or Nuclear Licensing have been contacted to make changes

B) Impact on License, Plans, or Programs [Check box(es) if no impact]

No Impact		No Impact		No Impact	
[X]	Operating License	[X]	Quality Assurance Program	[X]	Offsite Dose Calculation Manual (ODCM)
[X]	Technical Specifications (Including Bases)	[X]	Radiological Emergency Response Preparedness Plan (RERP)	[X]	Process Control Program (PCP)
[X]	Environmental Protection Plan	[X]	Physical Security Plan	[X]	Inservice Inspection - Inservice Testing Program (ISI-IST)
[X]	Core Operating Limits Report (COLR)	[X]	Safeguards Contingency Plan	[X]	Inservice Inspection - Non-Destructive Examination (ISI-NDE)
[X]	UFSAR	[X]	Security Personnel Training and Qualification Plan		
[X]	Fire Protection Program				

[ ] License Change Request (LCR) required
List LCR(s): ______ ______ ______

C) Effect on Environment

[X] No effect on environment
[ ] Environment affected - contact Fermi Environmental Engineer and indicate resolution

D) Need for Safety Evaluation (check appropriate answer) Safety Evaluation No. (if required) ______

Yes	No	
[ ]	[X]	1. Is this a change to the facility, including assumptions, as described in the UFSAR?
[ ]	[X]	2. Is this a change to a procedure, including assumptions, as described in the UFSAR?
[ ]	[X]	3. Does this change constitute a Special Test?

- If any answers are "yes" and the NRC Safety Evaluation Report is available, attach NRC Safety Evaluation.
- If any answers are "yes" and no NRC Safety Evaluation Report is available, initiate a Safety Evaluation.
- If all answers are "no", provide the basis to support that determination on a continuation sheet.

E) Prepared by H. Sahiner [signature] Date 6/13/94	F) Approved by [signature] Date 6/13/94

PRELIMINARY EVALUATION CONTINUATION SHEET

A) Document Identification	B) Revision if Approved
TSR-26565	0

Part 1D) Description of Change (continued)

The eliminated wraparound welds will relieve stresses at locations where fillet welds from each sides of the webs of T sections end. In addition, the fillet weld and base metal cracks will be ground, prepared and rewelded. The final configuration will be at least as strong as the original condition.

2D) Need for Safety Evaluation

1) This modification is not a change to the facility. The bearing beam weld details are not described in the UFSAR. The structural repairs performed do not impact the UFSAR or its assumptions.

2) This modification does not change any procedure, including assumptions, as described in the UFSAR.

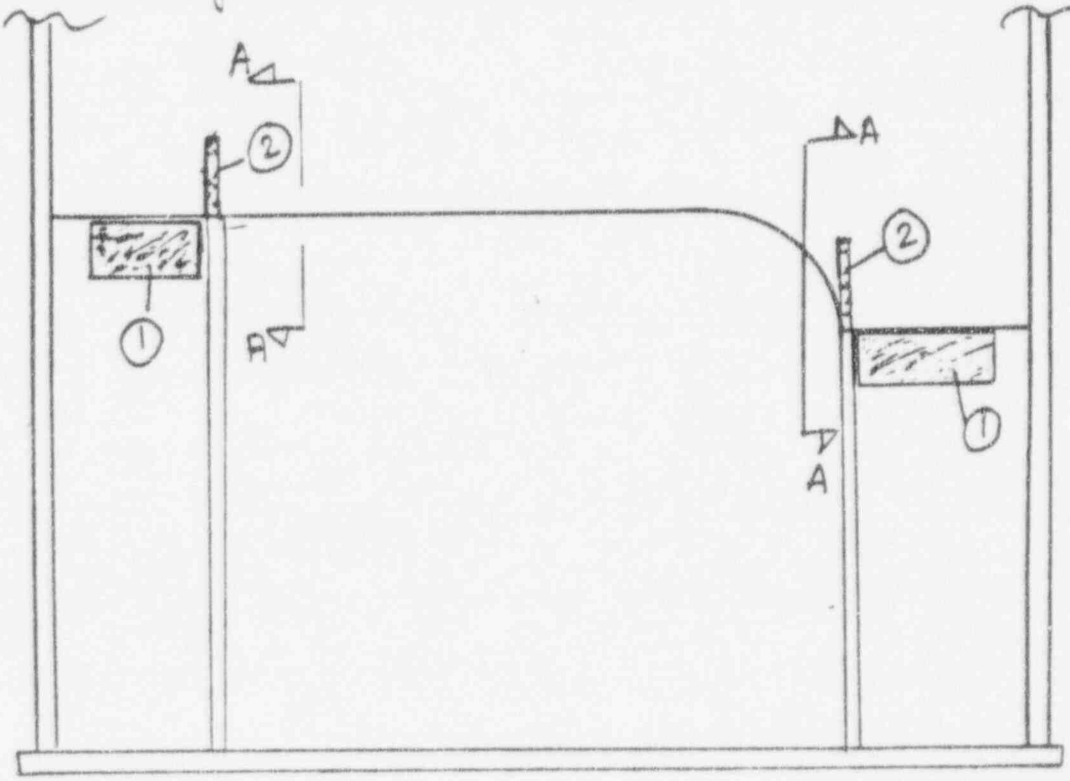
3) No testing is impacted. This change is mainly structural. It does not constitute a Special Test.

As all the answers the above questions are negative, a Safety Evaluation is not required. The subject TSR modification will repair and improve the bearing beam structure, which had been impacted from the December 93 turbine accident.

TSR - 26565 Rev. A

Bearing Beam #5 (Generator End) Reinforcement Details:

Ref. T1-637



Elevation – Looking West

Plate ① – 3/4" thick 8" x 12" ROS # C046144

Plate ② – 3/4" thick 3" x 8" ROS # C046144

8 of each required for #5 bearing beam.

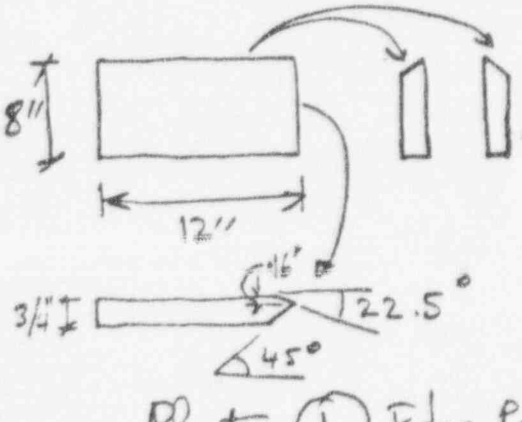


Plate ① Edge Prep.

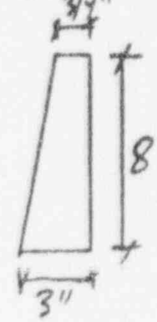
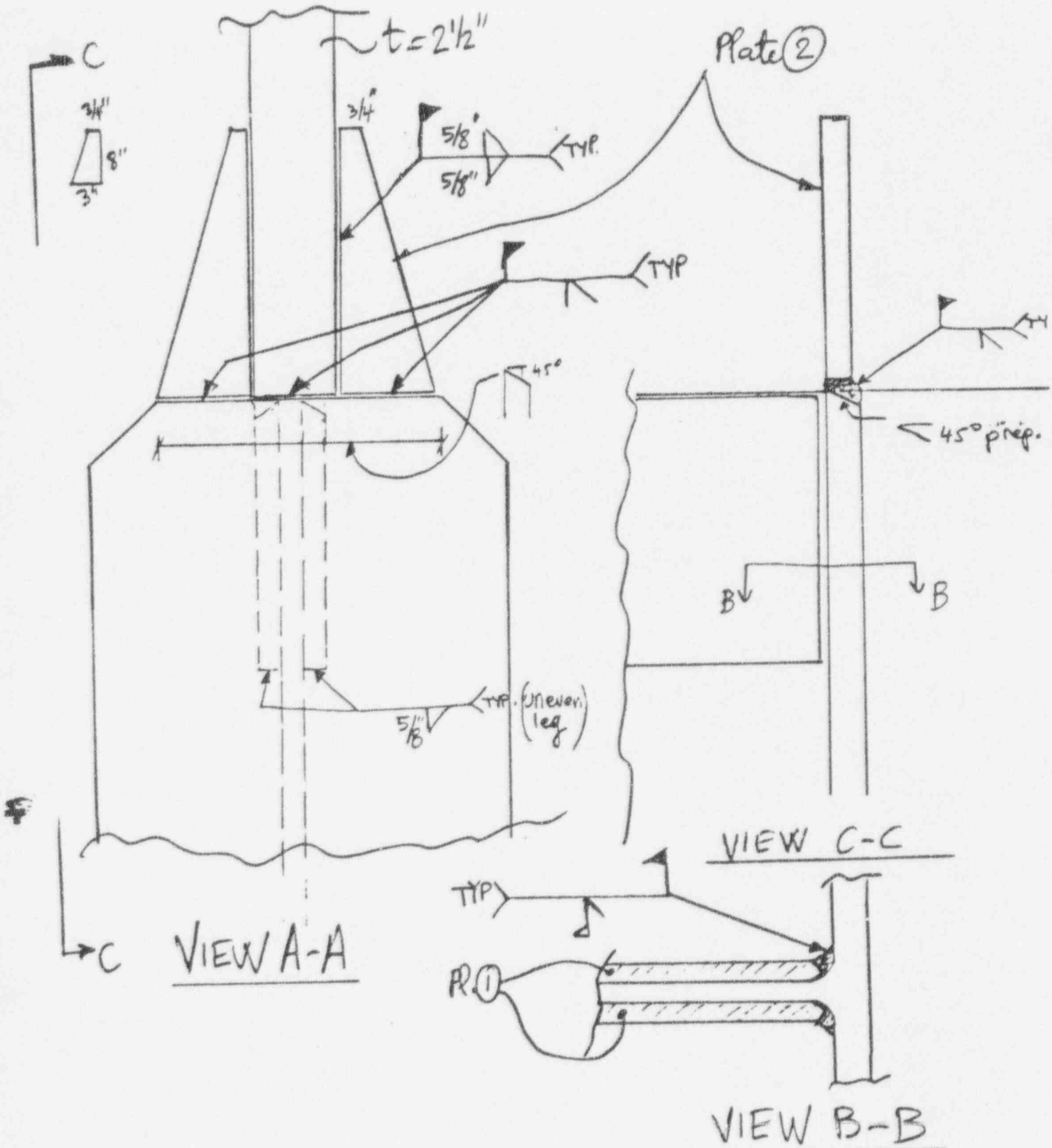


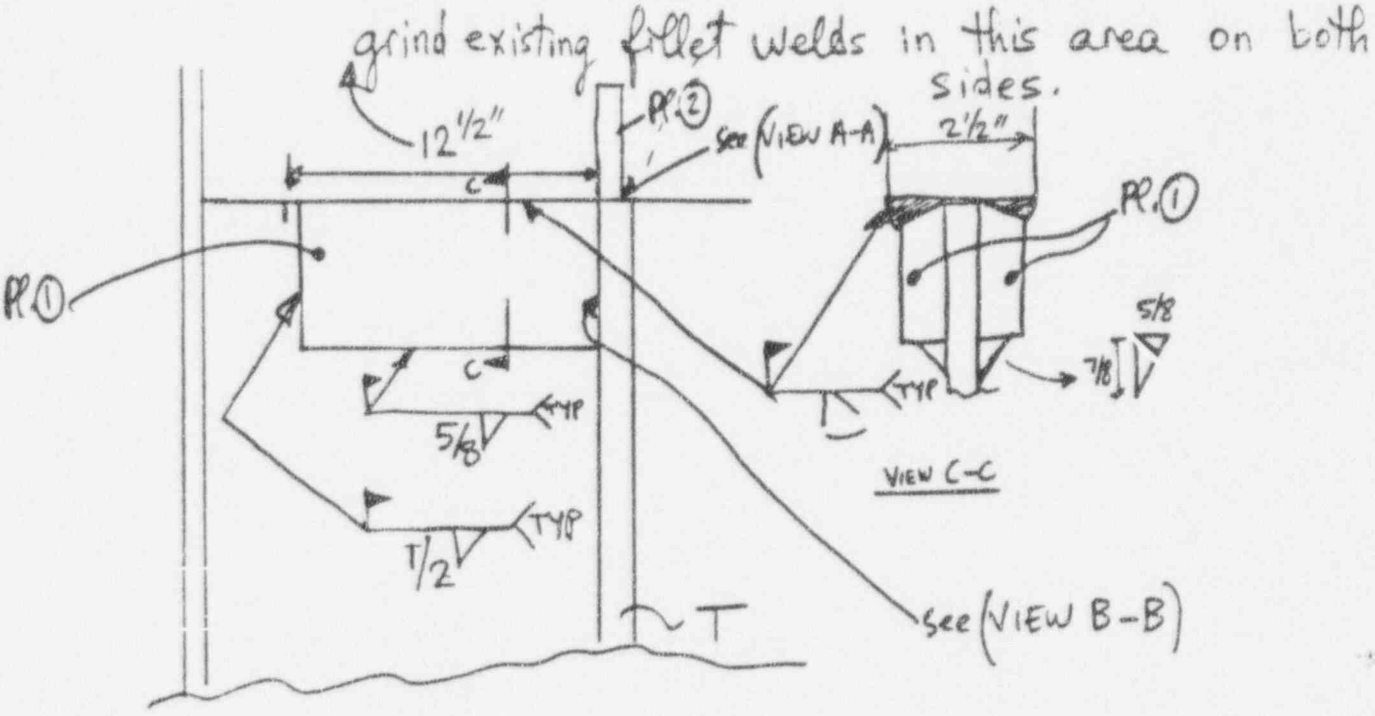
Plate ②

TSR-26565 Rev. A



Bearing Beam #5 Reinforcement Details - Typical at 4 places.

Ref. TI-637

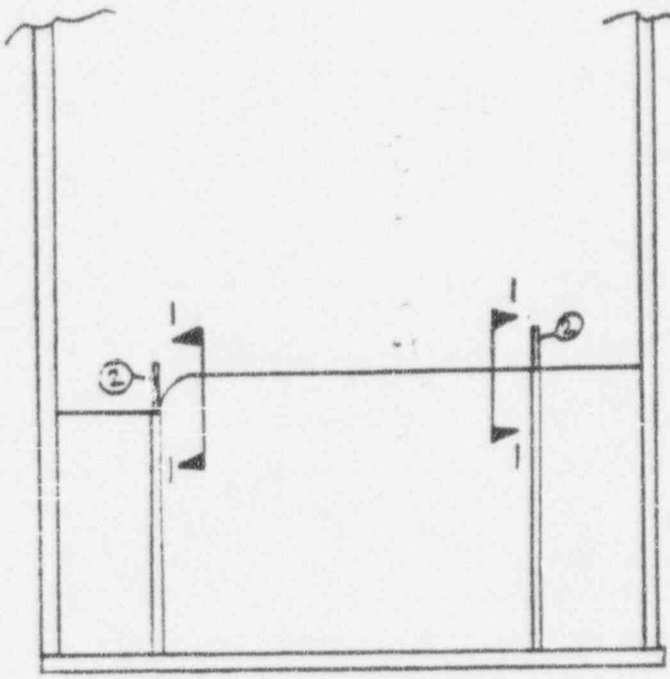


Elevation

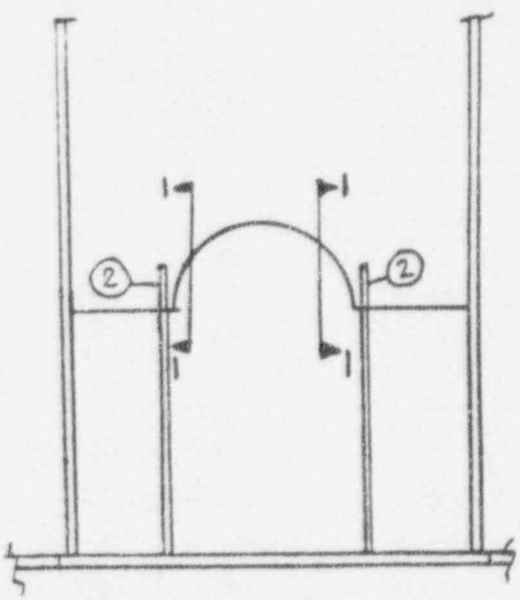
Reinforcing & Repair Details For Bearing Beam #3

Ref. T1-637

TSR-26565 Rev. A



BEARING BEAM #2 (SECTION ON DD) REF. TI-641 Pg. 3 of 3

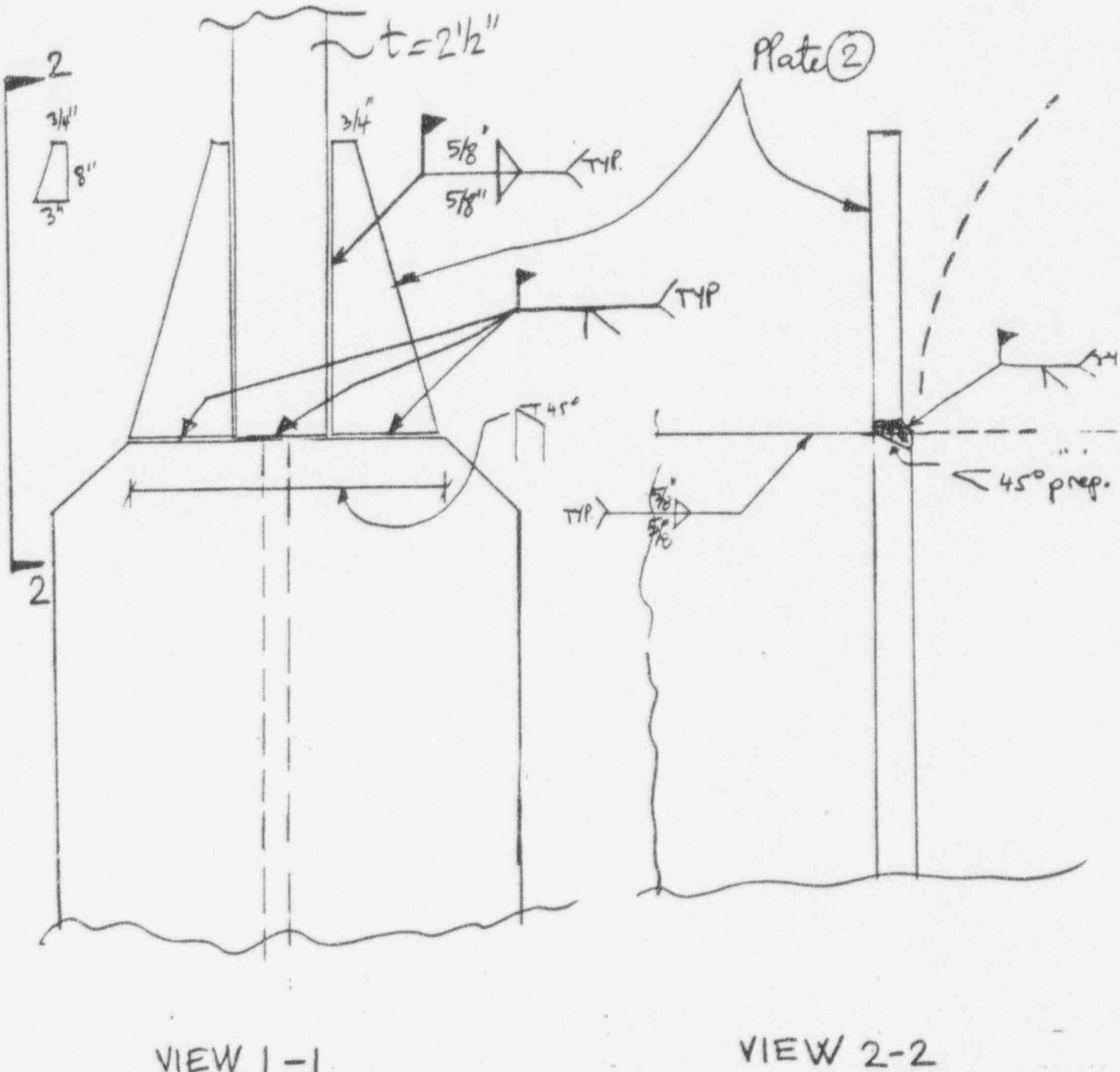


BEARING BEAMS #3 & #4

SECTION C-C Ref. TI-642 Pg. 3 of 3

TSR-26565 Rev. A

7/11/94



Typical for Bearing beams #2, #3 & #4. Ref. T1-641 & T1-642

For Plate ②, also see Bearing beam #5 details.

The above detail applicable for 4 locations per bearing beam.

John N.

Ref. Letter # SLAN-029

VENDOR DOCUMENT APPROVAL

DTC: TDPATR
DBM: 9250 45 PAGE: ___ REV: ___
PIN NO: N30
P.O. 667023 EDISON FILE NO: T1-3696
DATE: 5-16-94 ✓ VENDOR NAME: SL
SUPERSEDING EDISON DRAWING NO: ___

NUCLEAR ENGINEERING

TITLE	APPROVED	AS NOTED	NOT APPROVED
[illegible]	[illegible] 5/16/94		

FINAL: [illegible] 5/16/94
SUPERSEDED BY: ___

Assessment of Turbine Bearing Beam Cracking

Prepared by J. T. Louden Date 5/10/94
J. T. Louden, Principal Engineer

Reviewed by [illegible] for MMH Date 5/10/94
M. Hassaballa, Sr. Proj. Engineer

CMED-058757

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I. Introduction

In December 1993, the Fermi turbine sustained damage including the loss of blades. A walkdown of the low pressure turbine bearing beams was requested by Mr. A. Alchalabi of Detroit Edison Company to assess any possible structural damage. Also, possible explanations should be provided.

II Walkdown Results

The walkdown was performed by Jim Louden on 04-18 and 04-19-94.

The walkdown consisted of visual examination of the four turbine bearing beams each about 15 ft. high and almost 35 ft. long. There was no distortion or warpage noted on these large box beams. However, there were a number of locations where cracking was found and these are itemized in Attachments 1 to 3. A vertical plate in the #5 pedestal area adjacent to the generator foundation had a weld crack that also branched off into the plate base metal (see Attachment 3, last item). All other cracking was related to the fillet welds joining the 2 1/2" thick support ribs to the T's which were about 3/4" thick.

III. Discussion

After the Fermi turbine lost some blades the imbalance probably resulted in high stress fatigue loading of the bearing beams at a rate equivalent to its rotational speed, ~~3600~~ 1800 rpm. It is possible that the cause of the cracking was high stress-low cycle fatigue. Detroit Edison Company should be able to determine if the cause of cracking is

high stress-low cycle fatigue by cutting samples from the cracked weld metal and base metal areas and sending them to a metallurgical laboratory with Scanning Electron Microscope (SEM) equipment to perform a fracture surface examination.

If it is confirmed that fatigue is the cause of cracking, an explanation of why all (except one case) cracks occurred at the support rib to T welds should be determined. These stiffeners are centrally located under the turbine. Also, there is a thickness transition from 2 1/2" to 3/4" (see Fig. 1 of Attachment 4) which represents a stress riser. If this joint was required to be designed for fatigue, the 2 1/2" thick piece would have a 2.5 to 1 slope to blend in with the fillet welds as shown by the dashed lines on Figure 1. Another stress riser was present because the support rib to the web of the T weld was wrapped around the T flange edge to connect with the T flange weld. It should be noted that all the fillet welds that continued around the T flange edge were cracked the entire length. The AWS D1.1 "Structural Welding Code" states that "fillet welds deposited on opposite sides of a common plane of contact between two parts shall be interrupted at a corner common to both welds." When the Commentary to AWS D1.1 Code was introduced in the 1981 edition it stated that testing has shown that connecting such welds will result in lower fatigue strength.

The support rib to T flange weld is shown by the drawings to be a partial penetration groove weld beveled to a depth of 3/4" on the T flange. Except for the #2 Pedestal, Rear, RHS and LHS where the welds were flush, the support rib surface extended beyond the T flange and only fillet welds could be discerned.

IV. Repair

Materials - The English Electric Ltd. drawings for the turbine structurals show that the base metals used are either grade 40A or 43A per British Spec. (BS) 4360. The "Worldwide Guide to Equivalent Irons & Steels," 2nd Edition published by ASM International gives typ'cal chemical compositions and tensile properties for both of these grades. They are comparable to the ASTM A36 structural material commonly used in the USA in terms of strength and weldability. Therefore, an AWS A5.1 classification E7018 electrode would be an appropriate shielded metal arc welding (SMAW) for repair welding.

Crack Removal - The most efficient method for defect removal is air carbon arc gouging. This method should be acceptable for removal of most of the fillet weld cracking found. Removal of any crack surfaces for metallurgical examination should be by grinding and/or cutting wheels. Magnetic particle (MT) or liquid penetrant (PT) testing should be used to verify complete crack removal. The base metal cracked areas in the web of the T should be ground (or samples cut) for the length of the crack so that the resulting cavity is a double V-grove (i.e., each side of the web to a depth 1/2 thickness) with an included angle of at least 60°. A ramp or slope of about 45° maximum should be provided at the ends of the cavity (see Fig. 2, Attachment 4). The base metal crack in the plate abutting the generator foundation wall should be ground out to a single V-groove configuration with the angle and ramp as stated above. If the crack goes thru-wall, consideration should be given to positioning a backing strip for the repair weld provided there is sufficient space.

The fillet welds that wrapped around and connected the T web welds with the T flange welds should be removed entirely. The original joint gap or interface should be exposed. This area must not be re-welded (i.e., the web fillet weld must not be connected with the flange fillet weld).

Welding Instructions - Weld repair instructions for the excavated cavities are as follows:

Preheat: Preheat the weld area to 200°F minimum.
Electrodes: E7018, 1/8" and/or 5/32" diameter
Maximum Weld Size per Pass:
- Fillet Weld Restoration - 5/16"
- Groove Welds - 1/4" weld deposit thickness

Reducing the number of weld passes while staying within the maximum weld bead sizes given above should minimize the distortion and shrinkage stresses. Also, to balance the weld shrinkage stresses welding on the opposite side should be performed alternately whenever possible (e.g., after a weld pass in an in-board side cavity the next pass would be in the out-board side cavity).

Inspection - The root pass of each repair weld should be visually examined to verify that no cracks or fusion defects exist. I recommend that the final weld surfaces of repairs be magnetic particle or liquid penetrant inspected to verify that there are no linear indications.

CMED-058757

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Attachment 1 - Steam End Bearing Beam (#2 Pedestal)

Location	Fillet Weld Cracking Found
Rear, RHS	Cracking across T flange weld and about 6" into web weld I/B and O/B sides
Front RHS	Cracking across T flange weld and about 2" into web weld I/B side
Rear, LHS	Cracking across T flange weld and about 1 1/2" into web weld on O/B side and about 4" on I/B side
Front, LHS	Cracking across T flange weld and about 2 1/2" into web weld I/B and O/B sides

NOTES

Rear - side toward generator (south)

Front - north side

RHS - right hand side (east)

LHS - west

I/B - in-board (facing towards the center)

O/B - away from center

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Attachment 2 - Center Bearing Beams (#3 & #4 Pedestals)

A. Pedestal #3

Location	Fillet Weld Cracking Found
Rear, RHS	Cracking across T flange weld and about 1" into web weld on I/B side and about 2" on O/B side
Front RHS	Cracking across T flange weld and about 3" into web weld on I/B side and about 1" on O/B side
Rear, LHS	Cracking across T flange weld and about 1" into web weld on I/B and about 4" on O/B side
Front, LHS	Cracking across T flange weld and about 1" into web weld both sides I/B and O/B

B. Pedestal #4

Location	Fillet Weld Cracking Found
Rear, RHS	Cracking across T flange
Front, RHS	Same as above
Rear, LHS	Cracking across T flange weld and about 1" into web weld on O/B side
Front, LHS	Same as above

Attachment 3 - Generator End Bearing Beam (#5 Pedestal)

Location	Weld and Base Metal Cracking Found
Front, LHS	Cracking across T flange fillet weld and about 3" into web fillet weld then branching into base metal of web for about 8" on I/B and O/B sides
Front RHS	Cracking across T flange fillet weld and about 3" into web fillet weld then branching into web base metal for about 10" on I/B and O/B sides
Rear, LHS	Cracking across T flange fillet weld and about 6" into web fillet weld on I/B and O/B sides
Rear, RHS	Same as above
Vertical Plate Nearest Generator (adjacent to the above item)	In the southwest upper corner cracking about 2" at toe of weld branching into plate base metal for about 2"

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ATTACHMENT 4 - SKETCHES

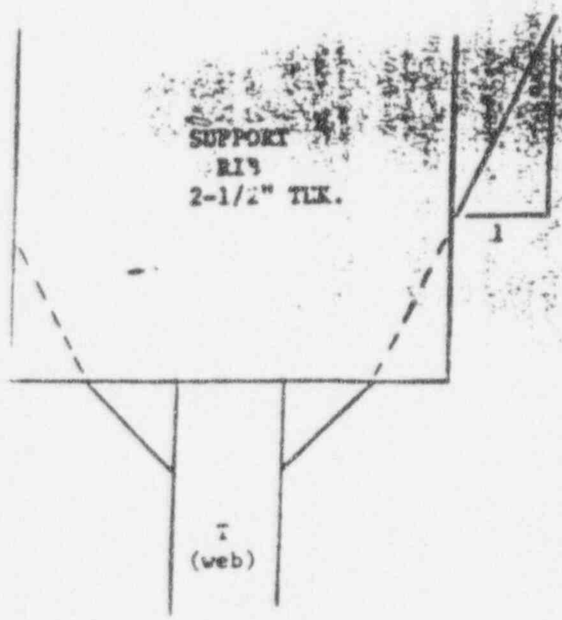

FIGURE 1 - Support Rib to T web Transition

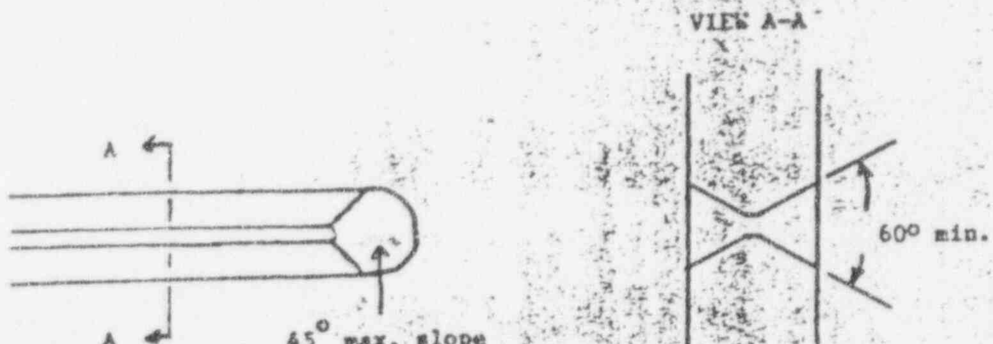

FIGURE 2 - Cavity Configuration on T-web Base Metal

Detroit
Edison

Technical and Engineering Services

Date: June 21, 1994 TDDATA 94V70 20

To: A. S. Young T4-27

From: D. J. Connell [signature]

Subject: Metallurgical Evaluation of Bearing Pedestal Box Beam Weld Cracking, Fermi 2
Technical & Engineering Services Report 94V70-20

Following visual inspection of the bearing pedestal box beams by DECo structural engineers and Sargent & Lundy engineers, ten samples were removed from cracked welds. The samples were sent to TES for metallurgical analysis.

Table I lists the location of each sample, as recorded from the field notes. Due to the condition of most of the weld samples, only limited metallographic and electron microscopy (SEM) was done. Sample 1 was the only sample which clearly showed service-related fracture. The sample had been taken from a crack that had propagated out of the weld into base metal, a structural tee in the No. 5 pedestal bearing beam. From this sample a metallographic mount was prepared and the fracture surface was examined in the SEM. Two other samples were examined in the SEM, numbers 5 and 6. Only visual exam was performed on the remaining samples.

Results

Table II reports the results of the visual examination. Little useful information was obtained from these samples due to the poor welding. In samples 4 and 9 plastic deformation (of the steel) and cracking in the paint is reported. This indicates that the stresses that caused cracking were very high.

The fracture surface of Sample 1 was heavily smeared so no fracture features were identifiable. Deformation of the crack surface is further evidence that extremely high alternating stresses were present.

Examination of Sample 5 in the SEM was the first direct evidence of high stress-low cycle fatigue. Figure 1 shows the fracture surface at relatively low magnification, approximately 47X. At this magnification fatigue striations can be clearly observed. In figure 2 the boxed area is magnified 10X on the right. This shows that ductile tearing has occurred within each fatigue cycle. This magnitude of cyclic stress is rarely observed in engineered structures.

Conclusions

The cracking found in the bearing pedestal box beams was caused during the December 25, 1993 turbine failure. The cracking is high stress-low cycle fatigue. Although all the samples taken in weld metal revealed very poor welding, the overall structure was adequate for normal operation.

All cracks should be removed and those areas rewelded. Although the quality of the welding in the beams is suspect based on the samples taken, I do not recommend replacement of weld beyond that required to repair the cracks.

Approved by: [signature]
J. D. Black
Supervisor
Metallurgy, NDE & Welding

cc: P. R. Tracy
L. C. Fron
G. J. McDonald
G. A. Horuczi (file)

Reports:94V70-20

Table I Sample Location

Sample No.	Sample Location
1	#5 pedestal, O/B side, NE., LHS
2	#5 pedestal, O/B side, SE corner, RHS
3	#5 pedestal, I/B side, NW, RHS
4	#5 pedestal, rear, SE corner, LHS
5	#4 pedestal, O/B, NE side
6	#4 pedestal, I/B, SE corner
7	#3 pedestal, LHS, NE
8	#3 pedestal, SW rear, I/S
9	#2 pedestal, LHS, front, NW corner
10	#2 pedestal, LHS, rear, O/B, SE corner

Note: The sample location is listed as recorded from the field notes

Table II Results of Visual Examination of Crack Samples

Sample No.	Description
1	Base metal, looks fresh, fracture overheated during removal
2	Shallow crack and "woody" fracture; paint shows cracks
3	Weld around corner; very poor weld; massive porosity & slag pockets
4	Weld around corner; considerable plastic deformation around cracking; cracks in paint; very rough & poor weld, slag, porosity
5	Sample had to be opened up; looks like sample came from where a weld ended at a corner; poor weld
6	Crack had to be opened up; porosity & shrinkage
7	Massive porosity; slag
8	Slag and massive porosity; lack of fusion
9	Considerable cracking in paint; poor, shallow welding; porosity and slag
10	Large pocket where weld bridged

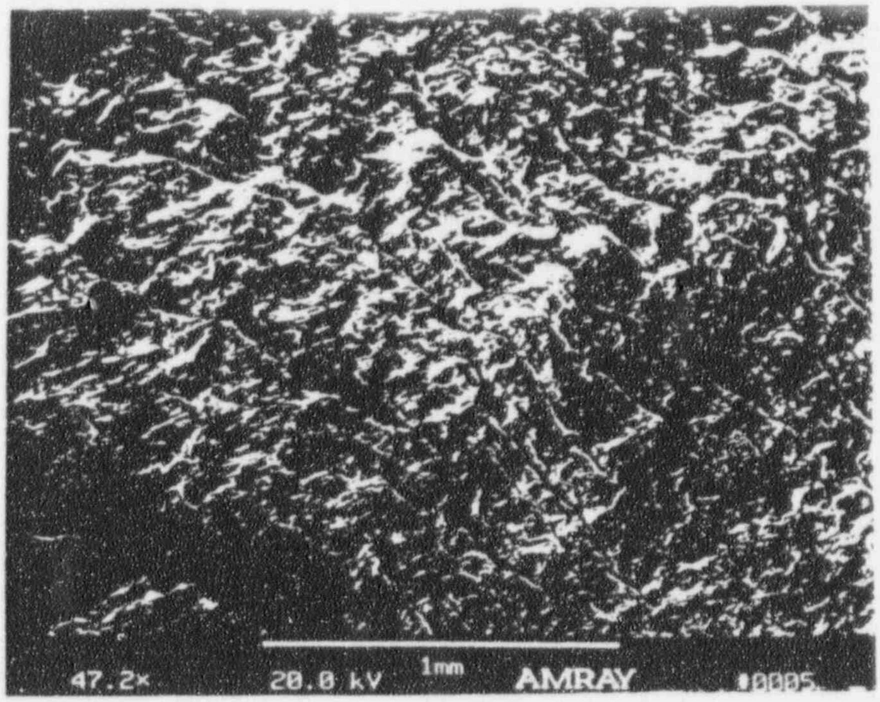

Figure 1 - SEM photo showing coarse fatigue striations

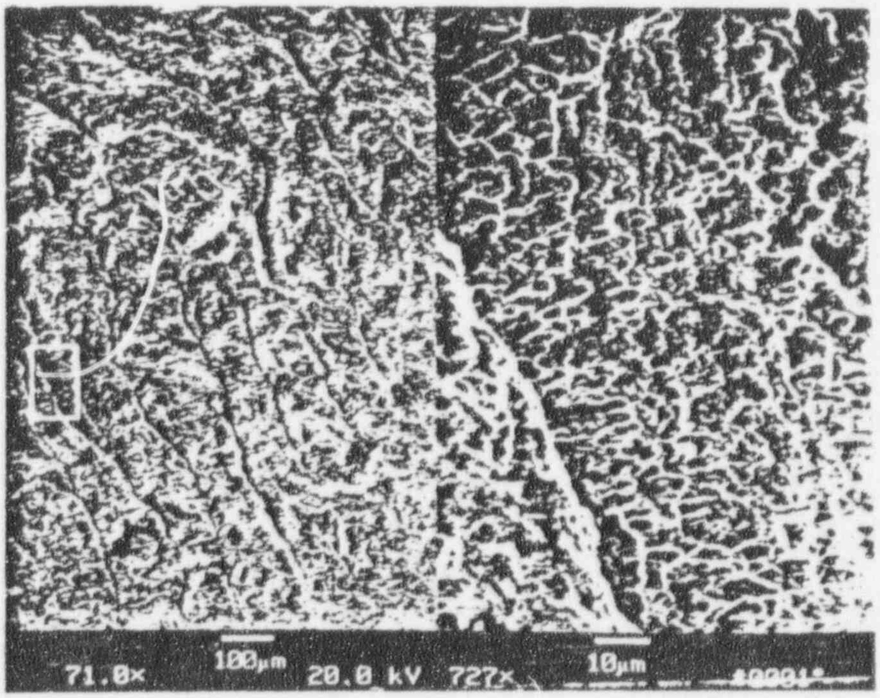

Figure 2 - SEM photo showing coarse fatigue striations and ductile tearing

ATTACHMENT 10