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RECIP. NAME RECIPIENT AFFILIATION
KNIGHTON, G. W. PWR Project Directorate 7

SUBJECT: Rev 1 to deficiency rept re weld failure on Unit 1 pipe support structure identified during 860313 surveillance insp. Caused by weld fracture due to overloading. Documents to implement repair issued for six supports.

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Arizona Nuclear Power Project
P.O. BOX 52034 • PHOENIX, ARIZONA 85072-2034

April 9, 1986
ANPP-36021-EEVB/RAB/98.05

Director of Nuclear Reactor Regulation
Attention: Mr. George W. Knighton, Project Director
PWR Project Directorate #7
Division of Pressurized Water Reactor Licensing - B
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Palo Verde Nuclear Generating Station
Unit 2
Docket No. STN 50-529 (License NPF-46)
Report on Pipe Support Failure
File: 86-073-419, P.3.04.1

Dear Mr. Knighton:

Attached, for your information, is a report concerning the single pipe support failure in the Unit 1 containment which was found on March 13, 1986.

This report describes the condition of the failure, the evaluation conducted to determine the root cause and the extent of the problem, and the corrective actions.

The corrective actions have been completed.

Very truly yours,

E. E. Van Brunt, Jr.
Executive Vice President
Project Director

EEVB/RAB/dk
Attachment

cc: E. A. Licitra (all w/a)
R. P. Zimmerman
A. C. Gehr
J. B. Martin

A001
1/1

WELD FAILURE ON PVNGS UNIT 1 PIPE SUPPORT STRUCTURE

I. CONDITION DESCRIPTION

A surveillance inspection of Unit 1 on March 13, 1986, identified a broken pipe support (Support No. 1-SG-005-H008). The broken support was located inside the containment building and was a strut type support for the 24 inch main feedwater line to Steam Generator No. 2. The break occurred in the weld between the flange connection of the upper and lower support beams. The lower portion of the support separated completely from the upper support beam (see Attachment A). The axes of the two beams were oriented 90°, and it was discovered that the two 4 inch long, 1/4 inch leg fillet welds between member A (upper beam) and E (lower beam) fractured. Attachment A shows the location of the failure. A distortion of the beam flanges at the weld location occurred.

The time of failure of the support is not known. A visual inspection of the hanger was performed by ANPP in March 1985, prior to Post-Core Hot Function Testing, at which time the support was intact.

II. EVALUATION

A. Summary

The evaluation of this condition included both an evaluation of the specific failure of support 1-SG-005-H008 as well as an evaluation of the potential for similar failures of other large and small bore Q-class and Seismic Category IX pipe supports, the overall pipe support design, and the additional support designs for raceways, HVAC, instrumentation, fire protection lines and major Q-class equipment.

B. Metallurgical Aspects at Weld Failure Location on Unit 1

The broken support was visually inspected. The upper beam's bottom flange edge showed substantial bending. Similarly, the lower beam's upper flange showed some bending. Part of the fractured weld remained on the upper beam with the remainder on the lower beam.

The weld surfaces on the lower beam were also examined under a Stereo Microscope. Part of the fracture was in the base metal near the fusion zone and part was in weld metal. The weld quality was satisfactory. The fractured surface of the beam had a woody appearance, but the fractured surface in the weld metal appeared smooth.

The fractured surfaces were additionally examined under a Scanning Electron Microscope (SEM). The examination showed elongated dimple structures typical of a ductile overload under shear stresses. The base metal had some equiaxed dimples and

elongated fibers indicating ductile overload fracture. No evidence of any striation was seen under the SEM, proving that fatigue was not a factor in this fracture.

Chemical analysis of the base material and weld material showed that the materials conform with ASTM A-36 and AWS SFA 5.1 Type E7018 requirements. Hardness tests showed the base material had an approximate tensile strength of 72,000 psi. The filler material tensile strength was approximately 90,000 psi. Typically this material has elongation, at fracture, of approximately 30%.

Based on the above observations, it was concluded that the weld fractured due to overloading. Deformation of the flanges indicate that the weld transferred the loads until it could no longer accommodate strains imposed by deformation of the flange, causing the weld to fracture.

C. Unit 1 Pipe Support Design and Loading

Attachment B summarizes the results of loading combinations and design capability of the failed Unit 1 support (1-SG-005-H008). The originally installed pipe support had a Faulted Maximum Permitted Load of approximately 15 Kips. The actual normal load (dead weight plus thermal) applied to the support was 17.7 Kips, thereby resulting in overloading of the support. The support has been modified to provide for normal and faulted conditions with adequate structural margin as shown in Attachment B.

The pipe support design loads were reviewed and determined to be proper and appropriate loads. Therefore, the design loads used for evaluating the pre-modified and modified design are the same for the three PVNGS Units.

D. Unit 2 Pipe Support Design and Loading

Investigation of the same support in Unit 2 (Support 2-SG-005-H008), which had experienced hydrotest and precore Hot Functional Testing (HFT) thermal loads as well as dead weight loads, determined no flange deformation or weld damage. Further examination revealed that the lower beam on that support was not a W6 x 12 but a W6 x 15.5 member. Since the flange is 2 inches wider than the member used in Unit 1, it provides four additional inches of weld (two inches on each side of the beam). The larger beam size substitution was permitted per installation Specification 13-PM-204, since it was an upgrade in beam size.

Results of the calculation of this support (with the larger beam member) is also shown in Attachment B. The increased capability (approximately 21 Kips) of the Unit 2 support to carry the thermal and dead weight load (approximately 17.7 Kips) of the associated piping without any flange deformation is apparent. This support has been modified to provide the structural margin as shown in Attachment B.

E. Review of Other Supports

The failure mechanism of the Unit 1 support was a result of localized flange bending not being adequately considered in the design. Therefore, it was decided to review the drawings for all Q Class supports for large bore pipe ($\geq$ 2-1/2 inches) to determine if other instances existed where local flange bending may have been overlooked.

A review was conducted on 100% of the large bore Q-class pipe supports which involved 3,678 design drawings and "as-built" documentation. Five supports in the Main Steam and Safety Injection systems were determined to be inadequately designed for flange bending and required modification as shown in Section V.A. Attachment C lists the six pre-modified and modified support calculations and indicates the location of the support configurations within these calculations for Unit 2.

A review of design documents was expanded beyond the specific area of the support failure to include:

a. Review of the overall pipe support design and a review of the design of pipe support attachment to plant structures. The result of this review confirmed the adequacy of the designs.

b. An investigation which sampled small bore Q-Class and seismic category IX pipe supports. The results of this selective investigation indicated the supports had adequate designs.

c. An investigation of the design of other equipment (structural steel, raceway supports, HVAC, instrumentation, fire protection, major Q-Class equipment supports) utilizing configurations that could be subject to localized flange bending failures. The results of this selective investigation indicated all had adequate designs.

These reviews were conducted to ensure that the loss of design control resulting in the failed support did not extend to other areas.

III. ROOT CAUSE

The root cause of the support weld failure on support 1-SG-005-H008 is improper consideration of localized flange bending loads during the original design of the support. The flange deformation without stiffeners caused additional bending stresses on the fillet welds and beam flange leading to weld failure.

IV. CONCLUSION

Based on the evaluation conducted and the limited number of problems identified (six), it is concluded that there was a loss of design control during the original design of the support but this loss was an isolated case resulting from an oversight on the part of the designer and checker, and not a generic breakdown of the design process.

V. CORRECTIVE ACTIONS

A. For the six supports that require rework, the following work documents have been issued:

System	Support	Unit 1 & 2 Engineering Document to Implement Repair	Unit 3 Document to Implement Repair
Feedwater	13-SG-005-H008	EER 86-SG-056	SFR-3SG-008
Mainsteam	13-SG-036-H011	EER 85-SG-094 Unit 1 EER 86-SG-056 Unit 2	SFR-3SG-008
Mainsteam	13-SG-042-H011	EER 86-SG-056	SFR-3SG-008
Mainsteam	13-SG-042-H017	EER 86-SG-056	SFR-3SG-008
Safety Injection	13-SI-220-H020	EER 86-SG-056	SFR-3RC-089
Safety Injection	13-SI-220-H024	EER 86-SG-056	SFR-3RC-089

B. Procedural Modifications

The Bechtel Group Supervisor of the Plant Design Stress and Support Group issued a memo on April 1, 1986, to all personnel providing definitive instructions regarding the requirements for stiffeners to be placed in the center of the load path.

J. T. Bingham for 4/9/86

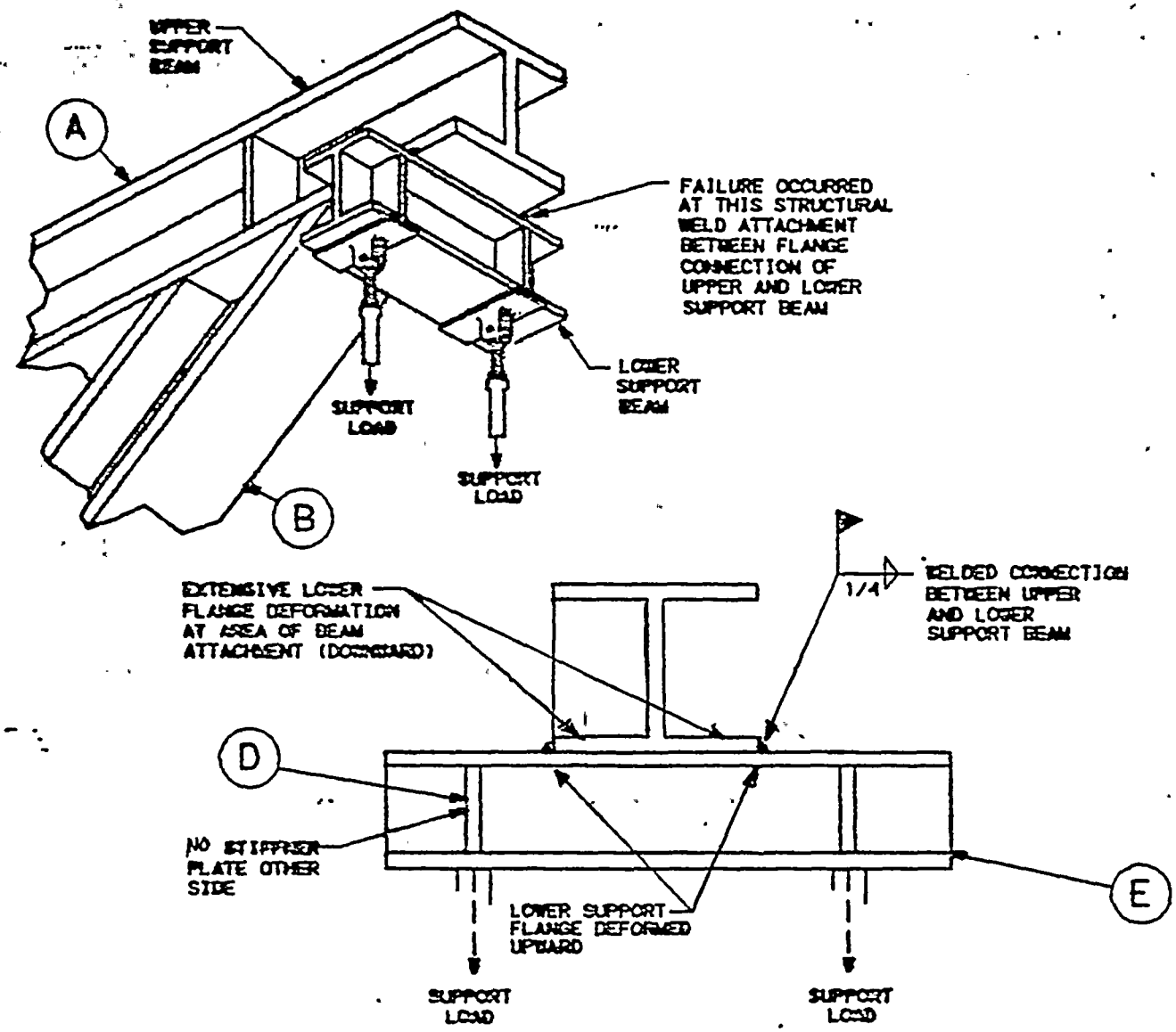
W. G. Bingham Date
Project Engineering Manager
Bechtel Power Corporation

4/9/86

M. F. Hodge Date
Supervisor, Mechanical/Chemical
Engineering

PIPE SUPPORT 1-SG-005-H008

FAILURE LOCATION



END VIEW

ITEM NO.	NO. REQ'D	DESCRIPTION
A	1	W6 X 25 X 3'-8"
B	1	W6 X 25 X 3'-6"
D	3	STIFF PL. 1/4" X 2 7/8 X 0'-5 1/2"
E	1	W6 X 12 X 1'-4"

ATTACHMENT "A"

ATTACHMENT B

LOAD SUMMARY	
TYPE	LOAD (KIP)
WEIGHT	-16.642
THRM	+4.873/-1.042
SSE	±11.839
Eq SSE (SAM)	±2.736
LOCA + J.I.	±16.245
W.H.	+34.950/-6.437

W.H. includes DW + THRM

LOAD COMBINATION

NORMAL LOAD = DW + THRM = $0/-17.684^k$

FAULTED LOAD = DW + TH + SSE + SAM + WH = $+49.525^k/-21.012^k$

OR

FAULTED LOAD = $DW+TH+[(SSE+SAM)^2+(LOCA+JI)^2]^{1/2}=+26.698^k/-39.509^k$

DESIGN LOAD = $+ 49.5^k/-39.5^k$

RESULTS TABLE

	PRE-MODIFIED				MODIFIED			
	NORMAL		FAULTED		NORMAL		FAULTED	
UNIT	MAX. PERMITTED LOAD(KIP)	ACTUAL LOAD (KIP)	MAX. PERMITTED LOAD(KIP)	ACTUAL LOAD (KIP)	MAX. PERMITTED LOAD(KIP)	ACTUAL LOAD (KIP)	MAX. PERMITTED LOAD(KIP)	ACTUAL LOAD (KIP)
1	-7.5	-17.684	+53.4 -15	+49.5 -39.5	-41.4	-17.684	+53.4 -43.86	+49.5 -39.5
2	-10.35	-17.684	+53.4 -20.69	+49.5 -39.5	-41.4	-17.684	+53.4 -43.86	+49.5 -39.5

ATTACHMENT C

PIPE SUPPORT	OLD CONFIGURATION	NEW CONFIGURATION (UNIT 2)
13-SI-220-H-024	Problem #SI517B 3/13/82 (Old Calc) Last Page (Titled 13-SI-220-H-024 Rev. 2)	Problem SI517B 3/23/86 (New Calc) Last Page (Titled Engr. Eval. Request 86-SG-056)
13-SG-042-H-017	Problem SG-501D dated 4/8/82 (Old Calc) Last 2 Pages (Titled 13-SG-042-H-017 Sheet 1 of 2 and Sheet 2 of 2)	Problem SG-501D dated 3/23/86 (New Calc) Last 2 Pages (Titled Engr. Eval. Request 86-SG-056, Pages 12 and 13)
13-SG-036-H-011	Problem SG-501C dated 11/12/81 (Old Calc) Last Page (Titled 13-SG-036-H-011 Rev. 2)	Problem SG-501C dated 3/22/86 (New Calc) Last Page (Titled Engr. Eval. Request 86-SG-056, Page 8)
13-SG-042-H-011	Problem SG-501D dated 11/12/81 (Old Calc) Last Page (Titled 13-SG-042-H-011 Rev. 4)	Problem SG-501D dated 3/23/86 (New Calc) Last Page (Titled Engr. Eval. Request 86-SG-056, Page 14)
13-SI-220-H-020	Problem SI-517B dated 8/20/80 (Old Calc) Last Page (Titled 13-SI-220-H-020 Rev. 1)	Problem SI-517B dated 3/23/86 (New Calc) FCR 59, 451 P (attached) (Dwg. included in new calc is for Unit 1 only)
13-SG-005-H-008	Problem FW-501A dated 5/21/85 (Old Calc) Last Page (Titled 13-SG-005-H-008 Rev. 8)	Problem FW-501A dated 3/23/86 (New Calc) Last 2 Pages (Titled EER 86-SG-056, Pages 5 and 6)

Attachment C

FIELD CHANGE REQUEST
JOB NO. 10407

PAGE 1 OF 1 | NO. 59.451-P | N/A
QUALITY CLASS QIB | 3. DATE MO 4 DAY 5 YR 83 | 13B. ECN NO. N/A

4. REF DWG OR SPEC 13-SI-220-H020 REV 1 | 5. TITLE PIPE SUPPORT ASSY - CTMT SU 2 RC01

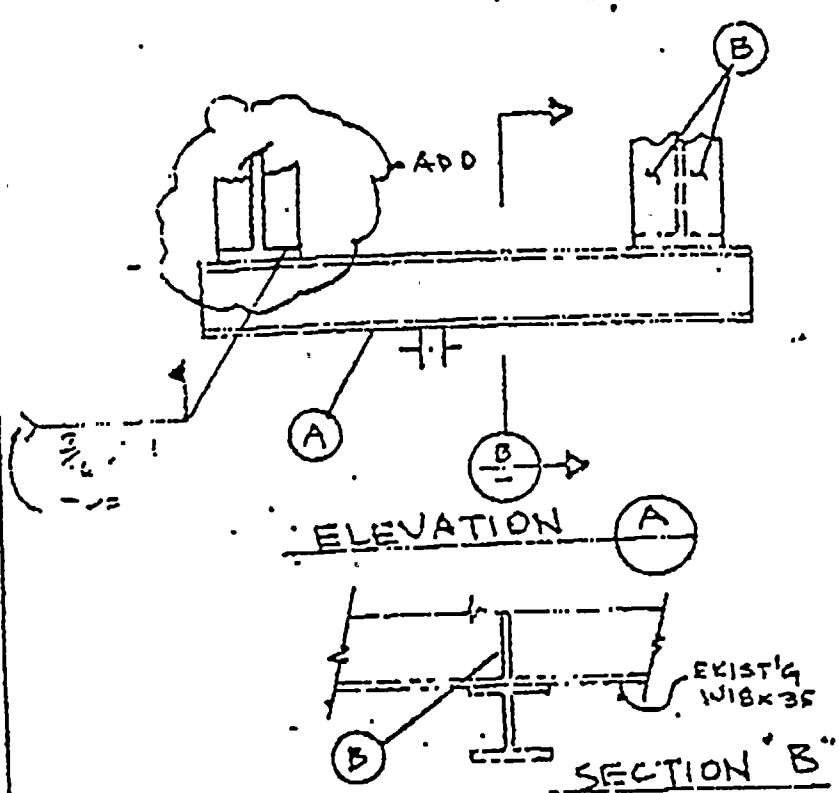
6. DESIGN ORIGIN: ☒ ENGINEERING ☐ SUPPLIER (IDENTIFY BY NAME) | 7. ☐ UNIT 1 ☐ UNIT 3 ☒ UNIT 2 ☐ COMMON

8. EXISTING CONDITION
SUPPORT WAS REVISED PER ECR 15427 P WHICH ALLOWED THE INSTALLATION OF TWO ITEM B. FOUR ITEM B WERE INSTALLED INSTEAD.
NFS 4/12/83 DELETED

9. CHANGE REQUEST/SKETCH

CHANGE TO:

QTY
REVISE ITEM B: 4 -
STIFF. PL 1/4 x 2 1/2" x 1'-4 3/4"



10. REVIEWED BY: TREND #2
R.S. Rather Jr. — DISCIPLINE FIELD ENGINEER — 4-7-83 DATE
DISCIPLINE FIELD ENGINEER — DATE

11. PREPARED BY: H. THOMAS

12. APPROVAL OF FIELD DISPOSITION:
PROJECT FIELD ENGINEER — 4/7/83 DATE

13. BECHTEL ENGINEERING ☒ APPROVED 4/7/83 ☐ DISAPPROVED
GROUP SUPERVISOR — 4/11/83 DATE
N/A — NUCLEAR GROUP SUPERVISOR (IF REQUIRED) — DATE
PROJECT ENGINEER — 4/12/83 DATE
POAE — N/A (ID-LISTED P&I AND SINGLE LINE DWGS) (QUALITY CLASS D AND R SPECS) — RECEIVED DATE
APR 28 1983

REMARKS Construction Hold
CS 4/21/83
CONSTRUCTION ENGINEER

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PF-1321 (10407) 8/74