Attachment
CEC-99-061

PIPING CONFIGURATION VERIFICATION PROGRAM
STATUS REPORT

Commonwealth Edison Company
Dresden Units 2 and 3
Quad Cities Units 1 and 2

Prepared by

NUTECH Engineers

July 28, 1987

nutech

1.0 INTRODUCTION

This report describes the status of activities being performed to resolve the issues regarding apparent discrepancies found between the as-built and as-analyzed condition of certain Mark I torus attached piping at Dresden Units 2 & 3 and Quad Cities Units 1 & 2. A previous report, "Program Description and Status Report," NUTECH Document CEC-99-024, dated June 22, 1987, describes the background, the details of the program for resolution, and the status of the effort at that time.

The purpose of this report is to advise the NRC of the current status of work being performed. This biweekly report is being issued earlier than the normally scheduled date so it will be available for a presentation to the NRC on July 30, 1987. Additional biweekly reports will be issued to update the status of these activities and highlight any new developments. The previous status report, CEC-99-039, was dated July 17, 1987.

2.0 STATUS

The status of the program is summarized on the Figures 2.0-1 and 2.0-2, and Tables 2.0-1 and 2.0-2, for Dresden and Quad Cities, respectively. The figures show the DDR status superposed on the program logic diagram. The tables present essentially the same information in tabular format, with "% complete" added. These figures and tables will be updated on each biweekly report to indicate progress. Status of the ongoing FSAR/ operability analyses will be reported as significant milestones are reached.

2.1 Second Level Screening

As of the last report, all DDRs for Quad Cities and Dresden had been processed through second level screening. This was completed on July 10, 1987. This means that all DDRs have now been processed through second level screening, with the exception of 13 DDRs which are included in models being addressed as part of the formal assessments discussed in 2.2 below.

2.2 Formal Assessments for FSAR/Operability Compliance

As identified in the last status report, five piping models are in the process of being formally assessed for FSAR/operability compliance. These five models are:

D2.02	D2 - ECCS Suction Header
D3.02	D3 - ECCS Suction Header
Q2.04	QC2 - HPCI Pump Suction
Q2.09.01	QC2 - RHR Pump Discharge A/B
D3.10	D3 - Pressure Suppression

The status of each of these is addressed below.

D2.02 and D3.02

These models have been updated and analyzed for the relevant static, thermal, seismic and hydrodynamic loads.

Currently, pipe stress and pipe support calculations are being completed. This work is scheduled for completion on 8/3/87.

Q2.04 and Q2.09.01

These models have been updated and analyzed for the relevant static, thermal, seismic, and hydrodynamic loads.

Currently, pipe stress and pipe support calculations are being completed and pipe supports are being evaluated. These models were originally scheduled for completion on 7/31/87. Our current projection is for a one-week slippage to 8/7/87. This slippage is due to slower general progress than anticipated. It is not the result of any particular technical problems in the analysis or the results.

D3.10

Work on this model is in progress. Completion of the formal assessment of this model is scheduled for 8/17/87.

2.3 FSAR Compliance of DDRs Which Passed 2nd Level Screening

The DDRs which "passed" the second level screening criteria now need to be evaluated for FSAR compliance.

Work on these is in progress. Completion of these FSAR evaluations is scheduled for 11/9/87.

The NUTECH instruction and criteria for FSAR and/or operability compliance (CEC-99-017) was presented to the NRC on 7/17/87 and has been revised and reissued to incorporate comments received at that meeting.

2.4 Miscellaneous

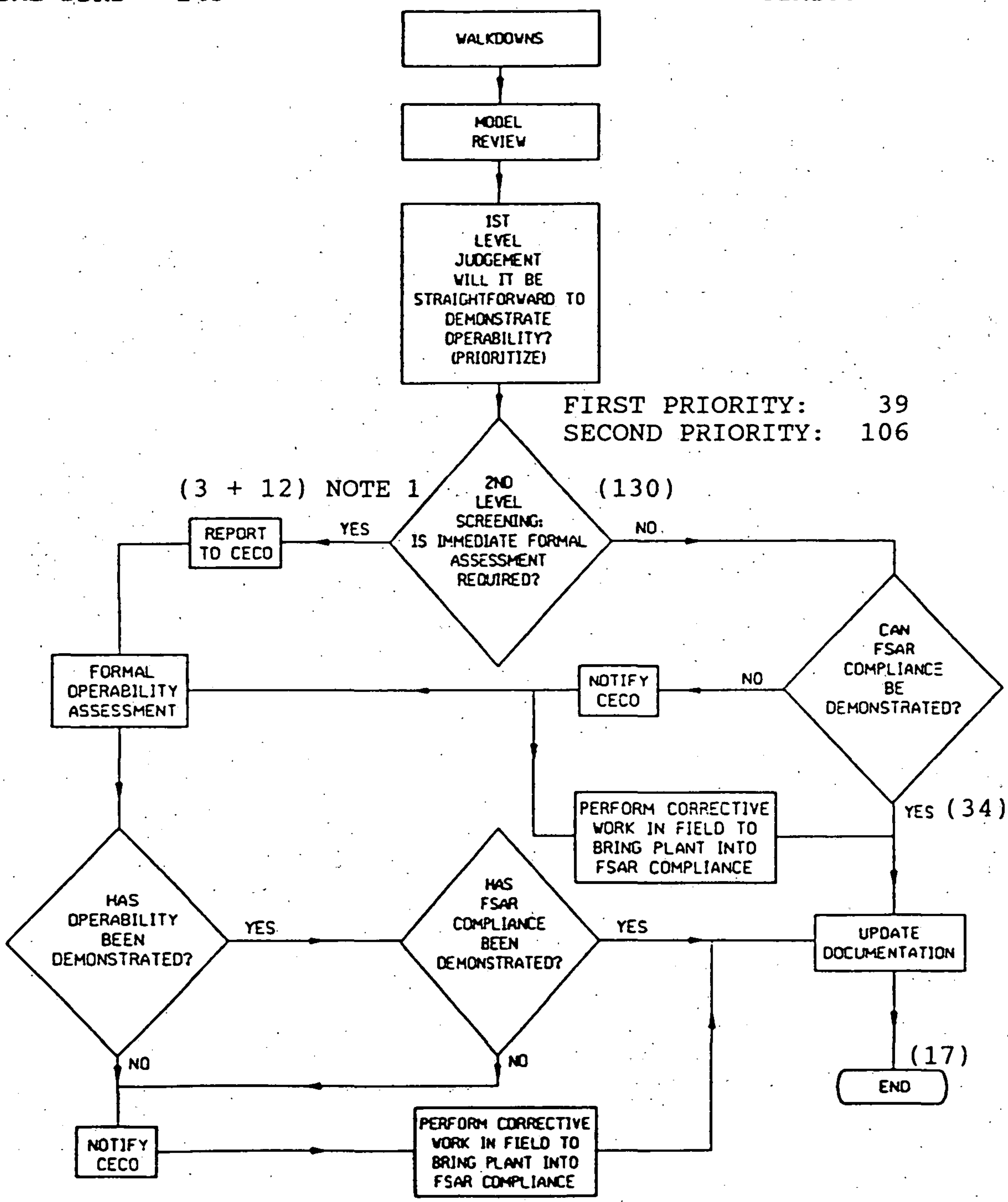
Meetings were held with Quad Cities (7/16/87) and Dresden (7/24/87) Stations to review the overall program and status to date, and to confirm the lines of communication between NUTECH, CECo's Station Nuclear Engineering Department, and Station personnel.

Figure 2.0-1

STATUS SUMMARY

DRESDEN 2 & 3

TOTAL DDRs = 145 STATUS DATE: 7-27-87



NOTE 1: 3 DDRs require formal assessment. 12 additional DDRs are being evaluated with those piping models being formally assessed.

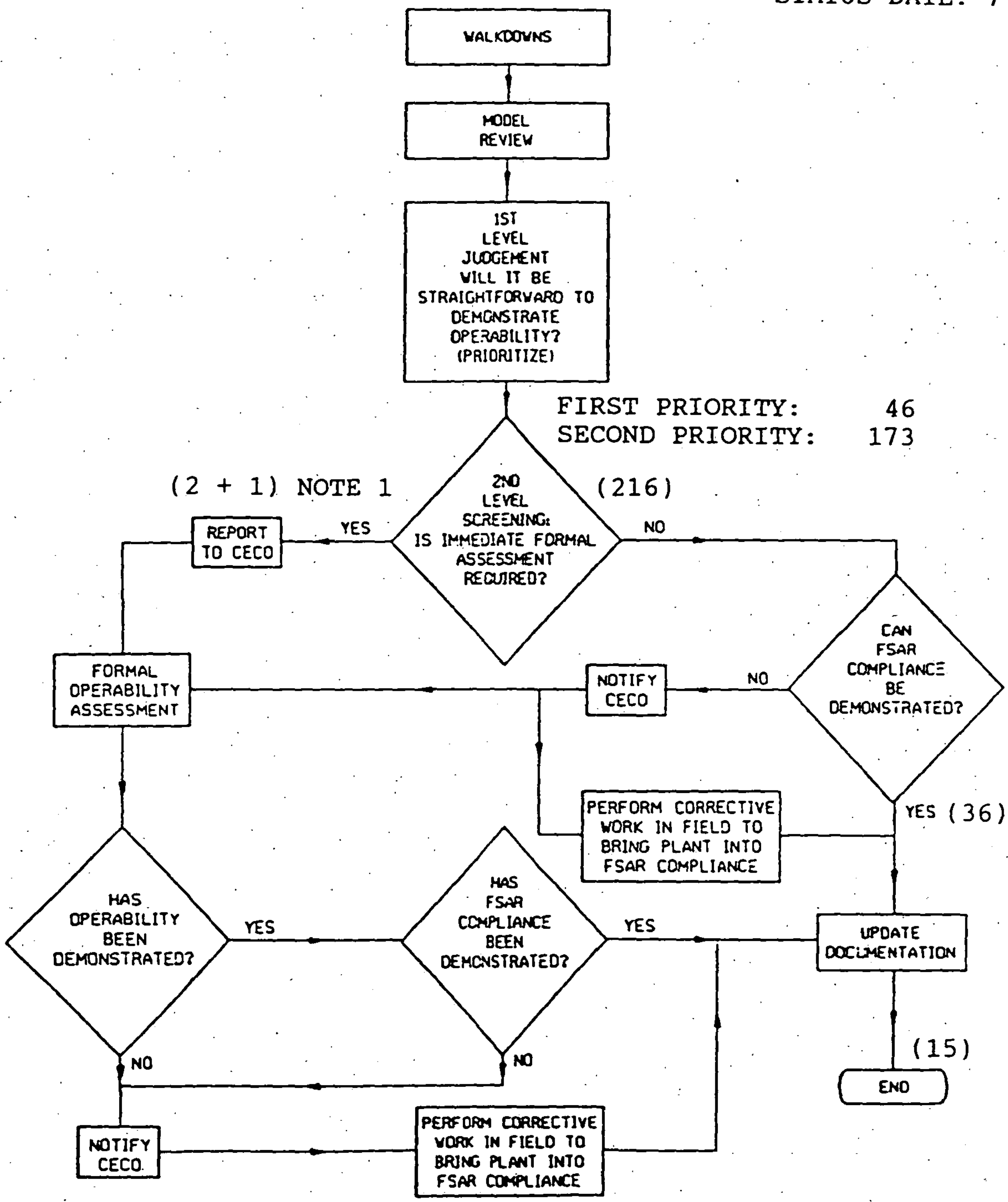
Figure 2.0-2

STATUS SUMMARY

QUAD CITIES 1 & 2

TOTAL DDRs = 219

STATUS DATE: 7-27-87



NOTE 1: 2 DDRs require formal assessment. 1 additional DDR is being evaluated with a model being formally assessed.

Table 2.0-1

STATUS SUMMARY

DRESDEN 2 & 3

Status Date: 7-27-87

Activity Description	Total Scope	Completed		% Complete
Configuration Walkdown				
D2	13	13		100%
D3	15	15		100%
Total (Models)	28	28		100%
Model Review				
D2	13	13		100%
D3	15	15		100%
Total (Models)	28	28		100%
1st Level Judgement of DDRs				
D2	66	66		100%
D3	79	79		100%
Total (DDRs)	145	145		100%
2nd Level Screening of First Priority DDRs				
D2	17	17		100%
D3	22	22		100%
Total (DDRs)	39	39		100%
2nd Level Screening of Second Priority DDRs				
D2	49	44	Note 1	89%
D3	57	50	Note 1	88%
Total (DDRs)	106	94		89%
DDRs Requiring Formal Operability				
D2	1	0		0
D3	2	0		0
Total (DDRs)	3	0		0
DDRs Resolved for FSAR				
D2	66	20		30%
D3	79	14		18%
Total (DDRs)	145	34		23%

Note 1: Five D2 and seven D3 Second Priority DDRs are being addressed with models having other DDRs which required formal assessment of those models.

Table 2.0-2

STATUS SUMMARY

QUAD CITIES 1 & 2

Status Date: 7-27-87

Activity Description	Total Scope	Completed		% Complete
Configuration Walkdown				
QC1	18	18		100%
QC2	19	19		100%
Total (Models)	37	37		100%
Model Review				
QC1	18	18		100%
QC2	19	18		95%
Total (Models)	37	36		97%
1st Level Judgement of DDRs				
QC1	100	100		100%
QC2	119	119		100%
Total (DDRs)	219	219		100%
2nd Level Screening of First Priority DDRs				
QC1	24	24		100%
QC2	22	22		100%
Total (DDRs)	46	46		100%
2nd Level Screening of Second Priority DDRs				
QC1	76	76		100%
QC2	97	96	Note 1	99%
Total (DDRs)	173	172		99%
2nd Priority DDRs Requiring Formal Operability				
QC1	0	0		100%
QC2	2	0		0
Total (DDRs)	2	0		0
DDRs Resolved for FSAR				
QC1	100	17		17%
QC2	119	19		16%
Total (DDRs)	219	36		16%

Note 1: One Q2 second priority DDR is being addressed with a model having another DDR which required formal assessment of that model.

3.0 SCHEDULE

A schedule of 11/9/87 has been set for completing the FSAR compliance evaluations of all DDRs not included in the formal operability assessments. The schedule for remaining activities (e.g. modifications, documentation updating) will be established as the need for those activities becomes known.

The schedules for the major activities are shown on Figures 3.0-1 and 3.0-2 for Dresden and Quad Cities, respectively. Other items and their scheduled or actual completion date are shown on Table 3.0-1.

Figure 3.0-1

PIPING CONFIGURATION VERIFICATION PROGRAM SCHEDULE

DRESDEN 2 & 3

4/13 4/27 5/11 5/23 6/8 6/22 7/6 7/20 8/3 8/17 8/31 9/14 9/28 10/12 10/26 11/9

4/6 4/20 5/4 5/18 6/1 6/15 6/29 7/13 7/22 8/10 8/24 9/7 9/21 10/5 10/19 11/2

Task	
o Walkdown	XXXXXXXXXXXXXXXXXX 5/19 - Completed
o Model Review	XXXXXXXXXXXXXXXXXXXXXXX 6/1 - Completed
o 1st Level Judgement	XXXXXXX 6/1 - Completed
o 2nd Level Screening	XXXXXXXXXXXXXXXX 7/10 - Completed
o Formal Assessment	XXXXXXXXXXXXXXXXXXXXXXX 8/3 (Model D2.02 & D3.02) XXXXXXXXXXXXXXXX 8/17 (Model D3.10)
o FSAR Compliance	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 11/9
o Modification Design (if needed)	
o Documentation Update	

Figure 3.0-2

PIPING CONFIGURATION VERIFICATION PROGRAM SCHEDULE

QUAD CITIES 1 & 2

Task	4/6, 4/13, 4/20, 4/27, 5/4, 5/11, 5/18, 5/23, 6/1, 6/8, 6/15, 6/22, 6/29, 7/6, 7/13, 7/20, 7/22, 8/3, 8/10, 8/17, 8/24, 8/31, 9/7, 9/14, 9/21, 9/28, 10/5, 10/12, 10/19, 10/26, 11/2, 11/9)
o Walkdown	XXXXXXXXXXXXXXXXXXXXXXXXXXX 6/13 * - Completed
o Model Review	XXXXXXXXXXXXXXXXXXXXXXXXXX 6/15 * - Completed
o 1st Level Judgement	XXXXXXXXXXXXXXX 6/15 * - Completed
o 2nd Level Screening	XXXXXXXXXXXXX 7/10 - Completed
o Formal Assessment	XXXXXXXXXXXXXXXXXXXXX 8/7 (Model Q2.09.01 & Q2.04)
o FSAR Compliance	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX 11/9
o Modification Design (If needed)	
o Documentation Update	

*Except QC2.11.2

Table 3.0-1

ACTIVITY/DELIVERABLE	SCHEDULED DATE	ACTUAL DATE
1. Revise Second Level Screening Criteria for NRC Comments	06/26/87	06/25/87
2. Complete Second Level Screening of 1st Priority DDRs, Quad Cities	06/26/87	06/26/87
3. Issue Commentary on Second Level Screening Criteria	07/01/87	07/01/87
4. Complete Second Level Screening of all DDRs, Dresden & Quad Cities (except those included in assessments)	07/10/87	7/10/87
5. Issue Instruction with FSAR/ Operability compliance criteria	07/13/87	07/13/87
6. Revise and Reissue FSAR/Operability Compliance Criteria to Incorporate NRC Comments	07/24/87	07/24/87
7. Complete Formal Assessment of Dresden Models D2.02 and D3.02	08/03/87(R1)	
8. Complete Formal Assessment of Quad Cities Models Q2.04 and Q2.09.01	08/07/87(R1)	
9. Complete Formal Assessment of Dresen Model D3.10	08/17/87	
10. Completion of FSAR Compliance Evaluations	11/09/87	

Commonwealth Edison
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Address Reply to: Post Office Box 767
Chicago, Illinois 60690 - 0767

July 29, 1987

Mr. Thomas E. Murley, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Dresden Station Units 2 and 3
Quad Cities Station Units 1 and 2
NRC Requests for Additional Information
Pertaining to the Embedment Plate
Assessment Program
NRC Docket Nos. 50-237 and 249, 50-254 and 265

Dear Mr. Murley:

In response to a conference call with members of your staff on July 14, 1987 Commonwealth Edison is providing additional information pertaining to the ongoing embedment plate assessment program.

Attached please find the following documents:

1) Table I "Nominal OBE and SSE allowable stresses" which has been revised to correct typographical errors and provide additional information.
2) Additional information concerning the relationship between the test report No. 1960-16 from the Nelson Stud Welding Division of Gregory Industries Incorporated and the strap anchors used at Dresden and Quad Cities.
3) Additional information confirming that the embedment plate bending stress and not the strap anchor pullout capacity is the controlling factor for the embedment plate capacity and a description of the typical design margin available against strap anchor pullout.
4) A discussion regarding the use of the linier action equation for the applied attention and moments.

We believe this information should address the conerns raised by your staff please direct any questions you may have to this department.

Yours very truly,

I. M. Johnson
Nuclear Licensing Administrator

Enclosure

cc: T. Ross - NRR
M. Grotenhuis - NRR
Dresden Resident Inspector
Quad Cities Resident Inspector

3409K

8708200120 870729
PDR ADOCK 05000237
P PDR

Attachment 1

This attachment provides Table 1, "Nominal OBE and SSE Allowable Stresses," which has been revised to correct typographical errors and provide additional information.

TABLE 1 NOMINAL OBE AND SSE ALLOWABLE STRESSES

Element	Type of Stress	OBE			SSE (See Note 1)		
		Stress Magnitude	Source Document		Stress Magnitude	Source Document	
Plate	Bending	0.75 Fy	FSAR AISC SRP	Section 12.1.1.3 1963 specification, Section 1.5.1.4.8 Section 3.8.4	0.95 Fy	FSAR AISC SRP	See Section 12.1.1.3 1.6 x AISC $\leq$ 0.95 Fy Section 3.8.4
	Flexural Shear	0.40 Fy	FSAR AISC SRP	Table 12.1.1 1963 specification, Section 1.5.1.2 Section 3.8.4	0.55 Fy	FSAR AISC SRP	Section 12.1.1.3 1.6 x AISC $\leq$ 0.95 $Fy/\sqrt{3}$ Section 3.8.4
	Bearing On Concrete	0.25 f'_c	FSAR ACI SRP	Table 12.1.1 318-63, Chapter 10, Table 1002 (a) Section 3.8.4	0.60 f'_c	FSAR ACI SRP	Section 12.1.1.3 318-71, Chapter 10 (10.14), $0.85\phi f'_c$, where ϕ = 0.70 Section 3.8.4
Strap Anchor	Axial Tension	0.60 Fy	FSAR AISC SRP	Table 12.1.1 1963 Specification, Section 1.5.1.1 Section 3.8.4	0.95 Fy	FSAR AISC SRP	Section 12.1.1.3 1.6 x AISC $\leq$ 0.95 Fy Section 3.8.4
	Weld	0.30 Fu	FSAR AISC SRP	Section 12.1.1.3 1969 spec. Supplement 3 Table 1.5.3 Section 3.8.4	0.48 Fu	FSAR AISC SRP	Section 12.1.1.3 1.6 x AISC Section 3.8.4
	Bond	$1.42\sqrt{f'_c}$	FSAR ACI SRP	Section 12.1.1.3 318-63, Chapter 18, Load Factor 1.9 Section 3.8.4	$2.70\sqrt{f'_c}$	FSAR ACI SRP	Section 12.1.1.3 318-63, Chapter 18, $9.5\phi\sqrt{f'_c}/2D$ (D = 1.47") Section 3.8.4
	Concrete Cone	$1.80\sqrt{f'_c}$	FSAR ACI SRP	Section 12.1.1.3 318-63, Chapter 17, Load Factor 1.9 Section 3.8.4	$3.40\sqrt{f'_c}$	FSAR ACI SRP	Section 12.1.1.3 318-63, Chapter 17, $4\phi\sqrt{f'_c}$, where ϕ = .85 Section 3.8.4

Note 1: AISC specification does not address SSE loading condition. Industry practice for SSE loads is to use 1.6 x AISC allowable SSE stresses. This is also in agreement with SRP Section 3.8.4. When the 1.6 x AISC value exceeds yield (Fy), 95% of Fy is used as allowable. For shear stress, 95% of $Fy/\sqrt{3}$ is used.

Notation:
Fy - Minimum specified yield strength
Fu - Nominal tensile strength of plate or weld metal
f'_c - Concrete strength

Attachment 2

This attachment provides additional information concerning the relationship between Test Report No. 1960-16 from Nelson Stud Welding Division of Gregory Industries, Inc. and the strap anchors used at Dresden and Quad Cities.

A comparison of tested strap anchor configurations (Report No. 1960-16) and the specified strap anchor configuration at Dresden/Quad Cities is shown in the attached table. Of the various strap sizes tested, the specimens comparable to the Dresden/Quad Cities are 2F8-a and 2F8-b for 1/4"x2" flat bar and 3F8-a and 3F8-b for 3/8"x2" flat bar. These tests bound the 5/16"x2" specified strap size for Dresden/Quad Cities. The steel strengths referenced in the test report correspond to typical A36 steel.

The strap configuration at Dresden/Quad Cities has a higher load capacity than those tested by Nelson for the following reasons:

A. The tested straps have shorter embedment length than that of the Dresden/Quad Cities straps.

B. The tested straps were embedded in concrete with a compressive strength of 3,000 psi. The installed straps are embedded in concrete with a minimum specified strength of either 4,000 psi or 3,500 psi. The actual concrete strengths, considering the age of concrete at Dresden/Quad Cites, are approximately 5,400 psi and 5,000 psi for 4,000 psi and 3,500 psi minimum specified strengths, respectively.

C The tested straps were installed at 90^{0} to the concrete surface where at the Dresden/Quad Cities straps are installed 60^{0} to the concrete surface. The 60^{0} angle permits the participation of concrete bearing stresses on the strap to resist pullout.

Each of the above factors contribute to additional tensile and shear strength.

In addition, the test data indicates that the strap anchor failure modes consist of either necking of the strap anchor or slippage of anchor from the concrete. In other words, the tested strap anchors exhibit ductile behavior which is a very desirable attribute for embedment.

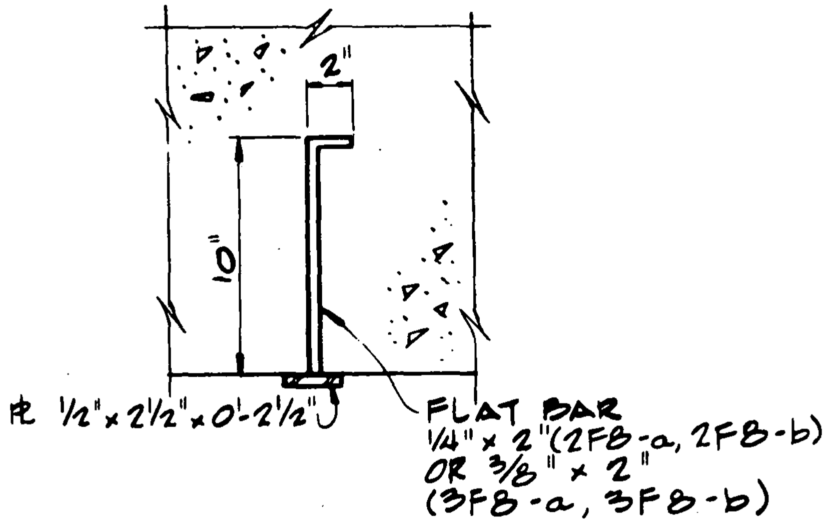
The ultimate pullout strengths reported were 30.0, 25.0, 42.0 and 45.7 kips for specimen numbers 2F8-a, 2F8-b, 3F8-a and 3F8-b respectively. The average of these values is 35.7 kips.

The computed SSE allowable strap tension load for Dresden/Quad Cities strap anchors is 18.1 kips, about half of the 35.7 kips shown to be available for concrete pullout for the Nelson stud welding tests. This 18.1 kip value is based on allowable stresses described in Attachment 1, Table 1, and the backup calculations in Attachment 3.

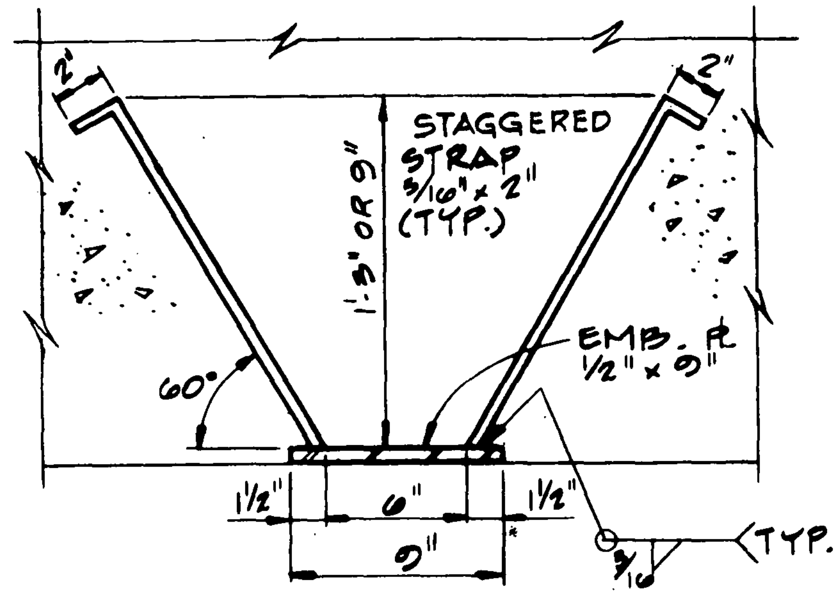
Comparison of Tested Versus Specified Strap Anchors

Specimen Nos. 2F8-a, 2F8-b and 3F8-a, 3F8-b
of
Nelson Stud Welding Division of Gregory Industries, Inc.

Test Report No. 1960-16



Typical Strap Configuration
Dresden/Quad Cities



Material Strengths

Concrete (21 day strength - 3005 PSI): 3000 PSI

Steel (2F8-a, 2F8-b), Yield: 37045 PSI

Steel (3F8-a, 3F8-b), Yield: 37840 PSI

Concrete: f'_c = 4000 and 3500 PSI[1]

Steel: F_y = 36000 PSI (A-36-Steel) [2]

(1) Procurement Specification Nos.
K-2187-Reactor Building
K-2200-Turbine Building

(2) Shop Drawing by Rippel Architectural Metals. Job No. 6682, Item K - Sheet 4

Attachment 3

This attachment provides additional information confirming that the embedment plate bending stress and not the strap anchor pullout capacity is the controlling factor for the embedment plate capacity and a description of the typical design margin available against strap anchor pullout.

The attached figure shows the SSE loading allowable tension loads used in the assessment program. As described in earlier transmittals to the NRC, the SSE allowable load in the exterior region (Location A) of plate for 2-1/2"x2-1/2" attachment size is 3.0 kips and that for the interior region (Location B) of plate is 9.0 kips. These loads correspond to SSE nominal allowable plate bending stresses when the loads are placed at critical locations on the plate to maximize the plate bending effect.

The computed SSE allowable strap tension load is 18.1 kips as shown in the attached calculations. Thus, the SSE allowable tension load for an attachment located just under a strap anchor (Location C) is 18.1 kips.

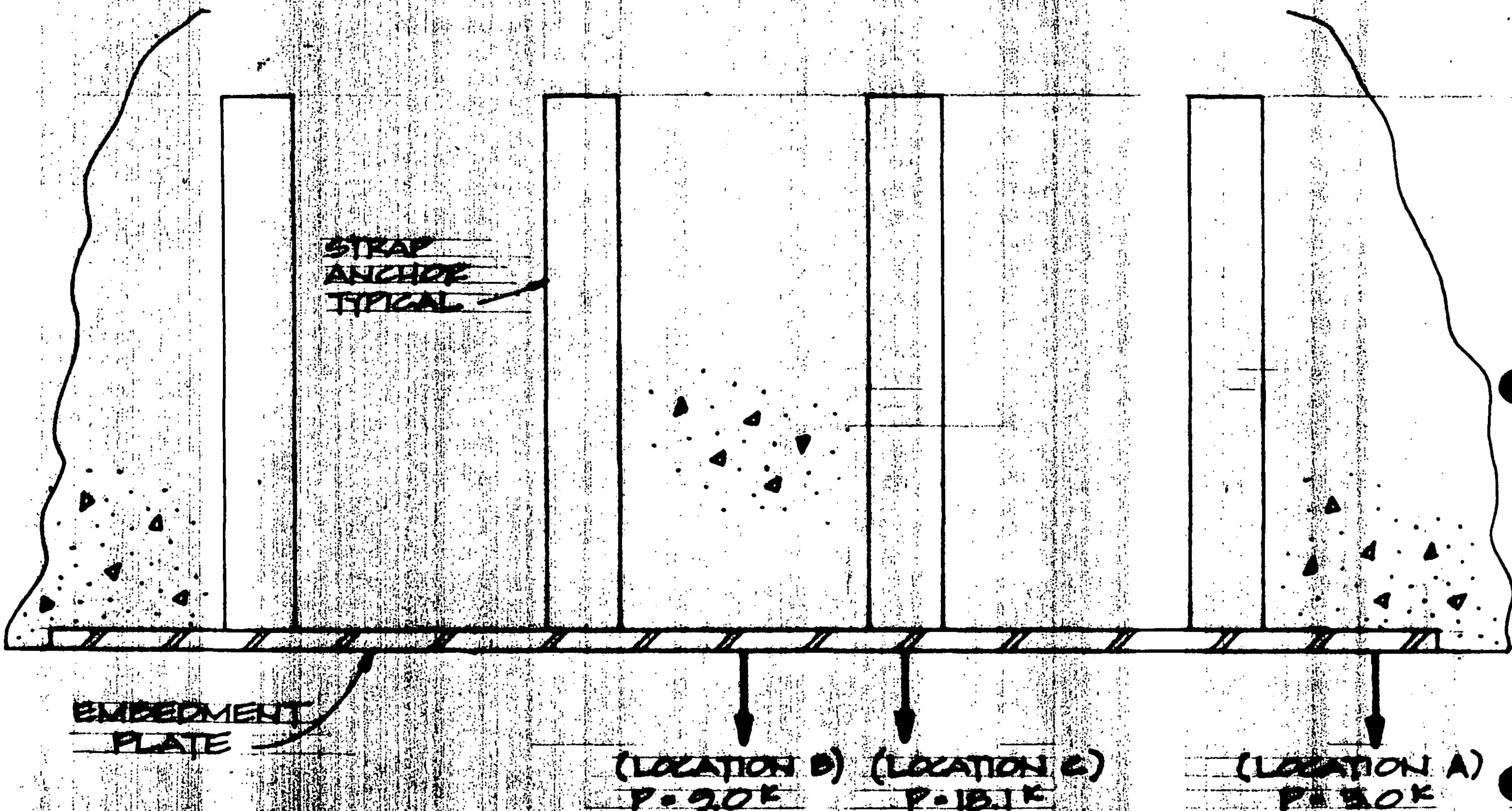
This allowable strap anchor load is two to six times the allowable attachment loads for plate bending. Hence the more controlling factor for the embedment plate load capacity is plate bending and not strap anchor pullout capacity.

It is also important to note that the actual applied attachment tension loads on the majority of the embedment plates are generally much lower than the embedment plate allowable load values. A review of a sample of about 200 pipe hanger attachments indicated that :

a) Ninety percent of hangers attached to interior portion of plate have SSE tension loads less than 80% of the initial SSE screening allowable load (9.0 kips)

b) Sixty-five percent of hangers attached to exterior portion of plate have SSE tension loads less than 80% of the SSE screening allowable loads (3.0 kips)

Thus over 90% of the attachments to embedment plates have applied tension loads below 7.2 kips (80% of allowable SSE screening load). When compared to the 18.1 kip anchor capacity, it is clear that the anchors for these attachments have an added margin of approximately 2.5 times the FSAR allowables.



SSE LOADING

ALLOWABLE TENSION LOADS

(2½" x 2½" ATTACHMENT SIZE)

SARGENT & LUNDY ENGINEERS	Calcs. For STRAP ANCHOR CAPACITIES		Calc. No. 794/DQ.01	
	[X] Safety-Related	[ ] Non-Safety-Related	Rev. ∅	Date
			Page	of

Client Commonwealth Edison Co.		Prepared by A. Shahkarami	Date 7.24.87
Project Dresden/Quad Cities		Reviewed by [signature]	Date 7/24/87
Proj. No. 7941-00	Equip. No.	Approved by [signature]	Date 7-27-87

Purpose:

To determine the anchor capacity for the analysis of the strap anchor embedment plates.

References:

1. DWG. B-260, Rev. G (S&L DWG., DET. K, Dresden)
2. Calc. no. 794/DQ.01.10 Tables 1 & 2 Acceptance criteria.
3. S&L Project structural Design criteria DC-SE-01-DQ REV. 4
4. ANSI/AWS D1.1-84

Form GQ-3.08.1 Rev. 2 SL-7647 10-85 KPS

SARGENT & LUNDY ENGINEERS	Calcs. For STRAP ANCHOR CAPACITIES		Calc. No. 79410a-01	
	X Safety-Related	Non-Safety-Related	Rev. Φ	Date
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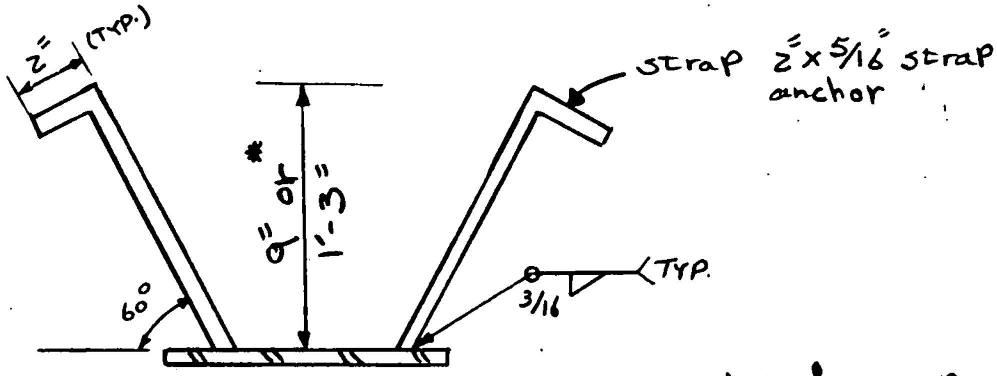
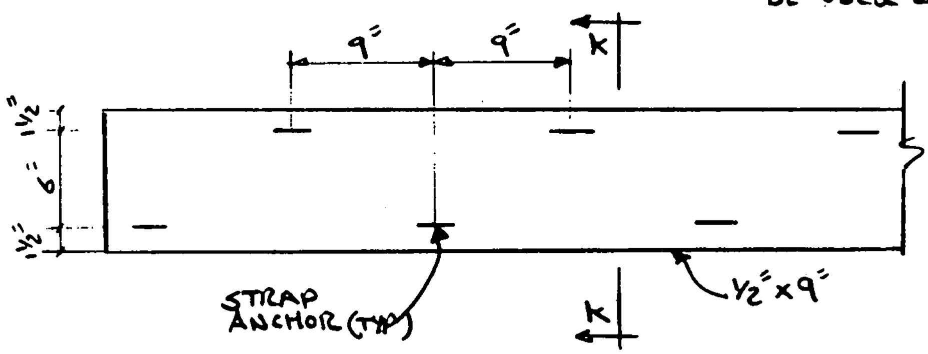
Client Commonwealth Edison Co.		Prepared by A. Shahkaram	Date 7.24.87
Project Dresden / Quad cities		Reviewed by [signature]	Date 7/[illegible]
Proj. No. 7941-00	Equip. No.	Approved by [signature]	Date [illegible]

Sketch :
(Ref. #1)



SECTION k-k

* Majority of straps are 1'-3" However, for Analysis Purpose 9" will be used conservatively.



Material Strengths: (Ref. # 3)

Concrete : $f'_c = 3500$ Psi
Steel : $f_y = 36000$ Psi
weld : $F_U = 60,000$ Psi

SARGENT & LUNDY ENGINEERS

Calcs. For STRAP ANCHOR CAPACITIES		Calc. No. 7941DD.01	
☒ Safety-Related	☐ Non-Safety-Related	Rev. ⌀	Date
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Client Commonwealth Edison Co.		Prepared by A. Shahkarami	Date 7.24.87
Project Dresden / Quad Cities		Reviewed by [illegible]	Date [illegible]
Proj. No. 7941-00	Equip. No.	Approved by [illegible]	Date [illegible]

Analysis:

The capacity of the anchor will be calculated considering four possible failure modes.

A. Weld capacity

B. Anchor capacity

C. Bond + Bearing capacity

d. Concrete cone pullout

SARGENT & LUNDY ENGINEERS	Calcs. For STRAP ANCHOR CAPACITIES	Calc. No. 7941DG-01
	✓ Safety-Related / Non-Safety-Related	Rev. ϕ Date
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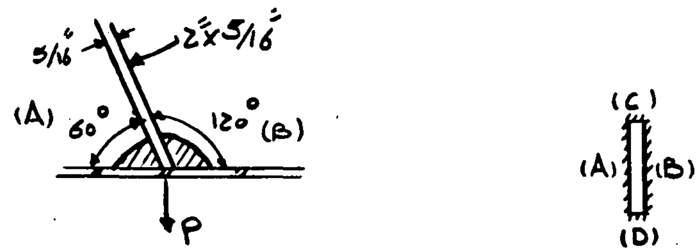
Client Commonwealth Edison Co.	Prepared by A. Shahbaran	Date 7.24.87
Project Dresden/Quad Cities	Reviewed by	Date
Proj. No. 7941-00 Equip. No.	Approved by	Date

Calculation:

A. Weld Capacity



Reference #4 Appendix B Table B.

C = Equivalent fillet weld leg size factor for skewed T-Joints

$60° \leq \psi \leq 135°$ when $\psi = 60°$, $C = 0.71$

$\psi = 120°$, $C = 1.23$

weld (A)

$P_{A\phi BE} = \underline{0.30 F_u} t / C\sqrt{2} = 0.30 (60 \text{ ksi})(3/16") / (0.71)(\sqrt{2})$

$= 3.36 \text{ K/"}$

weld (B)

$P_{(B)\phi BE} = 0.30 (60 \text{ ksi})(3/16") / (1.23)(\sqrt{2}) = 1.94 \text{ K/"}$

weld (C) + (D)

. for analysis purpose half the width of strap will be used for the weld length.

$P_{(C)+(D)\,\phi BE} = 0.3 (60 \text{ ksi})(3/16")(2)/\sqrt{2} = 4.77 \text{ K/"}$

ϕBE weld allowable

$P_{\phi BE} = (3.36 + 1.94)^{\text{K/"}}(2") + 4.77^{\text{K/"}} \left(\frac{5/16"}{2}\right) = 11.3^{\text{KIPS}}$

Form GQ-3.08.1 Rev. 2 BL-F847 10-85 KPS

SARGENT & LUNDY ENGINEERS	Calcs. For STRAP ANCHOR CAPACITIES		Calc. No. 7941DA.01	
	✓ Safety-Related	Non-Safety-Related	Rev. ϕ	Date
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Client Commonwealth Edison Co.	Prepared by A. [illegible]	Date 7.24.87
Project Dresden / Quad Cities	Reviewed by [illegible]	Date 7/24/[illegible]
Proj. No. 7941-00 Equip. No.	Approved by [illegible]	Date 7-27-[illegible]

$$P_{SSE} = \frac{.48\ F_u}{.30\ F_u} P_{\phi BE}$$ { 1.6 (.3 Fu) = .48 Fu }

$$= 1.6\ P_{\phi BE} = 1.6\ (11.3)^{KIPS}$$

$$= 18.1\ KIPS$$

$$P_{upper\ limit} = \frac{0.57\ F_u}{0.30\ F_u} P_{\phi BE}$$ { .95 (0.60 Fu) = 0.57 FU }

$$= 1.9\ P_{\phi BE} = 1.9\ (11.3)^{KIPS}$$

$$= 21.5\ KIPS$$

Allowable weld loads

$P_{\phi BE} = 11.3^{KIPS}$

$P_{SSE} = 18.1^{KIPS}$

$P_{upper\ limit} = 21.5^{KIPS}$

Form GQ-3.08.1 Rev. 2 SL-F847 10-85 KPS

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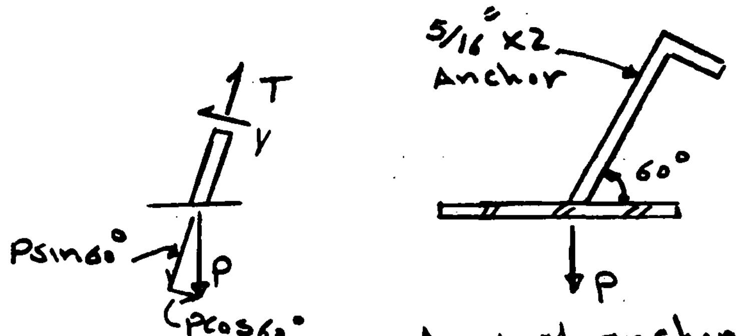
4.

B. Anchor material capacity

The components of applied vertical Load P along and perpendicular to strap anchor are $P\sin 60°$ & $P\cos 60°$ respectively



Area of anchor = $2"(5/16) = .625\ in^2$.

$T_{\phi BE} = P_{\phi BE}\sin 60° = \underline{0.6 F_y A_s} = 0.6(36)(0.625) = 13.5^{KIPS}$

$\therefore P_{\phi BE} = 15.6^{KIPS}$

$T_{SSE} = P_{SSE}\sin 60° = \underline{0.95 F_y A_s} = 0.95(36)(0.625) = 21.4^{KIPS}$

$T_{upper\ limit} = T_{SSE}$

$\therefore P_{SSE} = 24.7^{KIPS}$
$P_{upper\ limit} = 24.7^{KIPS}$

check shear stress

shear force $= V = P\cos 60°$ $\therefore V_{\phi BE} = 7.8^{KIPS}$

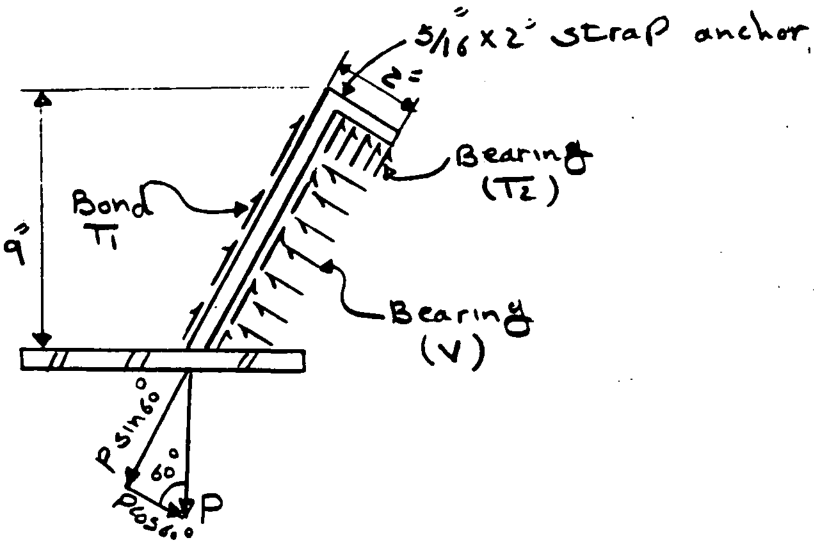
$V_{upper\ limit} = V_{SSE} = 12.35^{KIPS}$

shear stress $f_{v_{\phi BE}} = 7.8^{k}/.625^{in^2} = 12.48^{KSI} < \underline{.4(36)} = 14.4^{KSI}$

$f_{v_{upper\ limit}} = f_{v_{SSE}} = 12.35^{k}/.625^{in^2} = 19.76^{KSI} < \underline{0.55(36)} = 19.8^{KSI}$

7/

C. Bond + Bearing capacity



1. Bond

upper limit & SSE stress $= \phi \frac{9.5\sqrt{f'_c}}{2\,D_{eq}} = 0.85\,\frac{9.5\sqrt{f'_c}}{2(1.47")} = 2.7\sqrt{f'_c}$

ϕBE stress $= \frac{SSE}{1.9} = \frac{2.7\sqrt{f'_c}}{1.9} = 1.42\sqrt{f'_c}$

T_1 = stress x SA

SA = Surface area
= Perimeter x Length

Length $= 9"/\sin 60° = 10.4"$

Perimeter $= 2\,(2" + 5/16") = 4.625"$

D_{eq} = Equivalent diameter
= Perimeter $/\pi = 4.625/\pi = 1.47"$

$SA = 4.625"\,(10.4") = 48.1\ in^2$

upper limit & SSE : $T_1 = 2.7\sqrt{f'_c}\cdot SA = 2.7\sqrt{3500}\,(48.1)/1000 = 7.68$ kips

ϕBE : $T_1 = 1.42\sqrt{f'_c}\cdot SA = 1.42\sqrt{3500}\,(48.1)/1000 = 4.04$ kips

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2. Bearing

ϕBE Bearing stress $= 0.25 f'_c$

SSE & upper limit Bearing stress $= 0.85\phi f'_c$

(where $\phi = 0.70$) $= 0.60 f'_c$

Use increase factor of 2 when $\sqrt{A_2/A_1} \geq 2.0$

$T_{2\,\phi BE} = 0.25 f'_c A (2)$, $A = 2(2 - 5/16) = 3.375 \text{ in}^2$.

$= 0.25(3500^{psi})(3.375^{in^2})(2)/1000 = 5.91^{kips}$

$T_{2\,SSE\,\&\,upper\,limit} = 0.60 f'_c A (2)$

$= 0.60(3500^{psi})(3.375^{in^2})(2)/1000 = 14.18^{kips}$

$T_{\phi BE} = T_1 + T_2 = 4.04^{kips} + 5.91^{kips} = 9.95^{kips}$

$T_{SSE\,\&\,upper\,limit} = T_1 + T_2 = 7.68^{kips} + 14.18 = 21.86^{kips}$

$T_{\phi BE} = P_{\phi BE} \sin 60^\circ$

$P_{\phi BE} = T_{\phi BE}/\sin 60^\circ = 9.95/\sin 60^\circ = 11.5^{kips}$

$P_{SSE} = T_{SSE}/\sin 60^\circ = 21.86/\sin 60^\circ = 25.2^{kips}$

Form GQ-3.08.1 Rev. 2 SL-F647 10-85 KPS

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Determine the length required to develop "$P\cos\theta$" by Bearing V ($P\cos\theta \leqslant V_{all}$)

$\phi BE \Rightarrow P\cos 60 = 11.5^{k} \cos 60 = 5.75$ KIPS

SSE & upper limit $\Rightarrow P\cos 60 = 25.2^{k} \cos 60 = 12.60$ KIPS

allowable: $V_{\phi BE} = 0.25\,(3500)(2'' \times 1'')/1000 = 1.75$ KIPS/inch.

V_{SSE} & upper limit $= 0.60\,(3500)(2'' \times 1'')/1000 = 4.20$ KIPS/inch.

Length required

$\phi BE \Rightarrow 5.75^{KIPS} / 1.75^{KIPS/in} = 3.3''$

$SSE \Rightarrow 12.60^{KIPS} / 4.20^{KIPS/in} = 3.0''$

Allowable loads

$P_{\phi BE} = 11.50$ KIPS

$P_{SSE} = 25.20$ KIPS

$P_{UPPER\ LIMIT} = 25.20$ KIPS

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d. Concrete Cone Pullout

Stress:

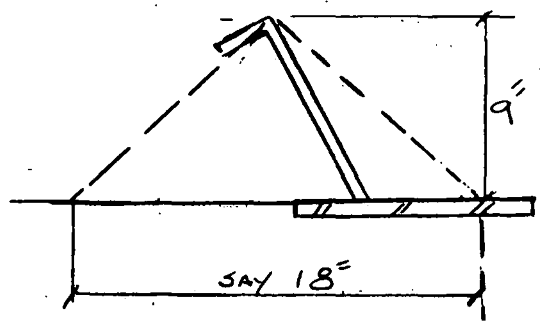
SSE & upper limit. $4\phi\sqrt{f'_c}$ where $\phi = .85$

or $4(.85)\sqrt{f'_c} = 3.4\sqrt{f'_c}$

ϕBE. $\frac{3.4\sqrt{f'_c}}{1.9} = 1.8\sqrt{f'_c}$

P = Stress x Area

Area = $(9")^2\pi = 254\ in^2$



$P_{\phi BE} = 1.8\sqrt{3500_{psi}}\,(254)/1000$

$= 27.0$ KIPS

P_{SSE} & $P_{upper\ limit} = 3.4\sqrt{3500_{psi}}\,(254)/1000$

$= 51.1$ KIPS

Allowable loads

$P_{\phi BE} = 27.0$ KIPS

$P_{SSE} = 51.1$ KIPS

$P_{upper\ limit} = 51.1$ KIPS

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SUMMARY OF RESULTS

FAILURE MODE	ALLOWABLE TENSION (KIPS)		
	ϕBE	SSE	UPPER LIMIT
WELD	11.3	18.1	21.5
ANCHOR	15.6	24.7	24.7
BOND + BEARING	11.5	25.2	25.2
CONE PULLOUT	27.0	51.1	51.1
GOVERNING	11.3	18.1	21.4

Attachment 4

This attachment provides a discussion regarding the use of the linear interaction equation for the applied tension and moments.

The 1969 AISC Specification Part 1 allowable stress design formulas 1.6-1a, 1.6-1b and 1.6-2 for checking the effects of combined axial load and bending are conservative linear interaction expressions for members in the elastic range. The origin of the expressions is, however, the result of numerous analytical and experimental investigations in which limiting combinations of axial force and bending moments were determined. Since the equations are intended for use in the design of beam-columns in the linear range, the straight forward conversion of the basic force-moment relationships to stress formulations was performed. The stress formulation renders the interaction equations in a format consistent with the balance of the AISC specification requirements.

For the embedment plates, the effects of combined loads on a plate structure are being examined; for loads normal to the surface and concentrated moments applied about axes in the plane of the plate. Both applied loadings result in flexural stresses in the plate. Yield line analysis was performed on several sets of force and moment values, and it was shown that a linear interaction would produce conservative results (Attachment 2, mid-May transmittal). To the extent that the AISC equations are also linear, it is clear that load interaction expression employed in this work is similar. Therefore, when evaluating the combined effects of loads on embedment plates, the application of a force-moment expression is appropriate and consistent with the essence of the AISC stress interaction expressions.

Attachment 1 to the mid-May transmittal to the NRC described the applicability and use of this interaction equation for the embedment plate assessment. The attachment describes the two-step approach utilized to assess and screen the attachments to embedment plates as follows:

1. The first step is to initially screen the attachments using the conservative P-M interaction equation. Allowables for P and M correspond to nominal stresses in the elastic range as required by the FSAR commitments.

2. The attachments exceeding the first step screening criteria were analyzed using detailed finite element analysis (FEM) with the normal load and two moments applied simultaneously to the plate being assessed. The results are evaluated against the embedment plate criteria. The use of the interaction equations, therefore, is not required for these embedment plates.

Additional details of the application of the two steps outlined above follow. Attachment 4 to the mid-May transmittal provided a flow chart and sample calculations for the assessment of a typical plate. The two step approach described above related to the embedment plate assessment work as follows:

Step 1: The conservative P-M interaction equations which sum ratios of actual to allowable loads are used in the first three phases. These phases can be characterized by the following:

Phase 1: Pre walkdown, using 2-1/2"x2-1/2" attachment size generic allowable loads.

Phase 2: Pre walkdown, using appropriate attachment size generic allowable loads.

Phase 3: Post walkdown, using appropriate attachment size and actual attachment location (relative to plate edges) allowable loads.

Step 2: The detailed FEM analysis is utilized only for those attachments which do not pass the conservative linear P-M interactions of the Step 1 screening. This phase can be characterized by the following:

Phase 4: Post walkdown, post ultrasonic testing, using appropriate strap and attachment locations.