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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION TITLE PAGE

A 2010 64 (FRONT)

CLIENT & PROJECT TEXAS UTILITIES GENERATING CO. /COMANCHE PEAK SES - UNIT NO.2	PAGE 1 TOTAL NO. OF PAGES=150
CALCULATION TITLE (Indicative of the Objective): PIPE SUPPORT DEVELOPMENT OF THE METHOD FOR EVALUATING LOCAL STRESS IN PIPE SUPPORT MEMBERS	SEISMIC CATEGORY (✓) ☒ I - NUCLEAR SAFETY RELATED ☐ II - NON-NUCLEAR SAFETY RELATED

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O NO.	DIVISION & GROUP	CURRENT CALC. NO.	OPTIONAL WORK PACKAGE NO.
15454	NZ(c)-	6E11X - 023	

PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)	REV. NO. OR NEW CALC NO.	SUPERSEDES CALC. NO OR REV. NO.	CONFIRMATION REQUIRED (✓) YES	NO
L. Rozinsky /3-25-86 C.L. Lin 3/25/86	C. L. Lin 3/31/86 L. ROZINSKY /3-31-86	F. Lee 4/18/86 (F. LEE)	0			✓
APPROVAL: F.L. Oglen 4/18/86						
L. ROSINSKY 4-3-86	Kawai R. Ho 5-5-86	F. Lee 5/6/86	1	0		✓
APPROVAL: F.L. Oglen 5/10/86						
Keith Powers 8-12-86	Kawai R. Ho 8-28-86	Kawai R. Ho 8-28-86	2	1		✓
APPROVAL:						
APPROVAL:						
APPROVAL:						
APPROVAL:						

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REVISION STATUS TABLE

REV NO.	PAGE NO.	DESCRIPTION/REASON
0		ORIGINAL
1	1	REV. NO, TOTAL PAGES NUMBER CHANGED.
	6, 7, 10, 11	DATE OF AWS CODE PUBLISHING CHANGED.
	8A	ADDED NEW PAGE.
	14-106	ALL PAGES RENUMBERED.
	36, 37, 38 38, 40	0.4Fy UPPER LIMIT FOR ALLOWABLE SHEAR STRESS ADDED FOR ALL CASES
	45-50	THESE PAGES REPLACED OLD TABLES ON ATTACHMENT 'A1' P 1.17-1.21
	70-74	THESE PAGES REPLACED OLD TABLES ON ATTACHMENT 'A1' P 1.23-TO 1.27
		SEE PG. 8A FOR REASON OF THIS REVISION.
2		REVISION MADE DUE TO REASONS STATED IN "DISCUSSION" SECTION OF THIS CALCULATION, (SEE P. 86)
	1, 2 -	REVISE TOTAL NUMBER OF PAGES
	4 -	ADD NOTE TO OBJECTIVE TABLE FOR LUG-TO-TUBE STEEL MEMBER CAPACITIES.
	34 -	ADD NEW FIG 4-13A SHOWING CURVES FOR VALUES OF β LESS THAN .4
	31 -	ADD TABULATION FOR VALUES OF δ FOR β LESS THAN .4
	36 -	ADD REFERENCE NOTE
	84, 86, 87	REVISE WASHER PLATE EVALUATION PROCEDURE; ADD NOTES FOR CLARIFICATION
	39a, 39b -	ADD ANALYSIS & EVALUATION OF CODE INTERPRETATION PER "DISCUSSION" FOR VARIOUS GEOMETRIES.
	44-50 -	REPLACE TABLES 4-13.4A - 4-13.4G FOR NEW WORST CASE BRACKET SIZES AS SHOWN ON EACH TABLE (OLD TABLES ADDED AS ATTACHMENT A2)
	43 -	ADD NOTE REGARDING OLD TABLES.
	52-53, 53a, 53b	REVISED DESIGN PROCEDURE TO FOLLOW NEW CODE INTERPRETATION
	54-63	REVISE TABLES 4.13.5A - 4-13.6 TO INCLUDE β = .85 VALUES
	ATTACH A2 ATTACH A3	ADD SUPERSEDED TABLES AND TELECON AS ATTACHMENTS

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Objective

The objective of this calculation is to provide a generic procedure for evaluating local stresses in the pipe support members. Topics covered in this calculation include:

1. Tube steel to tube steel connections.
2. Rear bracket to tube steel connections
3. Rear bracket to tube steel end plate connections.
4. Web crippling of I-shape member & tube steel.
5. Flange bending of I-shape member.
6. U-bolt nuts bearing against washer plate/tube steel chord.
7. EFFECT OF THE MAIN MEMBER EDGE DISTANCE ON THE JOINT LOCAL STRESS.
8. LUG-TO-TUBE STEEL CAPACITIES

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Assumptions

See analysis section for the assumptions used for each topic addressed in the objective.

Method

For topics such as tube-to-tube connection and rear bracket to tube, formulas listed in Section 10.5 of AWS D1.1-80 were used to check the punching shear effects, and alternately actual weld tensile force at the connection joint was calculated and checked against the tube wall shearing and crippling capacity.

For bracket to tube end plate, case 1c of Table 26 of Roark's "Formulas for Stress and Strain" was used to find the required plate thickness.

Flange and web of I-shape member were addressed and simplified formulas were provided to assess their adequacy.

Washer plate and/or tube wall with U-bolt nuts bearing against it were qualified by assuming simple plate bending loaded with two concentrated loads at each side of the bolt hole.

THE BUCKLING CAPACITY OF THE TUBE SECTION WALL WAS USED IN DETERMINING THE LUG-TO-TUBE STEEL CAPACITIES.

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Sources of Data / Equations

1. American welding society structural welding code, AWS D1.1-80
2. P.W. Marshall and A.A. Toprac, "Basis of Tubular Joint Design," Welding Research Supplement, May 1974.
3. "Manual of Steel Construction," AISC 7th edition
4. R. J. Roark and W. C. Young, "Formulas for Stress and Strain." 5th edition.
5. Component Support Certified Design Report Summaries, NPS Industries, Inc. 1981
6. J. Wardenier, "Hollow Section Joints," Delft University Press, the Netherlands, 1982

Equations were identified in the body of the calculation in the appropriate topic section.

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Conclusions

Based on the analysis carried out in this calculation, various tables accompanied with examples AND explanations were presented. They can be used as a guide when evaluating local stresses in the pipe support designs.

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DISCUSSION.

REVISION "O" OF THIS CALCULATION WAS BASED ON INTERPRETATION OF AWS CODE AND FORMULAS GIVEN IN APPENDIX "A" OF "TUBULAR STEEL STRUCTURES – THEORY AND DESIGN" BY H.C. TROITSKY, D. SC.

BUT AFTER CONVERSATION WITH O.W. BLODGETT, THE DECISION WAS MADE IN ORDER TO BE CONSERVATIVE TO INCORPORATE UPPER LIMIT OF $0.4 F_Y$ FOR ALLOWABLE SHEAR STRESS FOR ALL TYPE OF TUBE CONNECTINS INCLUDING THOSE WITH $0.8 < \beta \leq 1.0$ ($\beta = \frac{b}{D}$ SEE PG. 9)

THE ABOVE CHANGES ARE INCORPORATED IN REV. 1 OF THIS CALCULATION AND ATT. 4-13 OF CPPP-7 REV. 2.

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REF.

DISCUSSION - REASONS FOR REVISION 2

SEE ATTACH 3

1.) PER TELECON WITH P. MARSHALL, STRICT INTERPRETATION OF THE 1985 AWS CODE SECTION 10.5 REQUIRES ADDITIONAL CAPACITY CHECK FOR STEPPED TUBE CONNECTIONS FOR $.8 < \beta < 1.0$. THE JOINT CAPACITY IS LIMITED ~~BY~~ THE LESSER OF EQUATIONS IN SECT. 10.5.1 AND 10.5.1.3. THE VALUES FOR EACH ARE CALCULATED ON PAGES 39a-39b FOR VARIOUS GEOMETRY CONDITIONS. THE RESULTS ARE TABULATED AND REDUCTION FACTORS ESTABLISHED WHERE APPLICABLE.

2.) FACTORS FOR THE REDUCTION OF ALLOWABLE STRESS CAPACITY DUE TO EDGE DISTANCE FOR $\beta = .4$ TO .1 ARE PROVIDED. (PAGE 34)

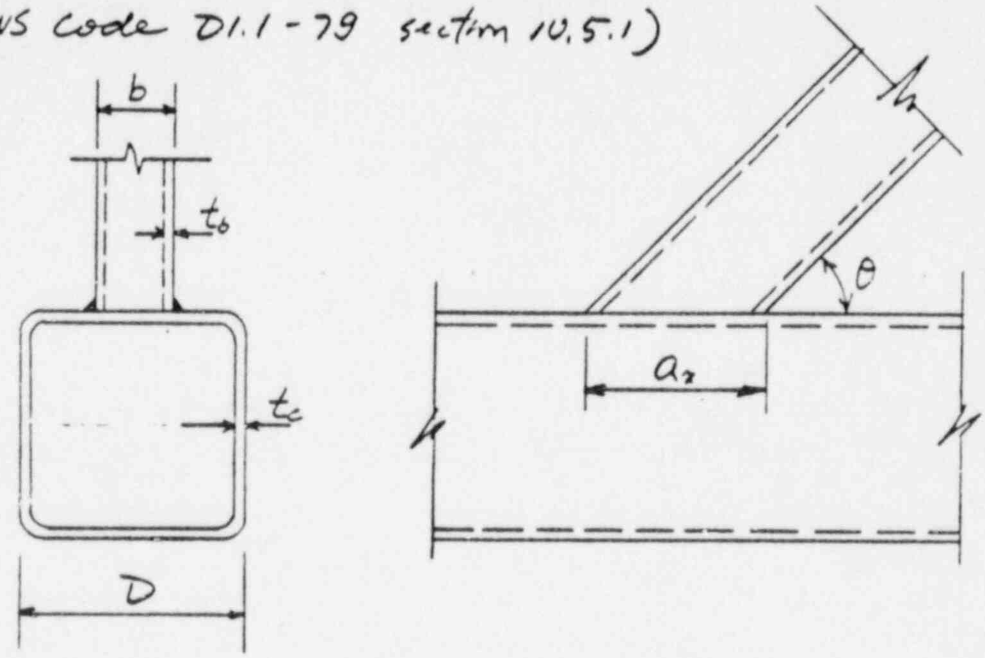
3.) ABSOLUTE WORST CASE REAR BRACKET SIZES WERE NOT CONSIDERED IN PREVIOUS REVISIONS OF THIS CALCULATION. (PAGES 44 TO 60)

4.) ALLOWABLE LOADING FOR LUG-TO-TUBE STEEL MEMBERS IS CALCULATED ON PAGE 107.

ANALYSIS

1. Tube steel to tube steel Connections

(AWS code D1.1-79 section 10.5.1)



PARAMETERS:

$$\beta = \frac{b}{D} \qquad \zeta = \frac{a_x}{D}$$

$$\gamma = \frac{D}{2t_c}$$

$$\tau = \frac{t_b}{t_c}$$

From AWS Code D1.1-80
Section 10.5.1

Punching shear stress on the potential failure surface:

$$\text{acting } V_p = \tau\left[\frac{f_a \sin\theta}{K_a} + \frac{f_b}{K_b}\right]$$

Acting V_p shall be less than the following allowables:

(1) $0.4 F_y$
(2) allowable $V_p = Q_\beta \cdot Q_f \cdot (\text{basic } V_p)$

less of (1) or (2)

Where

f_a, f_b are nominal axial and nominal bending stresses respectively in a branch member.

K_a, K_b are relative length and section factors

$\text{basic } V_p = \dfrac{F_y}{0.6\,\gamma}$ $\quad F_y = 36{,}000 \text{ PSI} < \frac{2}{3} F_u$

Q_β : Geometry modifier $= \dfrac{0.25}{\beta(1-\beta)}$ for $\beta > 0.5$

$= 1.0$ for $\beta \le 0.5$

Q_f : Stress interaction term $= 1.22 - 0.5U$ for $U > 0.44$

$= 1.0$ for $U \le 0.44$

U : ratio $= (f_a + f_b)/0.6F_y$ of main member

K_a, K_b FOR VARIOUS ANGLE θ (per AWS D1.1-80 Section 10.5.1)

θ	30°	45°	60°
K_a	1.5	1.20	1.1
K_b	2.5	1.57	1.2
$\frac{\sin\theta}{K_a}$	0.33	0.59	0.79
$\frac{1}{K_b}$	0.40	0.64	0.83

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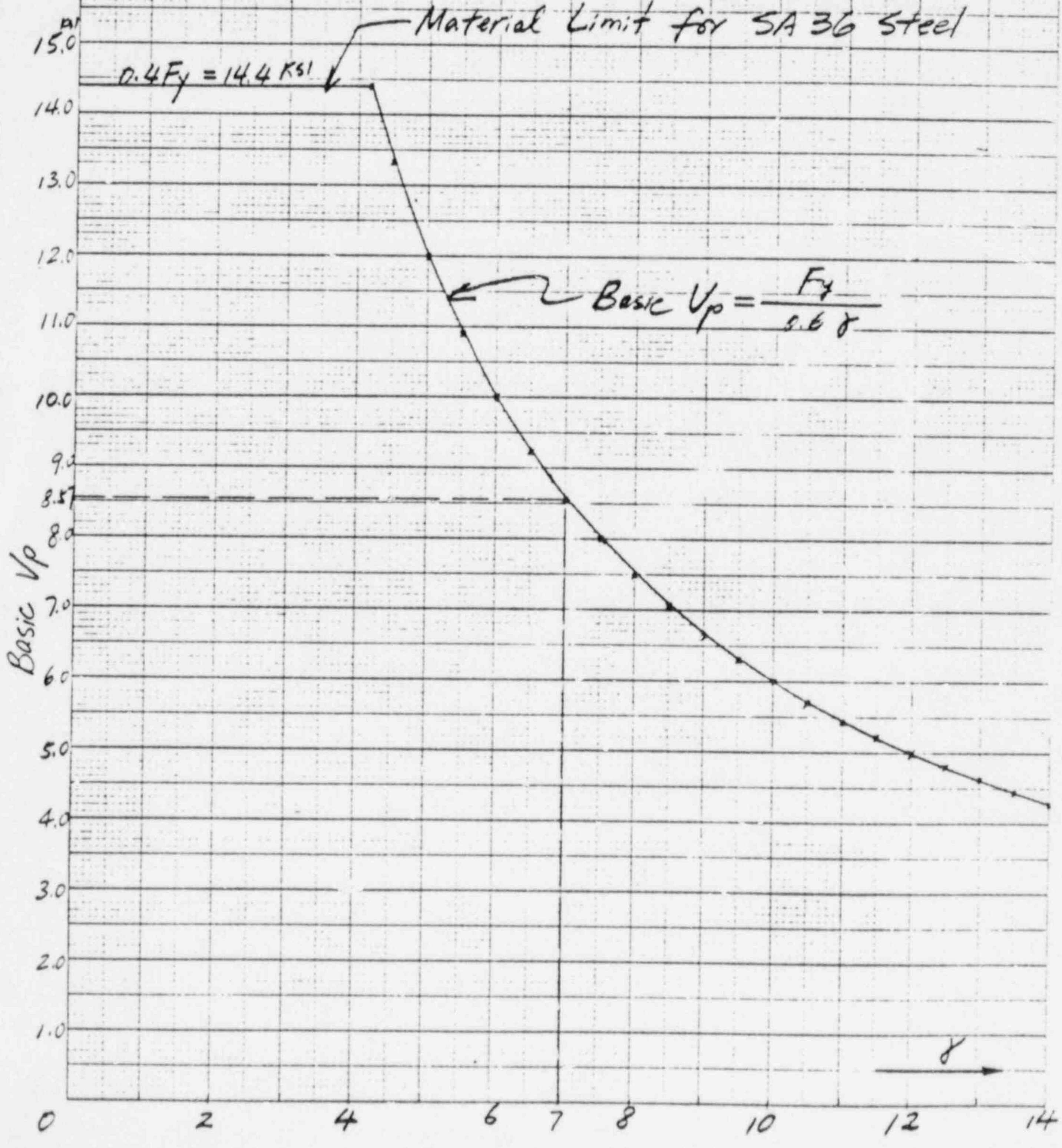
$$\gamma = \frac{D}{2t_c}$$

TUBE SIZE \ THICKNESS INCH	3/16	1/4	5/16	3/8	1/2	5/8
TS 3×3	8	6	4.8	—	—	—
TS 4×4	10.7	8	6.4	5.3	4.0	—
TS 5×5	13.3	10	8.0	6.7	5.0	—
TS 6×6	16.0	12	9.6	8.0	6.0	—
TS 8×8	—	16	12.8	10.7	8.0	6.4
TS 10×10	—	—	16.0	13.3	10.0	8.0
TS 12×12	—	—	—	16.0	12.0	—


Material Limit for SA 36 Steel
0.4Fy = 14.4 KSI
Basic $V_p = \frac{F_y}{2.6\,\gamma}$
Basic Vp
γ
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.57
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
2
4
6
7
8
10
12
14

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Source of data

1A.

Punching Shear for Stepped Tube Connection ($\beta < 0.8$)

(welded all-around, Results shown in Tables 4.13.1A ~ 4.13.1J)

How tabulated values were established?

Example: TS 7×7×5/16 Branch member connects to TS 10×10×5/16 @ angle of 45°

Solution: $\beta = \frac{7}{10} = 0.7$, $Q_\beta = \frac{0.25}{\beta(1.7\beta)} = 1.19$

1 $\gamma = \frac{10}{2 \times 0.3125} = 16$, Basic $V_p = \frac{F_y}{0.6\gamma}$

$\tau = 1.0$ $= \frac{36000}{0.6 \times 16} = 3750^{psi}$

Assume that the ratio of actual normal stress to the allowable normal stress for the branch and main member are the same.

$Q_\beta \theta_f \cdot$ Basic $V_p = 1.0 \times 1.19 \times 3750$

$= 4463^{psi} < 0.4 F_y = 14400^{psi}$

Acting $V_p = \tau \left[\frac{f_a \sin\theta}{K_a} + \frac{f_b}{K_b} \right]$

$= \tau [f_a + f_b][K]$ K = larger of $\frac{\sin\theta}{K_a}$ or $\frac{1}{K_b}$

$\frac{\text{Acting } V_p}{\text{Allowable}} = \frac{[f_a + f_b][K]}{4463} \leq 1.0$

or $f_a + f_b = \frac{4463}{K} = \frac{4463}{0.64} = 6973^{psi}$

$U_1 = \frac{6973}{0.6 \times 36000} = 0.32 < 0.44$ $\therefore Q_f = 1.0$ o.k.

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Source of data

EXAMPLE: TS 3 × 3 × 5/16 BRANCH MEMBER CONNECTS TO TS 5 × 5 × 5/16 @ ANGLE OF 45°

SOLUTION: $\beta = \frac{3}{5} = 0.6$ $Q_\beta = \frac{0.25}{\beta(1-\beta)} = \frac{0.25}{0.6(1-0.6)} = 1.04$

$\gamma = \frac{5}{2 \times 0.3125} = 8$ Basic $V_p = \frac{F_y}{0.6\gamma}$

$= \frac{36000}{0.6 \times 8} = 7500$ psi

$\tau = \frac{5/16}{5/16} = 1.0$

1

LET $U = 0.53$ THEN $Q_f = 1.22 - 0.5 \times 0.53 = 0.955$

$Q_\beta \cdot Q_f \cdot \text{Basic } V_p = 1.04 \times 0.955 \times 7500$

$= 7449$ psi

Acting $V_p = \tau\left[\frac{f_a \sin\theta}{K_a} + \frac{f_b}{K_b}\right]$

$= (f_a + f_b)(K)$ K = greater of $\frac{\sin\theta}{K_a}$ or $\frac{1}{K_b}$

$\frac{\text{Acting } V_p}{\text{Allowable } V_p} = \frac{(f_a + f_b)(K)}{Q_\beta \cdot Q_f \cdot \text{Basic } V_p} \leq 1.0$

$= \frac{(f_a + f_b)(K)}{7449} \leq 1.0$

or $(f_a + f_b) = \frac{7449}{K} = \frac{7449}{0.64} = 11639$ psi

$U = \frac{11639}{0.6 \times 36000} = 0.538 \approx U = 0.53$ (SHOWN IN THE TABLE)

$\therefore Q_f = 0.955$ OK

Tables 4-13.1A ~ 1J are to be used for stepped tube Connections ($\beta<0.8$) with all around weld.

TABLE 4-13.1A

$\gamma = 16$ Basic $V_p = 3750^{psi}$

	RATIO OF ACTUAL NORMAL STRESS TO ALLOWABLE STRESS IN THE MAIN & BRANCH MEMBER AT THE PT. OF CONSIDERATION, U_1							
	$\beta =$	0.50	0.55	0.60	0.65	0.70	0.75	0.80
	$Q_\beta =$	1.0	1.01	1.04	1.10	1.19	1.33	1.5625
	$Q_\beta \cdot Basic V_p =$	3750	3788	3900	4125	4463	4988	5859
ANGLE BETWEEN BRANCH MEMBER AND CHORD MEMBER θ, degree	90°	.17	.17	.18	.19	.21	.23	.27
	60°	.20	.21	.21	.23	.24	.27	.32
	45°	.27	.27	.28	.29	.32	.36	.42
	30°	.43	.43	.45	.46	.50	.54	.61

NOTES:

1. $t_b \leq t_c$
2. Joint is of all-round weld
3. No local failure exists if calculated ratio of normal stress to the allowable normal stress of both branch & main member is less than the tabulated value above.

TABLE 4-13.1B

$\gamma = 13.5$ Basic V_p = 4,444 PSI

	RATIO OF ACTUAL NORMAL STRESS TO ALLOWABLE STRESS IN THE MAIN & BRANCH MEMBER AT THE PT. OF CONSIDERATION, U							
	β =	0.50	0.55	0.60	0.65	0.70	0.75	0.80
	Q_β =	1.0	1.01	1.04	1.10	1.19	1.33	1.5625
	$Q_\beta \cdot$ Basic V_p =	4,444 PSI	4,488 PSI	4,621 PSI	4,888 PSI	5,288 PSI	5,910 PSI	6,943 PSI
ANGLE BETWEEN BRANCH MEMBER AND CHORD MEMBER θ, degree	90°	.20	.20	.21	.22	.24	.27	.32
	60°	.24	.24	.25	.26	.29	.32	.38
	45°	.31	.31	.32	.34	.37	.42	.48
	30°	.48	.49	.50	.53	.56	.61	.69

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TABLE 4-13.1C

$\gamma = 12$ Basic V_p = 5,000 PSI

	RATIO OF ACTUAL NORMAL STRESS TO ALLOWABLE STRESS IN THE MAIN & BRANCH MEMBER AT THE PT. OF CONSIDERATION, U							
	β =	0.50	0.55	0.60	0.65	0.70	0.75	0.80
	Q_β =	1.0	1.01	1.0[illegible]	1.10	1.19	1.33	1.5625
	$Q_\beta \cdot$ Basic V_p =	5,000 PSI	5,050 PSI	5,200 PSI	5,500 PSI	5950 PSI	6,650 PSI	7812 PSI
ANGLE BETWEEN BRANCH MEMBER AND CHORD MEMBER θ, degree	90°	.23	.23	.24	.25	.27	.30	.35
	60°	.27	.27	.28	.30	.32	.36	.43
	45°	.35	.35	.37	.39	.42	.47	.53
	30°	.53	.54	.55	.58	.61	.66	.75

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TABLE 4-13.1D

$\gamma = 11$ Basic V_p = 5,454 PSI

RATIO OF ACTUAL NORMAL STRESS TO ALLOWABLE STRESS IN THE MAIN & BRANCH MEMBER AT THE PT. OF CONSIDERATION, U_1								
	β =	0.50	0.55	0.60	0.65	0.70	0.75	0.80
	Q_β =	1.0	1.01	1.04	1.10	1.19	1.33	1.5625
	$Q_\beta \cdot$ Basic V_p =	5,454 PSI	5,508 PSI	5672 PSI	5,999 PSI	6490 PSI	7254 PSI	8522 PSI
ANGLE BETWEEN BRANCH MEMBER AND CHORD MEMBER θ, degree	90°	.25	.25	.26	.27	.30	.33	.39
	60°	.30	.30	.31	.33	.35	.40	.46
	45°	.39	.39	.40	.43	.46	.50	.57
	30°	.57	.58	.60	.62	.66	.70	.80

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TABLE 4-13.1E

$\gamma = 10$ Basic V_p = 6,000 psi

RATIO OF ACTUAL NORMAL STRESS TO ALLOWABLE STRESS IN THE MAIN & BRANCH MEMBER AT THE PT. OF CONSIDERATION, U								
	β =	0.50	0.55	0.60	0.65	0.70	0.75	0.80
	Q_β =	1.0	1.01	1.04	1.10	1.19	1.33	1.5625
	$Q_\beta \cdot$ Basic V_p =	6,000 psi	6,060 psi	6,240 psi	6,600 psi	7,140 psi	7,980 psi	9375 psi
ANGLE BETWEEN BRANCH MEMBER AND CHORD MEMBER θ, degree	90°	.28	.28	.29	.30	.33	.37	.43
	60°	.33	.33	.35	.36	.39	.44	.50
	45°	.41	.42	.43	.44	.50	.53	.60
	30°	.60	.63	.64	.67	.70	.75	.82

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TABLE 4-13.1F

$\gamma = 9$ Basic $U_p = 6{,}666$ PSI

		RATIO OF ACTUAL NORMAL STRESS TO ALLOWABLE STRESS IN THE MAIN & BRANCH MEMBER AT THE PT. OF CONSIDERATION, U_1						
	$\beta =$	0.50	0.55	0.60	0.65	0.70	0.75	0.80
	$Q_\beta =$	1.0	1.01	1.04	1.10	1.19	1.33	1.5625
	$Q_\beta \cdot$ Basic $U_p =$	6,666	6,732	6,932	7,332	7,932	8,866	10,415
ANGLE BETWEEN BRANCH MEMBER AND CHORD MEMBER θ, degree	90°	.30	.31	.32	.33	.36	.40	.47
	60°	.37	.37	.38	.40	.44	.48	.54
	45°	.47	.47	.48	.50	.54	.59	.66
	30°	.67	.68	.69	.71	.76	.80	.90

TABLE 4-13.1G

$\gamma = 8$ Basic $V_p = 7500$ psi

		RATIO OF ACTUAL NORMAL STRESS TO ALLOWABLE STRESS IN THE MAIN & BRANCH MEMBER AT THE PT. OF CONSIDERATION, U						
	β =	0.50	0.55	0.60	0.65	0.70	0.75	0.80
	Q_β =	1.0	1.01	1.04	1.10	1.19	1.33	1.5625
	$Q_\beta \cdot$ Basic V_p =	7500	7575	7800	8250	8925	9975	11718
ANGLE BETWEEN BRANCH MEMBER AND CHORD MEMBER θ, degree	90°	.34	.35	.36	.38	.41	.45	.51
	60°	.41	.42	.43	.45	.48	.53	.60
	45°	.51	.52	.53	.55	.59	.64	.72
	30°	.73	.74	.75	.78	.82	.88	.98

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TABLE 4-13.1H

$\gamma = 7$ Basic $V_p = 8571$ psi

RATIO OF ACTUAL NORMAL STRESS TO ALLOWABLE STRESS IN THE MAIN & BRANCH MEMBER AT THE PT. OF CONSIDERATION, U								
	$\beta =$	0.50	0.55	0.60	0.65	0.70	0.75	0.80
	$Q_\beta =$	1.0	1.01	1.04	1.10	1.19	1.33	1.5625
	$Q_\beta \cdot$ Basic $V_p =$	8,571 psi	8,656	8,913	9,428	10,199	11,399	13,392
ANGLE BETWEEN BRANCH MEMBER AND CHORD MEMBER θ, degree	90°	.39	.40	.41	.43	.46	.50	.55
	60°	.46	.47	.48	.50	.53	.57	.65
	45°	.57	.58	.59	.61	.65	.71	.77
	30°	.80	.81	.82	.85	.90	.95	1.00

TABLE 4-13.1I

$\gamma = 6$ Basic V_p = 10,000 psi

		RATIO OF ACTUAL NORMAL STRESS TO ALLOWABLE STRESS IN THE MAIN & BRANCH MEMBER AT THE PT. OF CONSIDERATION, U						
	β =	0.50	0.55	0.60	0.65	0.70	0.75	0.80
	Q_β =	1.0	1.01	1.04	1.10	1.19	1.33	1.5625
	$Q_\beta \cdot$ Basic V_p =	10,000	10,100	10,400	11,000	11,900	13,300	14,400
ANGLE BETWEEN BRANCH MEMBER AND CHORD MEMBER θ, degree	90°	.45	.46	.47	.48	.51	.57	.60
	60°	.52	.53	.54	.55	.60	.65	.69
	45°	.64	.65	.66	.68	.72	.77	.82
	30°	.88	.89	.91	.94	.98	1.00	1.00

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CALCULATION SHEET

5010.65

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TABLE 4-13.1J

$\gamma = 5$ Basic $V_p = 12{,}000$ psi

	RATIO OF ACTUAL NORMAL STRESS TO ALLOWABLE STRESS IN THE MAIN & BRANCH MEMBER AT THE PT. OF CONSIDERATION, U							
	$\beta =$	0.50	0.55	0.60	0.65	0.70	0.75	0.80
	$Q_\beta =$	1.0	1.01	1.04	1.10	1.19	1.33	1.5625
	$Q_\beta \cdot$ Basic $V_p =$	12,000	12,120	12,480	13,200	14,280	14,400	14,400
ANGLE BETWEEN BRANCH MEMBER AND CHORD MEMBER θ, degree	90°	.52	.53	.54	.56	.60	.60	.60
	60°	.60	.61	.62	.65	.69	.69	.69
	45°	.73	.74	.75	.78	.83	.83	.83
	30°	.99	1.00	1.00	1.00	1.00	1.00	1.00

REF

Effect of Main Member Edge distance On The Joint Local Stress

6 In general, yield line model for a chord face failure of T-joint is shown below:

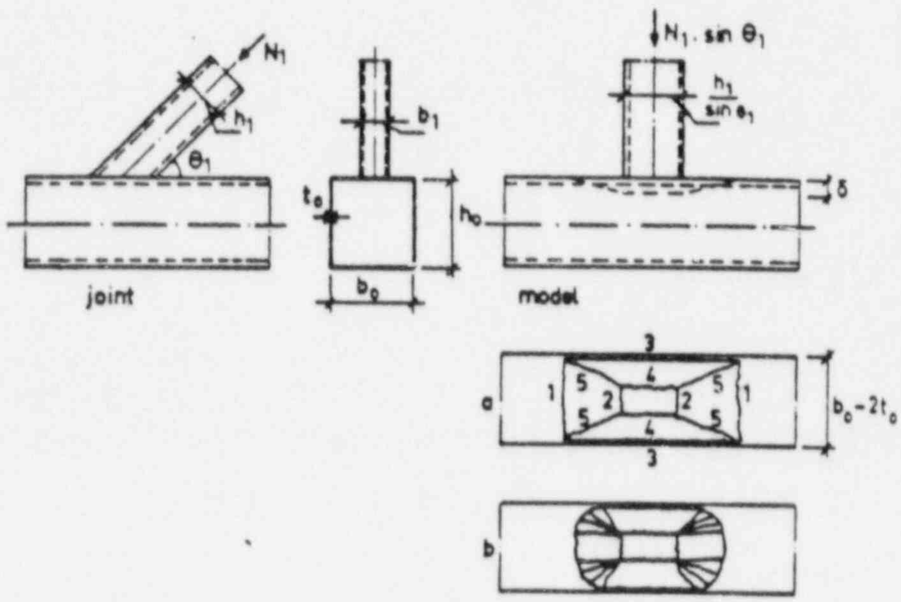

Fig. V-2. Yield line model for a T-, Y- and X-joint. (chord face failure).

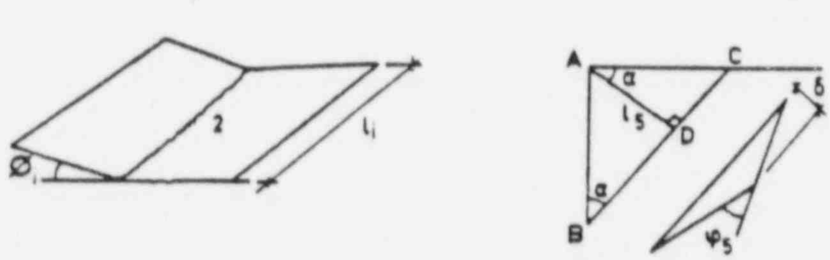

Fig. V-3. Yield lines 2 and 5.

REF

The energy participated in the yield lines is given by

6 $E_d = \sum l_i \cdot \phi_i \cdot m_p$

where
- l_i : length of a yield line i.
- ϕ_i : rotation of a yield line i.
- m_p : plastic moment per unit length.

When the joint is at a location near the edge of the main member, the yield line model may be assumed conservatively as

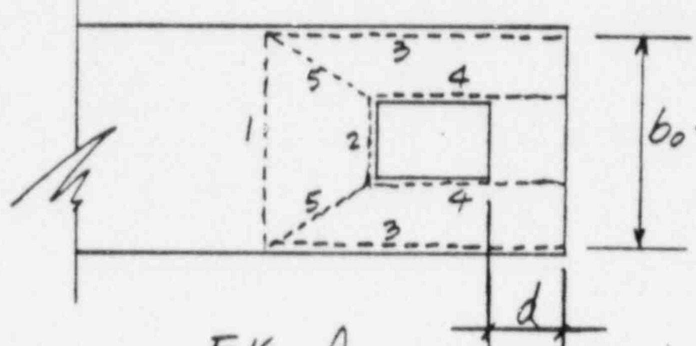

FIG. A

The total energy participated in the yield lines 1 to 5 is as follows:

Yield lines 1 : $b_o \dfrac{2\delta}{(b_o - b_1)\cot\alpha} \cdot m_p = \dfrac{2\tan\alpha}{1-\beta} \cdot \delta \cdot m_p$

Yield line 2 : $b_1 \cdot \dfrac{2\delta}{(b_o - b_1)\cot\alpha} \cdot m_p = \dfrac{2\beta\tan\alpha}{1-\beta} \cdot \delta \cdot m_p$

REF

6 Yield lines 3: $2\left[\frac{h_1}{\sin\theta_1} + \frac{b_0-b_1}{2}\cot\alpha + d\right]\cdot\frac{2\delta}{b_0-b_1}\cdot m_p$

$$= 2\left[\frac{\eta}{(1-\beta)\sin\theta_1} + \cot\alpha + \frac{2d}{b_0(1-\beta)}\right]\delta\cdot m_p$$

Yield lines 4: $2\left(\frac{h_1}{\sin\theta_1} + d\right)\cdot\frac{2\delta}{b_0-b_1}\cdot m_p$

$$= 2\left[\frac{2\eta}{(1-\beta)\sin\theta_1} + \frac{2d}{(1-\beta)b_0}\right]\delta\, m_p$$

Yield lines 5: $2l_5\cdot\left(\frac{\delta}{l_5\cdot\tan\alpha} + \frac{\delta}{l_5\cdot\cot\alpha}\right)\cdot m_p$

$$= 2(\tan\alpha + \cot\alpha)\cdot\delta\cdot m_p$$

$\therefore E_d = \sum l_i\cdot\phi_i\cdot m_p$

$$\therefore E_d = \left\{\frac{2\tan\alpha}{1-\beta} + \frac{2\beta\tan\alpha}{1-\beta} + 2\left[\frac{2\eta}{(1-\beta)\sin\theta_1} + \cot\alpha + \frac{2d}{b_0(1-\beta)}\right] + 2\left[\frac{2\eta}{(1-\beta)\sin\theta_1} + \frac{2d}{b_0(1-\beta)}\right] + 2(\tan\alpha + \cot\alpha)\right\}\delta\cdot m_p$$

$$= \frac{2\cdot\delta m_p}{1-\beta}\left\{\tan\alpha + \beta\tan\alpha + \frac{2\eta}{\sin\theta_1} + (1-\beta)\cot\alpha + \frac{2d}{b_0} + \frac{2\eta}{\sin\theta_1} + \frac{2d}{b_0} + (1-\beta)(\tan\alpha + \cot\alpha)\right\}$$

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$$E_d = \frac{2\delta M_p}{1-\beta}\left\{\tan\alpha + \cancel{\beta\tan\alpha} + \frac{4\eta}{\sin\theta_1} + \frac{4d}{b_0} + \cot\alpha - \beta\cot\alpha + \tan\alpha + \cot\alpha - \cancel{\beta\tan\alpha} - \beta\cot\alpha\right\}$$

$$= \frac{2\cdot\delta\cdot M_p}{1-\beta}\left\{2\tan\alpha + \frac{4\eta}{\sin\theta_1} + \frac{4d}{b_0} + 2\cot\alpha - 2\beta\cot\right\}$$

$$= \frac{4\cdot\delta\cdot M_p}{1-\beta}\left\{\frac{2\eta}{\sin\theta_1} + \frac{2d}{b_0} + \tan\alpha + (1-\beta)\cot\alpha\right\}$$

$$= \frac{4\cdot\delta\cdot M_p}{1-\beta}\left\{\frac{2\eta}{\sin\theta_1} + \frac{2d}{b_0} + \tan\alpha + \frac{(1-\beta)}{\tan\alpha}\right\}$$

$$= \frac{\cancel{4}\cdot\delta\cdot\frac{\sigma_{eo}\cdot t_0^2}{\cancel{4}}}{1-\beta}\left\{\frac{2\eta}{\sin\theta_1} + \frac{2d}{b_0} + \tan\alpha + \frac{(1-\beta)}{\tan\alpha}\right\}$$

$$= \frac{\delta\cdot\sigma_{eo}\cdot t_0^2}{1-\beta}\left\{\frac{2\eta}{\sin\theta_1} + \frac{2d}{b_0} + \tan\alpha + \frac{(1-\beta)}{\tan\alpha}\right\}$$

The energy by the external load $N_1\cdot\sin\theta_1\cdot\delta$ is equal to the participated energy in the yield lines which gives:

$$N_1\cdot\sin\theta_1\cdot\cancel{\delta} = \frac{\cancel{\delta}\cdot\sigma_{eo}\cdot t_0^2}{1-\beta}\left\{\frac{2\eta}{\sin\theta_1} + \frac{2d}{b_0} + \tan\alpha + \frac{(1-\beta)}{\tan\alpha}\right\}$$

or
$$N_1 = \frac{\sigma_{eo}\cdot t_0^2}{1-\beta}\left\{\frac{2\eta}{\sin\theta_1} + \frac{2d}{b_0} + \tan\alpha + \frac{(1-\beta)}{\tan\alpha}\right\}\frac{1}{\sin\theta_1}$$

REF

To get minimum N_1, we have

$$\frac{dN_1}{d\alpha} = 0$$

$$\frac{dN_1}{d\alpha} = \frac{\sigma_{eo} \cdot t_o^2}{(1-\beta)\sin\theta_1} \left\{ \sec^2\alpha + (1-\beta)(-\csc^2\alpha) \right\} = 0$$

i.e. $\sec^2\alpha + (1-\beta)(-\csc^2\alpha) = 0$

$$\frac{\sec^2\alpha}{\csc^2\alpha} = (1-\beta)$$

$$\tan^2\alpha = (1-\beta)$$

$$\tan\alpha = \sqrt{1-\beta}$$

$$N_1 = \frac{\sigma_{eo} \cdot t_o^2}{1-\beta} \left\{ \frac{2\eta}{\sin\theta_1} + \frac{2d}{b_o} + \sqrt{1-\beta} + \frac{(1-\beta)}{\sqrt{1-\beta}} \right\} \frac{1}{\sin\theta_1}$$

$$N_1 = \frac{\sigma_{eo} \cdot t_o^2}{1-\beta} \left\{ \frac{2\eta}{\sin\theta_1} + \frac{2d}{b_o} + 2\sqrt{1-\beta} \right\} \frac{1}{\sin\theta_1} \quad \text{— (1)}$$

This is the yield line capacity for the joint near the edge of the main member.

The yield line capacity for the joint away from the edge of the main member, N_2:

$$N_2 = \frac{\sigma_{eo} \cdot t_o^2}{1-\beta} \left\{ \frac{2\eta}{\sin\theta_1} + 4\sqrt{1-\beta} \right\} \cdot \frac{1}{\sin\theta_1} \quad \text{— (2)}$$

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Ratio of N_1 & N_2:

$$\frac{N_1}{N_2} = \frac{\frac{2\eta}{\sin\theta_1} + \frac{2d}{b_0} + 2\sqrt{1-\beta}}{\frac{2\eta}{\sin\theta_1} + 4\sqrt{1-\beta}}$$

The joint is the weakest when $\theta_1 = 90°$

Therefore when branch member is perpendicular to main member, then

$$\frac{N_1}{N_2} = \frac{2\eta + \frac{2d}{b_0} + 2\sqrt{1-\beta}}{2\eta + 4\sqrt{1-\beta}}$$

For the two yield models to have the same capacity then $\frac{N_1}{N_2} = 1$

or $2\eta + \frac{2d}{b_0} + 2\sqrt{1-\beta} = 2\eta + 4\sqrt{1-\beta}$

and $d = b_0\sqrt{1-\beta}$ ——— ③

The equation ③ can be used to calculate the rigid length d, in terms of fraction of main member width b_0, in order to develop the full capacity of N_2:

$\beta = 0.5$	$d = 0.707 b_0$	$\beta = .3$	$d = .837 b_0$
$\beta = 0.6$	$d = 0.632 b_0$	$\beta = .2$	$d = .894 b_0$
$\beta = 0.7$	$d = 0.548 b_0$	$\beta = .1$	$d = .949 b_0$
$\beta = 0.8$	$d = 0.447 b_0$		
$\beta = 0.4$	$d = 0.774 b_0$		

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If edge distance d is less than that calculated above, then the reduced capacity N_1 for the joint is calculated as follows:

For $\beta = \eta = 0.5$ $\quad N_1 = \left(\dfrac{2\eta + \frac{2d}{b_0} + 2\sqrt{1-\beta}}{2\eta + 4\sqrt{1-\beta}} \right) N_2$

When $d=0$ $\quad N_1 = \left(\dfrac{1 + 0 + 2\sqrt{0.5}}{1 + 4\sqrt{0.5}} \right) N_2 = 0.63 N_2$

$d = 0.1b_0$ $\quad N_1 = \left(\dfrac{1 + 0.2 + 2\sqrt{0.5}}{1 + 4\sqrt{0.5}} \right) N_2 = 0.68 N_2$

$d = 0.2b_0$ $\quad N_1 = \left(\dfrac{1 + 0.4 + 2\sqrt{0.5}}{1 + 4\sqrt{0.5}} \right) N_2 = 0.73 N_2$

$d = 0.3b_0$ $\quad N_1 = \left(\dfrac{1 + 0.6 + 2\sqrt{0.5}}{1 + 4\sqrt{0.5}} \right) N_2 = 0.79 N_2$

$d = 0.4b_0$ $\quad N_1 = \left(\dfrac{1 + 0.8 + 2\sqrt{0.5}}{1 + 4\sqrt{0.5}} \right) N_2 = 0.84 N_2$

$d = 0.5b_0$ $\quad N_1 = \left(\dfrac{1 + 1.0 + 2\sqrt{0.5}}{1 + 4\sqrt{0.5}} \right) N_2 = 0.89 N_2$

$d = 0.6b_0$ $\quad N_2 = \left(\dfrac{1 + 1.2 + 2\sqrt{0.5}}{1 + 4\sqrt{0.5}} \right) N_2 = 0.94 N_2$

$d = 0.707b_0$ $\quad N_2 = \left(\dfrac{1 + 1.414 + 2\sqrt{0.5}}{1 + 4\sqrt{0.5}} \right) N_2 = 1.0 N_2$

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For $\beta = \eta = 0.6$

when $d = 0$ $\quad N_1 = \left(\frac{1.2 + 2\sqrt{0.4}}{1.2 + 4\sqrt{0.4}}\right) N_2 = 0.66 N_2$

$d = 0.632 b_0$ $\quad N_1 = \left(\frac{1.2 + 1.264 + 2\sqrt{0.4}}{1.2 + 4\sqrt{0.4}}\right) N_2 = 1.0 N_2$

For $\beta = \eta = 0.7$

when $d = 0$ $\quad N_1 = \left(\frac{1.4 + 2\sqrt{0.3}}{1.4 + 4\sqrt{0.3}}\right) N_2 = 0.69 N_2$

$d = 0.548 b_0$ $\quad N_1 = N_2$

For $\beta = \eta = 0.8$

when $d = 0$ $\quad N_1 = \left(\frac{1.6 + 2\sqrt{0.2}}{1.6 + 4\sqrt{0.2}}\right) N_2 = 0.736 N_2$

$d = 0.447 b_0$ $\quad N_1 = N_2$

For $\beta = \eta = 0.55$ when $d = 0$ $\quad N_1 = 0.645 N_2$

$d = 0.67 b_0$ $\quad N_1 = N_2$

For $\beta = \eta = 0.65$ when $d = 0$ $\quad N_1 = 0.677 N_2$

$d = 0.59 b_0$ $\quad N_1 = N_2$

For $\beta = \eta = 0.75$ when $d = 0$ $\quad N_1 = 0.71 N_2$

$d = 0.5 b_0$ $\quad N_1 = N_2$

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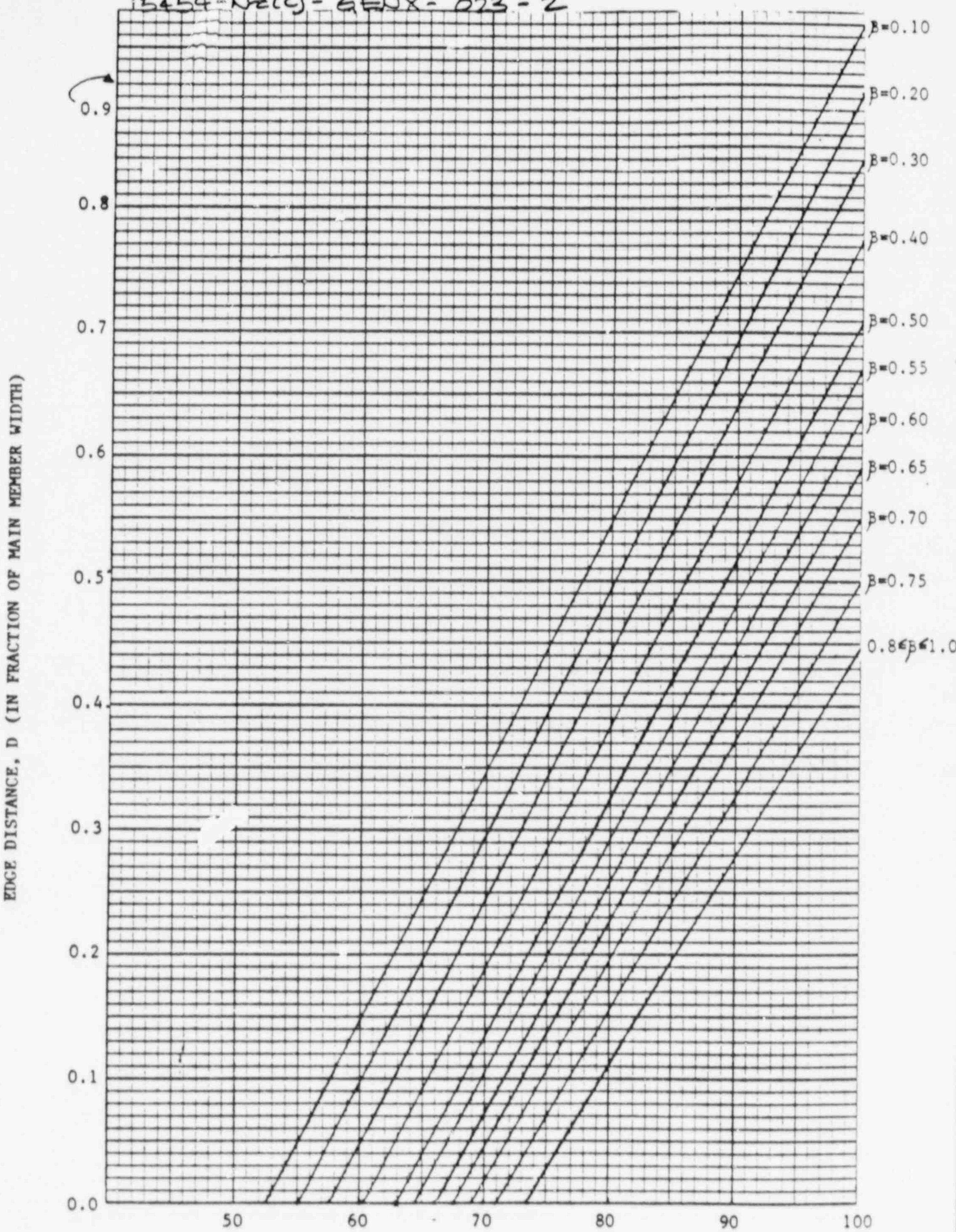

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Alternate Method

Since connections of tube steel to tube steel or component bracket to tube steel are not always welded all around, an alternate method is adopted as the following:

The maximum unit force on the connecting weld (regardless of the type of weld) may be found by multiplying the punching shear stress (V_p) by the thickness of the main member (t_c). i.e.,

1 $$F_w = \text{Acting } V_p \times t_c \quad (\#/in)$$

Let Acting V_p = Allowable $V_p = V_p$, the allowable weld unit force is $F_w = V_p \times t_c$ (#/in)

To change from the normal force component to the actual value in the case of skewed connection, we must divide through by $\sin\theta$ (by doing this we will also include the parallel component).

therefore, in general

$$F_w = \frac{V_p \times t_c}{\sin\theta}$$

By substituting $V_p = Q_\beta Q_f \times (\text{basic } V_p)$, the allowable connecting weld unit force F_w to avoid punching shear failure

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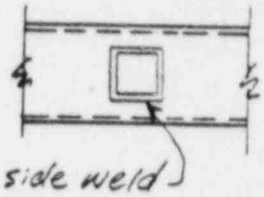
for a 90° joint with $\beta < 0.8$ becomes:

1 NOTE : $V_p \leq 0.4 F_Y$ △ ADD

$$F_W = Q_\beta \cdot Q_f \cdot (\text{basic } V_p) \cdot t_c$$

$$= \left[Q_\beta \cdot Q_f \cdot \frac{F_y}{0.6\gamma}\right] \cdot t_c \ (1) \text{ OR } △$$



(2) $F_W = 0.4 F_Y \, t_c$. Joint is not necessary 4-side weld

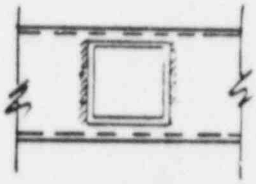
Similarly: (LESSER OF (1) OR (2) F_W SHALL BE USED) △

For stepped box connection with $\beta > 0.8$ or $\beta > \eta$ and 2-side weld across the main member width

$$F_W = \left[Q_\beta \cdot Q_f \cdot \frac{F_y}{0.6\gamma}\right] t_c \ (1)$$

$$F_W = 0.4 F_Y \, t_c \ (2)$$

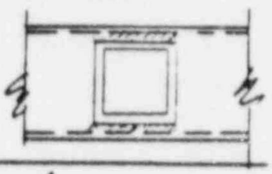
LESSER OF (1) OR (2)



For stepped box connection with $\beta > 0.8$ or $\beta > \eta$ and 2-side weld parallel to the main member axis

$$F_W = (0.4 F_y) t_c$$

[SEE EVALUATION PAGES 39a & 39b]

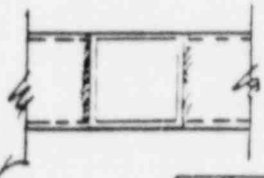


For matched box connection ($\beta = 1.0$) and 2-side weld across the main member width:

△ ADD

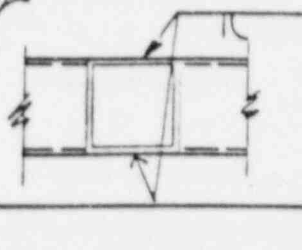
(1) $F_W = \left[Q_\beta \cdot Q_f \cdot \frac{F_y}{0.6\gamma}\right] \cdot t_c$ LESSER OF (1) OR (2)

△ (2) $F_W = 0.4 F_Y \, t_c$



2-side weld parallel to the main member axis:

$$F_W = [0.6 \, Q_f \, F_y] \cdot t_c$$



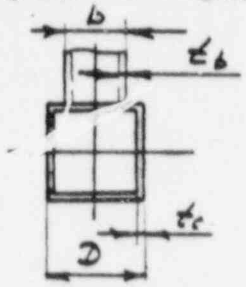
REF

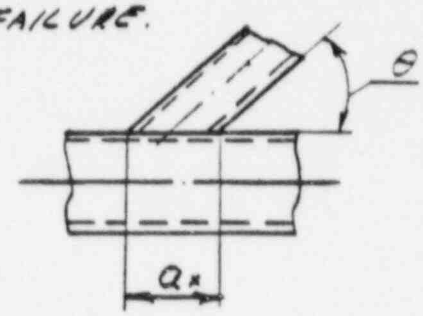
ALTERNATE METHOD – BASED ON WELD FORCE CRITERIA

EVALUATION OF LOCAL STRESS FOR THE

WELDED ATTACHMENT TO THE TUBE SECTIONS

THE METHOD DESCRIBED IN AWS SECTION 10.5 IS USED TO EVALUATE LOCAL FAILURE.





$$\gamma = \frac{D}{2t_c} \quad ; \quad \beta = \frac{b}{D} \quad ; \quad \eta = \frac{a_x}{D}$$

(I) **FOR $\beta < 0.8$**

ALLOWABLE PUNCHING SHEAR LESSER OF (1) OR (2)

$V_p = Q_\beta \, Q_f \times V_{p(BASIC)}$ (1) (2) $V_p = 0.4 F_Y$

$V_{P(BASIC)} = \frac{F_Y}{0.6\gamma}$ $F_Y = 36000$ psi

F_Y – SPECFIED MINIMUM YIELD STRENGTH OF THE MAIN MEMBER

$Q_\beta = \frac{0.25}{\beta(1-\beta)}$ FOR $\beta > 0.5$

$Q_\beta = 1.0$ FOR $0.5 \geq \beta$

ACTING V_p WAS CALCULATED USING UNIT WELD FORCE $V_p' = \frac{F_w}{t_c}$

F_w – WELD TENSILE UNIT FORCE

REF

$F_W = V_p' t_c$

USING $V_p' = V_p$ THE MAX. ALLOWABLE WELD TENSILE

1 FORCE CAN BE CALCULATED.

$F_W = V_p t_c$

(1) $F_W = \frac{F_Y}{0.6Y} Q_\beta Q_f t_c$ OR $F_W = 0.4 F_Y t_c$ (2)
USE LESSER OF (1) OR (2).

$Q_f = 1.0$ FOR $U \leq 0.44$

$U = \frac{f_a}{F_a}$ RATIO OF ACTUAL MAIN MEMBER NORMAL STRESS TO THE ALLOWABLE STRESS.

THE VALUES OF "F_W" FOR DIFFERENT Y ; β & t_c

ARE TABULATED IN TABLES 4-13.5A - 4-13.5D

(II) FOR $0.8 < \beta \leq 1.0$

a) BRANCH MEMBER WELDED (ON 2 SIDES) ACROSS THE MAIN MEMBER.

ALLOWABLE JOINT FORCE

$F_2 = 2 t_c b \left[Q_\beta Q_f \frac{F_Y}{0.6Y} \right]$ (1) LESSER OF (1) OR (2)

$F_2 = 2 t_c b \, 0.4 F_Y$ (2)

$Q_\beta = 1.25 (1 + \eta)$ FOR $\eta < 1.0$

$Q_\beta = 2.5$ FOR $\eta \geq 1.0$

$\eta = \frac{a_x}{D}$

ACTING TENSILE JOINT FORCE

$F = F_W \times 2b$

$F_2 = F$

REF

SUBSTITUTING GIVES

$F_W 2b = 2t_c b\, 0.4 F_Y$

$F_W 2b = 2t_c b \left[Q_\beta Q_\ell \dfrac{F_Y}{0.6\gamma} \right]$

(2) $F_W = t_c\, 0.4 F_Y$

(1) $F_W = t_c Q_\beta Q_\ell \dfrac{F_Y}{0.6\gamma}$ — LESSER OF (1) OR (2) — $Q_\ell = 1.0$ FOR $U < 0.44$

THE VALUES FOR DIFFERENT γ; η; t_c ARE TABULATED IN TABLES 4-13.7A - 4.13.7J

b) BRANCH MEMBER WELDED (on 2 SIDES) ALONG MAIN MEMBER.

ALLOWABLE JOINT FORCE

1 — $F_1 = 2t_c a_x (0.4 F_Y)$ — $0.8 < \beta < 1.0$

ACTING FORCE USING WELD UNIT FORCE

$F = F_W \times 2a_x$

$F_1 = F$

$F_W \times 2a_x = 2t_c a_x (0.4 F_Y)$

$F_W = t_c \times 0.4 F_Y$

$Q_\ell = 1.0$ FOR $U < 0.44$

$Q_\ell = 1.22 - 0.5U$ FOR $U \geq 0.44$

FOR $\beta = 1.0$

$F_1 = 2t_c a_x (0.6 F_Y Q_\ell)$

$F_W = t_c \times 0.6 F_Y Q_\ell$

THE VALUES FOR DIFFERENT t_c FOR $\beta = 1.0$ AND $0.8 < \beta < 1.0$; $Q_\ell = 1$ TABULATED IN TABLE 4-13.6

NOTE: DESCRIPTION OF TABLE 4-13.6

THE FOLLOWING IS A COMPARISON OF THE ALLOWABLE STRESS BASED ON THE 1985 AWS CODE INTERPRETATION (SEE DISCUSSION, P. 86)

1 $V_P = Q_B Q_F \frac{F_Y}{.6 Y}$ $\quad Q_F = 1.0$

$Q_B = \frac{.25}{\beta(1-\beta)}$ $\quad Q_B = 1.0$ FOR $\beta \leq .5$

β	.5	.6	.7	.8	.85	.8789	.9	.95	.99
Q_B	1.0	1.042	1.190	1.563	1.961	2.349	2.78	5.26	25.25

$V_P = Q_q Q_F \frac{F_Y}{.6 Y}$ $\quad Q_F = 1.0$

$Q_q = 1.25(1+\eta)$

$Q_q = 2.5$ FOR $\eta \geq 1.0$

η	.5	.6	.7	.8	.85	.8789	.9	.95	1.0
Q_q	1.875	2.0	2.125	2.25	2.313	2.349	2.375	2.438	2.5

ALSO. VALUES FOR $\eta < .4$ USE: (CONS.)

η	0.0	.1	.2	.3	.4
Q_q	1.25	1.375	1.5	1.625	1.75

REF.

1

BY INSPECTION, IT IS SHOWN THAT FOR VALUES OF β AND/OR η GREATER THAN .8789, Qq (WHICH VARIES WITH η) WILL GOVERN. THEREFORE, SINCE THE LESSER OF BOTH EQUATIONS MUST BE USED, DIRECTION IS PROVIDED TO CHECK BOTH TABLES FOR $.8 \le \beta < .9$ & AND TO USE THE LOWER ALLOWABLES.

$\beta = .85$ IS ADDED TO THE TABLES 4.13.5A THROUGH 4.13.5J.

IN ADDITION, FOR CONSERVATIVE ALLOWABLES, A FACTOR IS PROVIDED TO REDUCE THE ALLOWABLE GENERATED BY Qq FOR $\eta < .5$. THE ALLOWABLES FOR $\eta < .5$ ARE GENERATED BY THEIR RATIO WITH RESPECT TO $\eta = .5$, I.E $F_W = \frac{F_W}{R}$

$\eta = .5$, $Q_q = 1.875$

$\eta = .4$, $Q_q = 1.75$ USE $R = 1.875/1.75 = \underline{1.07}$

$\eta = .3$, $Q_q = 1.625$ USE $R = 1.875/1.625 = \underline{1.15}$

$\eta = .2$, $Q_q = 1.5$ USE $R = 1.875/1.5 = \underline{1.25}$

$\eta = .1$, $Q_q = 1.375$ USE $R = 1.875/1.375 = \underline{1.36}$

$\eta = 0$, $Q_q = 1.25$ USE $R = 1.875/1.25 = \underline{1.50}$

REF

c) REAR BRACKET WELDED TO THE TUBE

TABLES 4-13-4A-4G WERE DEVELOPED USING METHOD DESCRIBED ABOVE.

1. FOR TYPE A LOADING BRACKET RATED LOAD WAS USED AS A TENSILE FORCE.

FOR DIFFERENT γ; β AND DIFFERENT DIRECTION OF WELD ALLOWABLE PUNCHING SHEAR (FOR $\beta < 0.8$) OR JOINT FORCE (FOR $0.8 < \beta \le 1.0$) WERE CALCULATED.

1 FOR $\beta < 0.8$ $V_P = \frac{F_Y}{0.6\gamma} Q_\beta Q_f$ BUT $V_P \le 0.4 F_Y$

FOR $0.8 < \beta < 1.0$ $F_1 = 2t_c\, a \times 0.4 F_Y$

(2) $F_2 = 2t_c\, b\, 0.4 F_Y$ (1) $F_2 = 2t_c\, b \left[Q_\beta Q_f \frac{F_Y}{0.6\gamma} \right]$ LESSER OF (1) OR (2)

CONSERVATIVE BRACKET LOCATION ON THE TUBE SECTION ASSUMED IN ALL CASES.

ACTING PUNCHING SHEAR FORCE OR JOINT FORCE WERE CALCULATED USING UNIT WELD FORCE METHOD $F_W = F/\ell$

ℓ - WELD LENGTH

$V_P' = F_W / t_c$ (ACTING FORCE IN TERMS OF WELD FORCE)

RATIO $K = V_P'/V_P$ OR $K = F_2/F$; $K = F_1/F$

IS TABULATED FOR DIFFERENT BRACKET AND TUBE SIZES IN TABLE 4-13.4A - 4-13.4G

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2. LOADING TYPE B. (SEE PG. 42)

TENSILE COMPONENT F_W OF UNIT WELD FORCE WAS CALCULATED FOR EACH BRACKET USING RATED LOAD AND ANGLE Θ WHICH GIVES THE MAXIMUM F_W FOR EACH WELD TYPE.

$$F_W = \frac{F \sin\Theta}{e} + \frac{F \cos\Theta \times H}{S_W}$$

F - RATED BRACKET LOAD

e - WELD LENGTH

S_W - WELD SECTION MODULAS

FOR $\beta < 0.8$ ACTING PUNCHING SHEAR FORCE WAS CALCULATED $V_p' = F_W / t_e$

FOR $0.8 < \beta \leq 1.0$ JOINT FORCE WAS CALCULATED

$F' = F_W \times e$

THE RATIO $K = V_p / V_p'$ OR $K = F_2 / F_2'$; $K = F_1 / F_1'$ TABULATED IN TABLES 4.13-4A - 4-13.4G DIFFERENT BRACKET AND TUBE SIZES.

NOTE: THE DESCRIPTION OF TABLE 4 AND METHOD OF IT USING SEE PG. 42-43

FOR AN EXAMPLE SEE PG. 48

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CALCULATION SHEET

▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				
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REF

DESCRIPTION OF TABLE 4-13.4A THRU 4-13.4G

1. COMPARE THE BRACKET SIZE, TUBE SIZE, TYPE OF LOAD (A OR B) AND WELD TYPE WITH THOSE IN TABLE 4-13.4A - 4-13.4G BASED ON UTILIZATION RATIO $U \leq 0.44$ △

2. NO FURTHER EVALUATION IS REQUIRED IF THE RATIO "K" OF ACTUAL DESIGN LOAD TO THE RATED BRACKET LOAD FOR NORMAL AND UPSET CONDITIONS AND AT 70°F, IS SMALLER THAN THE VALUE OK "K_I" SHOWN IN THE TABLE.

3. USE THE APPROPRIATE INCREASE OF "K_I" FOR EMERGENCY AND FAULTED CONDITIONS.

4. FOR THE DESIGN TEMPERATURE HIGHER THAN 70°F, TABULATED NUMBERS "K_I" SHALL BE REDUCED BY THE RATIO OF $\frac{F_Y^T}{F_Y^{T70}}$

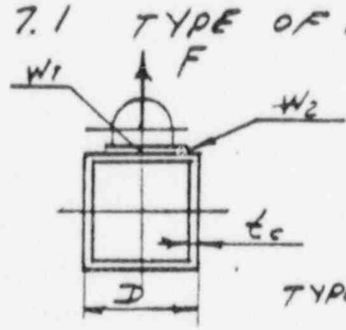
$F_Y^{T70} = 36000$ psi (YEILD STRENGTH OF THE BASE METAL AT 70°F)
F_Y^T — YEILD STRENGTH OF THE BASE METAL AT ANALYSED TEMPERATURE

5. IF BRACKET SIZE DIFFERS FROM THAT SHOWN IN THE TABLE 4-13.4A - 4-13.4G, THE BRACKET WITH SMALLER DIMENSIONS MAY BE CONSERVATIVELY USED.

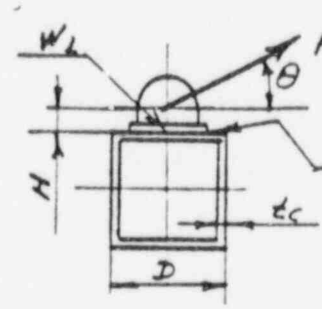
6. IF THE CENTER LINE OF THE BRACKET IS NOT IN LINE WITH THE TUBE AXIS, THE FOLLOWING CONSERVATIVE METHOD MAY BE USED:
MULTIPLY THE BIGGEST DISTANCE FROM THE CENTER OF THE BRACKET TO THE EDGE OF THE TUBE BY 2 AND USE IT AS A "D" DIMENSION IN THE TABLE 4-13.4A - 4-13.5A

7. SYMBOLS AND ASSUMPTIONS USED IN TABLES 4-13.4A - 4-13.4G.

7.1 TYPE OF LOAD.



TYPE A



TYPE B

REF

7.2 F - RATED BRACKET LOAD FOR NORMAL AND UPSET CONDITIONS
7.3 W - WELD SYMBOLS

7.4 || - W_1 WELD ALONG SHORT SIDES OF THE BRACKET
= - W_2 WELD ALONG LONG SIDES OF THE BRACKET
□ - ALL AROUND WELD

8. LOAD PER INCH OF WELD LENGTH FOR TYPE "B" LOAD HAVE BEEN CALCULATED WITH THE EFFECT OF ANGLE θ IN ORDER TO GENERATE THE BIGGEST LOAD.

9. THE RATIO OF ALLOWABLE LOAD ON THE JOINT TO THE RATED BRACKET LOAD IN EACH CASE HAVE BEEN CALCULATED USING THE WORST ORIENTATION OF THE BRACKET ON THE TUBE WALL

10. THE CENTER LINES OF THE BRACKET IS IN LINE WITH THE TUBE AXIS.

11. FOR THE TUBE SIZE MARKED WITH ASTERISK (*) WELD LENGTH ACROSS THE TUBE WIDTH WAS BASED ON $D-4t_c$, OTHERWISE WELD LENGTH IS EQUAL TO THE BRACKET DIMENSIONS OR TUBE DIMENSIONS WHICH EVER IS SMALLER

NOTE: FOR THE TUBE SIZE MARKED WITH AN ASTERISK (*), WELD LENGTH ACROSS THE TUBE WIDTH WAS BASED ON $D-4t_c$. OTHERWISE WELD LENGTH IS EQUAL TO THE BRACKET DIMENSIONS OR TUBE WIDTH WHICH EVER IS SMALLER.

__NOTE:__ THE FOLLOWING TABLES HAVE BEEN REVISED IN REV 2 OF THIS CALCULATION TO ACCOUNT FOR ABSOLUTE WORST CASE REAR BRACKETS. THE PREVIOUS REVISON'S TABLES ARE NOT TO BE USED FOR FUTURE DESIGNS; HOWEVER, THEY ARE STILL VALID AND HAVE BEEN INCLUDED AS AN ATTACHMENT TO REV 2 OF THIS CALC FOR REFERENCE.

TABLE 4-13.4A

K_I - Ratio of Maximum Design Load to the Rated Bracket Load, F_{RB}

Bracket: 1 x 1 3/8 (W1 x W2) H = 1.625 in. F_{RB} = 2,700 lb

TUBE SIZE AND THICKNESS	LOAD TYPE A			LOAD TYPE B		
	‖	=	□	‖	=	□
* TS 2 x 2 x 1/4	1.0	1.0	1.0	0.27	1.0	1.0
TS 3 x 3 x 1/4	1.0	1.0	1.0	0.19	0.75	0.95
TS 4 x 4 x 3/16	0.78	1.0	1.0	—	0.31	0.40
TS 4 x 4 x 1/4	1.0	1.0	1.0	0.14	0.56	0.71
TS 4 x 4 x 5/16	1.0	1.0	1.0	0.22	0.87	1.0
TS 4 x 4 x 3/8	1.0	1.0	1.0	0.31	1.0	1.0
TS 4 x 4 x 1/2	1.0	1.0	1.0	0.54	1.0	1.0
TS 5 x 5 x 3/16	0.62	0.86	1.0	—	0.25	0.32
TS 5 x 5 x 1/4	1.0	1.0	1.0	0.11	0.45	0.57
TS 5 x 5 x 3/8	1.0	1.0	1.0	0.25	1.0	1.0
TS 5 x 5 x 1/2	1.0	1.0	1.0	0.45	1.0	1.0
TS 6 x 6 x 3/16	0.52	0.72	1.0	—	0.21	0.27
TS 6 x 6 x 1/4	0.92	1.0	1.0	—	0.37	0.47
TS 6 x 6 x 5/16	1.0	1.0	1.0	0.15	0.58	0.74
TS 6 x 6 x 3/8	1.0	1.0	1.0	0.21	0.84	1.0
TS 6 x 6 x 1/2	1.0	1.0	1.0	0.37	1.0	1.0
TS 8 x 8 x 1/4	0.69	0.95	1.0	—	0.28	0.35
TS 8 x 8 x 3/8	1.0	1.0	1.0	0.16	0.63	0.80
TS 8 x 8 x 1/2	1.0	1.0	1.0	0.28	1.0	1.0
TS 10 x 10 x 3/8	1.0	1.0	1.0	0.12	0.50	0.64
TS 10 x 10 x 1/2	1.0	1.0	1.0	0.22	0.9	1.0
TS 10 x 10 x 5/8	1.0	1.0	1.0	0.35	1.0	1.0
TS 12 x 12 x 3/8	1.0	1.0	1.0	0.11	0.42	0.53
TS 12 x 12 x 1/2	1.0	1.0	1.0	0.19	0.75	0.95
TS 14 x 14 x 1/2	1.0	1.0	1.0	0.16	0.64	0.81

*Weld length across the tube width was based on $D - 4t_c$

TABLE 4-13.4B

K_I - Ratio of Maximum Design Load to the Rated Bracket Load, F_{RB}

Bracket: 1 1/2 x 1 3/8 (W1 x W2) H = 2 1/16 in. F_{RB} = 5,000 lb

TUBE SIZE AND THICKNESS	LOAD TYPE A			LOAD TYPE B		
	‖	=	□	‖	=	□
* TS 2 x 2 x 1/4	1.0	1.0	1.0	0.26	0.65	0.95
* TS 3 x 3 x 1/4	1.0	1.0	1.0	0.18	0.49	0.66
TS 4 x 4 x 3/16	0.63	0.58	1.0	-	0.20	0.28
TS 4 x 4 x 1/4	1.0	1.0	1.0	0.13	0.35	0.49
TS 4 x 4 x 5/16	1.0	1.0	1.0	0.21	0.55	0.77
TS 4 x 4 x 3/8	1.0	1.0	1.0	0.30	0.79	1.0
TS 4 x 4 x 1/2	1.0	1.0	1.0	0.52	1.0	1.0
TS 5 x 5 x 3/16	0.50	0.46	0.96	-	0.15	0.22
TS 5 x 5 x 1/4	0.9	0.82	1.0	0.10	0.28	0.39
TS 5 x 5 x 3/8	1.0	1.0	1.0	0.24	0.63	0.89
TS 5 x 5 x 1/2	1.0	1.0	1.0	0.43	1.0	1.0
TS 6 x 6 x 3/16	0.42	0.38	0.81	-	0.13	0.18
TS 6 x 6 x 1/4	0.75	0.68	1.0	-	0.23	0.33
TS 6 x 6 x 5/16	1.0	1.0	1.0	0.14	0.36	0.51
TS 6 x 6 x 3/8	1.0	1.0	1.0	0.20	0.52	0.74
TS 6 x 6 x 1/2	1.0	1.0	1.0	0.36	0.93	1.0
TS 8 x 8 x 1/4	0.56	0.51	1.0	-	0.17	0.24
TS 8 x 8 x 3/8	1.0	1.0	1.0	0.15	0.39	0.55
TS 8 x 8 x 1/2	1.0	1.0	1.0	0.27	0.70	0.99
TS 10 x 10 x 3/8	1.0	0.93	1.0	0.12	0.31	0.44
TS 10 x 10 x 1/2	1.0	1.0	1.0	0.21	0.56	0.79
TS 10 x 10 x 5/8	1.0	1.0	1.0	0.34	0.88	1.0
TS 12 x 12 x 3/8	0.84	0.77	1.0	0.10	0.26	0.37
TS 12 x 12 x 1/2	1.0	1.0	1.0	0.18	0.47	0.66
TS 14 x 14 x 1/2	1.0	1.0	1.0	0.15	0.40	0.56

*Weld length across the tube width was based on $D - 4t_c$

TABLE 4-13.4C

K_I - Ratio of Maximum Design Load to the Rated Bracket Load, F_{RB}

Bracket: 2 1/4 x 2 1/8 (W1 x W2)   H = 2.625 in. F_{RB} = 8,000 lb

TUBE SIZE AND THICKNESS	LOAD TYPE A			LOAD TYPE B		
	‖	=	□	‖	=	□
*TS 3 x 3 x 1/4	1.0	1.0	1.0	0.17	0.53	0.72
TS 4 x 4 x 3/16	0.59	0.55	1.0	-	0.22	0.31
TS 4 x 4 x 1/4	1.0	1.0	1.0	0.15	0.39	0.55
TS 4 x 4 x 5/16	1.0	1.0	1.0	0.23	0.61	0.86
TS 4 x 4 x 3/8	1.0	1.0	1.0	0.33	0.88	1.0
TS 4 x 4 x 1/2	1.0	1.0	1.0	0.57	1.0	1.0
TS 5 x 5 x 3/16	0.47	0.44	0.92	-	0.17	0.25
TS 5 x 5 x 1/4	0.84	.80	1.0	0.12	0.31	0.44
TS 5 x 5 x 3/8	1.0	1.0	1.0	0.26	0.70	1.0
TS 5 x 5 x 1/2	1.0	1.0	1.0	0.47	1.0	1.0
TS 6 x 6 x 3/16	0.4	0.37	0.76	-	0.14	0.20
TS 6 x 6 x 1/4	0.70	0.66	1.0	0.10	0.26	0.37
TS 6 x 6 x 5/16	1.0	1.0	1.0	0.15	0.40	0.58
TS 6 x 6 x 3/8	1.0	1.0	1.0	0.22	0.58	0.83
TS 6 x 6 x 1/2	1.0	1.0	1.0	0.39	1.0	1.0
TS 8 x 8 x 1/4	0.53	0.49	1.0	-	0.19	0.27
TS 8 x 8 x 3/8	1.0	1.0	1.0	0.16	0.44	0.62
TS 8 x 8 x 1/2	1.0	1.0	1.0	0.29	0.78	1.0
TS 10 x 10 x 3/8	0.95	0.89	1.0	0.13	0.35	0.50
TS 10 x 10 x 1/2	1.0	1.0	1.0	0.23	0.62	0.89
TS 10 x 10 x 5/8	1.0	1.0	1.0	0.37	0.98	1.0
TS 12 x 12 x 3/8	0.79	0.74	1.0	0.11	0.29	0.41
TS 12 x 12 x 1/2	1.0	1.0	1.0	0.20	0.52	0.74
TS 14 x 14 x 1/2	1.0	1.0	1.0	0.17	0.44	0.63

*Weld length across the tube width was based on $D - 4t_c$

TABLE 4-13.4D

K_I - Ratio of Maximum Design Load to the Rated Bracket Load, F_{RB}

Bracket: 3 x 3 1/4 (W1 x W2) H = 3 7/16 in. F_{RB} = 15,700 lb

TUBE SIZE AND THICKNESS	LOAD TYPE A			LOAD TYPE B		
	||	=	□	||	=	□
* TS 3 x 3 x 1/4	1.0	1.0	1.0	—	0.40	0.51
TS 4 x 4 x 3/16	0.53	0.57	1.0	—	0.23	0.31
TS 4 x 4 x 1/4	0.95	.95	1.0	0.13	0.41	0.56
* TS 4 x 4 x 5/16	1.0	1.0	1.0	0.15	.51	0.69
* TS 4 x 4 x 3/8	1.0	1.0	1.0	0.17	.62	0.82
* TS 4 x 4 x 1/2	1.0	1.0	1.0	0.17	.81	1.0
TS 5 x 5 x 3/16	0.33	0.36	0.69	-	0.14	0.20
TS 5 x 5 x 1/4	0.6	0.64	1.0	-	0.25	0.35
TS 5 x 5 x 3/8	1.0	1.0	1.0	0.19	0.58	0.79
TS 5 x 5 x 1/2	1.0	1.0	1.0	0.34	1.0	1.0
TS 6 x 6 x 3/16	0.27	0.29	0.55	-	0.11	0.16
TS 6 x 6 x 1/4	0.47	0.51	1.0	-	0.20	0.28
TS 6 x 6 x 5/16	0.74	0.80	1.0	0.10	0.32	0.44
TS 6 x 6 x 3/8	1.0	1.0	1.0	0.15	0.46	0.63
TS 6 x 6 x 1/2	1.0	1.0	1.0	0.27	0.82	1.0
TS 8 x 8 x 1/4	0.35	0.38	0.74	-	0.15	0.21
TS 8 x 8 x 3/8	0.8	0.87	1.0	0.11	0.35	0.47
TS 8 x 8 x 1/2	1.0	1.0	1.0	0.20	0.62	0.85
TS 10 x 10 x 3/8	0.64	0.69	1.0	-	0.28	0.38
TS 10 x 10 x 1/2	1.0	1.0	1.0	0.16	0.49	0.68
TS 10 x 10 x 5/8	1.0	1.0	1.0	0.25	0.77	1.0
TS 12 x 12 x 3/8	0.54	0.58	1.0	-	0.23	0.32
TS 12 x 12 x 1/2	0.95	1.0	1.0	0.13	0.41	0.56
TS 14 x 14 x 1/2	0.81	0.88	1.0	0.11	0.35	0.48

*Weld length across the tube width was based on $D - 4t_c$

TABLE 4-13.4E

K_I - Ratio of Maximum Design Load to the Rated Bracket Load, F_{RB}

Bracket: 6 x 7 (W1 x W2)   H = 4 in. F_{RB} = 33,500 lb

TUBE SIZE AND THICKNESS	LOAD TYPE A			LOAD TYPE B		
	||	=	□	||	=	□
* TS 6 x 6 x 3/16	0.50	0.50	1.0	0.10	0.34	0.50
* TS 6 x 6 x 1/4	0.67	0.67	1.0	0.13	0.45	0.66
* TS 6 x 6 x 5/16	0.84	.84	1.0	0.16	0.56	0.82
* TS 6 x 6 x 3/8	1.0	1.0	1.0	0.18	0.68	0.99
* TS 6 x 6 x 1/2	1.0	1.0	1.0	0.22	.92	1.0
TS 8 x 8 x 1/4	0.44	0.52	0.96	0.10	0.31	0.44
TS 8 x 8 x 3/8	1.0	1.0	1.0	0.24	0.70	1.0
TS 8 x 8 x 1/2	1.0	1.0	1.0	0.43	1.0	1.0
TS 10 x 10 x 3/8	0.63	0.73	1.0	0.15	0.44	0.62
TS 10 x 10 x 1/2	1.0	1.0	1.0	0.27	0.78	1.0
TS 10 x 10 x 5/8	1.0	1.0	1.0	0.42	1.0	1.0
TS 12 x 12 x 3/8	0.50	0.58	1.0	0.12	0.35	0.50
TS 12 x 12 x 1/2	0.89	1.0	1.0	0.21	0.62	0.89
TS 14 x 14 x 1/2	0.76	0.89	1.0	0.18	0.53	0.76

*Weld length across the tube width was based on $D - 4t_c$

EXAMPLE:

BRACKET 6" x 7" x 1" H = 4" F = 33,500#

TUBE 10 x 10 x 3/8   WELD TYPE "A" – ||

$\beta = .6 \quad \gamma = 13.33 \quad \eta = .7$

$F_W = F/\ell = 33{,}500/12 = 2791\ \#/\text{in} \qquad Q_B = \frac{.25}{.6(1-.6)} = 1.04$

$V_P' = F_W/t_e = \frac{2791}{.375} = 7443$

$V_P = \frac{F_y}{.6\gamma} Q_B Q_F = \frac{36000}{.6(13.33)} \times (1.04) \times 1.0 = 4681\ \text{psi}$

$K = \frac{V_P}{V_P'} = \frac{4681}{7443} = \underline{.63}$ (SEE NO. IN CHART)

TABLE 4-13.4F

K_I - Ratio of Maximum Design Load to the Rated Bracket Load, F_{RB}

Bracket: 7 x 9 (W1 x W2) H = 5 1/4 in. F_{RB} = 50,600 lb

TUBE SIZE AND THICKNESS	LOAD TYPE A			LOAD TYPE B		
	||	=	□	||	=	□
TS 8 x 8 x 1/4	0.59	0.59	1.0	0.12	0.39	0.57
* TS 8 x 8 x 3/8	0.88	.88	1.0	0.18	0.60	0.86
* TS 8 x 8 x 1/2	1.0	1.0	1.0	0.22	0.82	1.0
TS 10 x 10 x 3/8	0.55	0.67	1.0	0.12	0.39	0.54
TS 10 x 10 x 1/2	0.98	1.0	1.0	0.21	0.7	0.96
TS 10 x 10 x 5/8	1.0	1.0	1.0	0.33	1.0	1.0
TS 12 x 12 x 3/8	0.40	0.51	0.91	—	0.28	0.39
TS 12 x 12 x 1/2	0.71	0.91	1.0	0.15	0.50	0.69
TS 14 x 14 x 1/2	0.59	0.76	1.0	0.12	0.42	0.57

*Weld length across the tube width based on $D-4t_c$

TABLE 4-13.46

K_I - Ratio of Maximum Design Load to the Rated Bracket Load, F_{RB}

Bracket: 12 1/2 x 12 1/2 (W1 x W2) H = 8 in. F_{RB} = 123,000 lb

TUBE SIZE AND THICKNESS	LOAD TYPE A			LOAD TYPE B		
	||	=	□	||	=	□
* TS 10 x 10 x 3/8	0.45	.45	1.0	-	0.28	0.40
* TS 10 x 10 x 1/2	0.60	.60	1.0	0.10	0.38	0.54
* TS 10 x 10 x 5/8	0.76	.76	1.0	0.11	0.48	0.67
* TS 12 x 12 x 3/8	0.56	.56	1.0	0.12	0.35	0.51
* TS 12 x 12 x 1/2	0.73	.73	1.0	0.15	0.45	0.66
* TS 14 x 14 x 1/2	0.85	.85	1.0	0.20	0.53	0.78

*Weld length across the tube width based on $D-4t_c$

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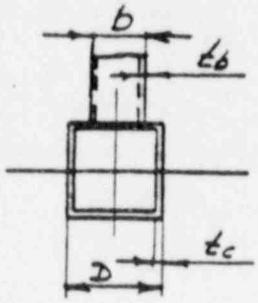
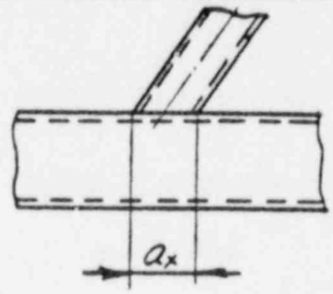
DESCRIPTIONS OF TABLES: 4-13.5A THRU 4-13.5J
4-13.6
4-13.7A THRU 4-13.7J





1. CALCULATE $\gamma = \frac{D}{2t_c}$

2. CALCULATE $\beta = \frac{b}{D}$; $\eta = \frac{a_x}{D}$

(USE ACTUAL WELD LENGTH FOR b AND a_x DIMENSIONS IF THE JOINT IS NOT WELDED ALL AROUND.)

3 CALCULATE WELD TENSILE UNIT FORCE (lb/IN)

$$f_a = \frac{F_T}{A} + \frac{M_1}{S_1} + \frac{M_2}{S_2}$$

F_T - COMPONENT OF BRANCH MEMBER AXIAL FORCE NORMAL TO THE JOINT WELD CONFIGURATION.
M_1 ; M_2 - BENDING MOMENTS.
S_1 ; S_2 - S. M. OF THE WELD CONFIGURATION.

(CONSERVATIVELY TOTAL WELD UNIT FORCE FROM SANDUL OUTPUT, OR CALCULATED MANUALY, MAY BE USED)

4. FOR $\beta < 0.8$

4.1 COMPARE THE CALCULATED WELD UNIT FORCE f_a WITH VALUES $\underline{F_W}$ SHOWN IN THE TABLES 4-13.5A - 4-13.5J WITH THE PROPER γ, β & t_c.

4.2. a) IF $f_a < F_W$, NO LOCAL FAILURE EXISTS.

b) IF $f_a > F_W$, USE YIELD LINE ANALYSIS PER

4.3 AWS SECTION 10.5.1.4 AND CONSIDER PROPER LENGTH OF CONTACT BETWEEN BRANCH AND MAIN MEMBER

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4.4 USE THE APPROPRIATE REDUCTION OF FW IF THE RATIO OF THE MAIN MEMBER NORMAL STRESS TO THE ALLOWABLE NORMAL STRESS U, IS GREATER THAN 0.44.

$$U = \frac{f}{F_{ALL}} > 0.44$$

THE REDUCTION FACTOR IS $Q_f = 1.22 - 0.5U$

4.5 FOR THE DESIGN TEMPERATURE HIGHER THAN 70°F REDUCE FW BY THE RATIO OF F_Y^{T70} / F_Y^{T}

F_Y^{T70} – YIELD STRENGTH OF THE BASE METAL AT 70°F
F_Y^{T} – YIELD STRENGTH OF THE BASE METAL AT THE ANALYZED TEMPERATURE.

4.6 USE THE APPROPRIATE INCREASES OF FW FOR EMERGENCY AND FAULTED CONDITIONS.

5. FOR $.9 \le \beta \le 1.0$

5.1 FOR THE BRANCH MEMBER WELDED ON TWO SIDES ACROSS THE MAIN MEMBER, FOLLOW THE STEPS 1 TO 4.5 AND USE TABLES 4-13.7A – 4-13.7J

5.2 FOR THE BRANCH MEMBER WELDED ON TWO SIDES PARALLEL TO THE MAIN MEMBER AXIS.
COMPARE THE CALCULATED WELD UNIT FORCE, fa, WITH THE VALUES, FW, SHOWN IN THE TABLE 4-13.6

5.3 FOR THE DESIGN TEMPERATURE HIGHER THAN 70°F REDUCE FW BY THE RATIO OF F_Y^{T} / F_Y^{T70}

5.4 USE THE APPROPRIATE REDUCTION OF FW IF THE RATIO OF THE MAIN MEMBER NORMAL STRESS TO THE ALLOWABLE NORMAL STRESS, U, IS GREATER THAN 0.44

$$U = \frac{f}{F_{ALL}} > 0.44$$

THE REDUCTION FACTOR IS $Q_f = 1.22 - 0.5U$

5.5 NO INCREASES OF FW FOR EMERGENCY AND FAULTED LOAD CONDITIONS ARE ALLOWED, BECAUSE CAPACITY BASED ON BUCKLING ALLOWABLE LOAD.
a) IF fa < FW NO LOCAL FAILURE EXISTS.
b) IF fa > FW SUPPORT SHOULD BE MODIFIED.

6. FOR $.9 \leq \beta < 1.0$

IF BRANCH MEMBER WELDED ON THREE OR FOUR SIDES TO MAIN MEMBER

6.1. COMPARE THE CALCULATED WELD UNIT FORCE WITH THE VALUES FW SHOW IN TABLES 4-13.7A - 4-13.7J FOR THE WELD ACROSS THE MAIN MEMBER

a) IF $f_a < F_W$ NO LOCAL FAILURE EXIST.

b) IF $f_a > F_W$ USE THE FOLLOWING METHOD.

6.2 CALCULATE THE TOTAL ALLOWABLE FORCE FOR THE JOINT.

$$F_A = (F_{W_1} \times \ell_1) + (F_{W_2} \times \ell_2)$$

F_{W_1} - ALLOWABLE UNIT WELD FORCE FOR WELD ACROSS THE MAIN MEMBER

F_{W_2} - ALLOWABLE UNIT WELD FORCE FOR WELD PARALLEL TO THE MAIN MEMBER AXIS.

ℓ_1 ; ℓ_2 - WELD LENGTH FOR CORRESPONDING WELD.

CALCULATE TOTAL TENSILE FORCE NORMAL TO THE JOINT WELD:

$$F = f_a \ell$$

f_a - UNIT WELD FORCE

ℓ - TOTAL WELD LENGTH.

a) IF $F < F_A$ NO LOCAL FAILURE EXIST.

b) IF $F > F_a$ SUPPORT SHALL BE MODIFIED.

7 Stepped Tube Connections For $0.8 \leq \beta < 0.9$

7.1 Branch Member Welded on Two Sides to the Main Member

a. For the branch member welded on the two sides that are normal to the axis of the main member (i.e., across the flange of the main member), follow the steps outlined in Section 4.4.2. However, obtain F_W in step a from Tables 4-13.3A through 4-13.3J or Tables 4-13.5A through 4-13.5I reduced as indicated below for $\eta < 0.5$ and use the smallest allowable F_W from both tables.

If $\eta < 0.5$, obtain F_W' from Tables 4-13.5A through 4-13.5I for $\eta = 0.5$ then calculate F_W using reduction factor R_1 as shown below

η	0.0	0.1	0.2	0.3	0.4
R_1	1.5	1.36	1.25	1.15	1.07

$$F_W = F_W'/R_1$$

b. For the branch member welded on the two sides that are parallel to the main member axis, obtain F_W from Table 4-13.4 or Tables 4-13.3A through 4-13.3J and use the smallest allowable from both tables.

c. For a design temperature higher than 100°F, reduce F_W by the ratio of F_{yt}/F_y.

d. For increases of F_W for emergency and faulted conditions, see notes under the appropriate tables.

e. Compare the calculated weld unit force f_w from Section 4.4.1 with the F_W obtained in Step b as modified by steps c and d.

If $f_w \leq F_W$, the design is acceptable.

If $f_w > F_W$, support should be modified.

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(CON'T)

7.2 Branch Member Welded on Three or Four Sides to the Main Member

As a conservative approach:

a. Follow the steps outlined in Section 4.4.2. However, obtain in Step a from Tables 4-13.3A through 4-13.3J.

b. If the joint does not pass the check in Step a above, then:

1) Obtain F_{W1} from Tables 4-13.3A through 4-13.3J or Tables 4-13.5A through 4-13.5I reduced as indicated in 2.1 for $\eta < 0.5$ and use the smallest F_W from both tables.

2) Obtain F_{W2} from Tables 4-13.3A through 4-13.3J or Table 4-13.4 and use the smallest allowable F_{W2} from both tables.

3) Modify F_{W1} in accordance with 4.4.2, steps b through d.

4) Modify F_{W2} in accordance with 4.4.3, steps c through d.

5) Calculate the total allowable force F_{AW} of the joint as follows:

$$F_{AW} = (F_{W1} \times L_1) + (F_{W2} \times L_2)$$

F_{W1} = Allowable unit weld force for weld across the main member axis from Table 4-13.5A through 4-13.5I or 4-13.3A through 4.13.3J

F_{W2} = Allowable unit weld force for weld parallel to the main member axis from Table 4.13.4 or 4.13.3A through 4-13.3J

6) Calculate the total tensile force, F_T, normal to the joint weld.

$$F_T = f_w \times L$$

7) If $F_T < F_{AW}$, the design is acceptable.

If $F_T > F_{AW}$, modify the support or the joint shall be reinforced.

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TABLE 4-13.5A

$\gamma = 16$ BASIC $V_p = 3750$

ALLOWABLE TENSILE WELD UNIT FORCE Fw (lb/in,

ALLOWABLE FILLET WELD SIZE W (in)

t_c	β	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
0.1875	F_W	703	710	731	773	837	935	1097	1378
	W	0.047	0.048	0.049	0.052	0.056	0.063	0.074	0.093
0.25	F_W	938	947	975	1031	1116	1247	1463	1838
	W	0.063	0.064	0.066	0.069	0.075	0.084	0.099	0.124
0.3125	F_W	1172	1184	1219	1289	1394	1559	1828	2298
	W	0.079	0.080	0.082	0.087	0.094	0.105	0.123	0.155
0.375	F_W	1406	1420	1462	1547	1673	1870	2194	2758
	W	0.095	0.096	0.098	0.104	0.113	0.126	0.148	0.186
0.50	F_W	1875	1894	1950	2063	2231	2994	2925	3677
	W	0.126	0.127	0.131	0.139	0.150	0.168	0.197	0.248

EXAMPLE.

WELD TS 6x6x3/8 TO TS 12x12x3/8

$\beta = 6:12 = 0.5 \quad \gamma = 16 \quad Q_\beta = 1.0 \quad Q_f = 1.0$

$$F_W = \frac{F_Y}{0.6\gamma} Q_\beta Q_f t_c$$

$$F_W = \frac{36000}{0.6 \times 16} \times 1.0 \times 1.0 \times 0.375 = 1406 \ \#/\text{in}$$

$$W = \frac{F_W}{0.707 \times S_S} = \frac{1406}{0.707 \times 21000} = 0.095$$

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TABLE 4-13.5B

$\gamma = 14$ BASIC $V_p = 4286$

ALLOWABLE TENSILE WELD UNIT FORCE F_w (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_c	β	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
0.1875	F_W	804	812	836	884	956	1069	1254	1575
	W	0.054	0.055	0.056	0.060	0.064	0.072	0.084	0.106
0.25	F_W	1071	1082	1114	1179	1275	1425	1671	2101
	W	0.072	0.073	0.075	0.079	0.085	0.096	0.113	0.142
0.3125	F_W	1339	1353	1393	1473	1594	1781	2089	2626
	W	0.090	0.091	0.094	0.099	0.107	0.120	0.141	0.177
0.375	F_W	1607	1623	1671	1768	1913	2138	2507	3152
	W	0.108	0.109	0.112	0.119	0.129	0.144	0.169	0.212
0.50	F_W	2143	2164	2228	2357	2550	2850	3343	4202
	W	0.144	0.146	0.15	0.159	0.172	0.192	0.225	0.283

TABLE 4-13.5C

Y = 12 BASIC Vp = 5000

ALLOWABLE TENSILE WELD UNIT FORCE Fw (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_c	β	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
0.1875	F_W	937	947	975	1031	1116	1247	1467	1838
	W	0.063	0.064	0.065	0.069	0.075	0.084	0.098	0.124
0.25	F_W	1250	1263	1300	1375	1488	1663	1950	2451
	W	0.084	0.085	0.088	0.093	0.100	0.112	0.131	0.165
0.3125	F_W	1562	1578	1625	1719	1859	2078	2438	3064
	W	0.105	0.106	0.109	0.116	0.125	0.140	0.164	0.206
0.375	F_W	1875	1894	1950	2062	2231	2494	2925	3677
	W	0.126	0.127	0.131	0.139	0.150	0.168	0.197	0.248
0.50	F_W	2500	2525	2600	2750	2975	3325	3900	4902
	W	0.168	0.170	0.175	0.185	0.200	0.224	0.263	0.330

TABLE 4-13.5D

$Y = 13.33$ BASIC $V_p = 4501$

ALLOWABLE TENSILE WELD UNIT FORCE F_W (lk/in)

ALLOWABLE FILLET WELD SIZE W (IN)

t_c	β	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
0.1875	F_W	844	852	878	928	1004	1122	1316	1655
	W	0.057	0.057	0.059	0.063	0.068	0.076	0.089	0.111
0.25	F_W	1125	1136	1170	1238	1339	1496	1755	2207
	W	0.076	0.077	0.079	0.083	0.090	0.10	0.118	0.149
0.3125	F_W	1406	1421	1463	1547	1674	1871	2194	2758
	W	0.095	0.096	0.099	0.104	0.113	0.126	0.148	0.186
0.375	F_W	1688	1705	1755	1857	2009	22[illegible]	2633	3310
	W	0.114	0.115	0.118	0.125	0.135	0.151	0.177	0.223
0.50	F_W	2250	2273	2340	2475	2678	2993	3511	4413
	W	0.152	0.153	0.158	0.167	0.180	0.202	0.236	0.297

TABLE 4-13.5E

$Y = 10.67$ BASIC $V_p = 5623$

ALLOWABLE TENSILE WELD UNIT FORCE F_w (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_c	β	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
0.1875	F_W	1054	1065	1096	1160	1255	1402	1645	2068
	W	0.071	0.072	0.074	0.078	0.085	0.094	0.111	0.139
0.25	F_W	1406	1420	1462	1546	1673	1870	2193	2757
	W	0.095	0.096	0.098	0.104	0.113	0.126	0.148	0.186
0.3125	F_W	1757	1775	1827	1933	2091	2337	2741	3446
	W	0.118	0.119	0.123	0.130	0.141	0.157	0.185	0.232
0.375	F_W	2109	2130	2193	2319	2509	2804	3289	4135
	W	0.142	0.143	0.148	0.156	0.169	0.189	0.222	0.279
0.50	F_W	2811	2840	2924	3093	3346	3739	4386	5514
	W	0.189	0.191	0.197	0.208	0.225	0.252	0.295	0.371

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TABLE 4-13.5F

$\gamma = 10$ BASIC $V_p = 6000$

ALLOWABLE TENSILE WELD UNIT FORCE F_W (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_c	β	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
0.1875	F_W	1125	1136	1170	1238	1339	1496	1755	2206
	W	0.076	0.077	0.079	0.083	0.090	0.101	0.118	0.149
0.25	F_W	1500	1515	1560	1650	1785	1995	2340	2942
	W	0.101	0.102	0.105	0.111	0.120	0.134	0.158	0.198
0.3125	F_W	1875	1894	1950	2063	2231	2494	2925	3677
	W	0.126	0.128	0.131	0.139	0.150	0.168	0.197	0.248
0.375	F_W	2250	2273	2340	2475	2676	2993	3510	4412
	W	0.151	0.153	0.158	0.167	0.180	0.201	0.236	0.297
0.50	F_W	3000	3030	3120	3300	3570	3990	4680	5883
	W	0.202	0.204	0.210	0.222	0.24	0.269	0.315	0.396

TABLE 4-13.5G

Y = 9.33 BASIC Vp = 6431

ALLOWABLE TENSILE WELD UNIT FORCE Fw(lb/in)

ALLOWABLE FILLET WELD SIZE W(in)

t_c	β	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
0.1875	F_W	1206	1218	1254	1326	1435	1604	1881	2365
	W	0.081	0.082	0.084	0.089	0.097	0.108	0.126	0.159
0.25	F_W	1608	1624	1672	1768	1913	2138	2508	3153
	W	0.108	0.109	0.113	0.119	0.129	0.144	0.169	0.212
0.3125	F_W	2010	2030	2090	2211	2391	2673	3135	3941
	W	0.135	0.137	0.141	0.149	0.161	0.180	0.211	0.265
0.375	F_W	2412	2436	2508	2653	2870	3207	3762	4729
	W	0.162	0.164	0.169	0.179	0.193	0.216	0.253	0.319
0.50	F_W	3215	3248	3344	3537	3826	4277	5016	6305
	W	0.216	0.218	0.225	0.238	0.258	0.288	0.338	0.425

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TABLE 4-13.5H

Y = 8 BASIC V_p = 7500

ALLOWABLE TENSILE WELD UNIT FORCE FW (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_c	β	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
0.1875	F_W	1406	1420	1462	1547	1673	1870	2194	2700
	W	0.095	0.096	0.099	0.104	0.113	0.126	0.148	0.182
0.25	F_W	1875	1894	1950	2063	2231	2494	2925	3600
	W	0.126	0.128	0.131	0.139	0.150	0.168	0.197	0.242
0.3125	F_W	2344	2367	2437	2578	2789	3117	3656	4500
	W	0.158	0.159	0.164	0.174	0.188	0.210	0.246	0.303
0.375	F_W	2812	2841	2925	3094	3347	3741	4387	5400
	W	0.189	0.191	0.197	0.208	0.225	0.252	0.296	0.364
0.50	F_W	3750	3787	3900	4125	4463	4988	5850	7200
	W_W	0.253	0.255	0.263	0.278	0.300	0.336	0.394	0.485

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TABLE 4-13.5I

Y = 6 BASIC Vp = 10000 psi

ALLOWABLE TENSILE WELD UNIT FORCE FW (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_c	β	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
0.1875	F_W	2250	2273	2340	2475	2677	2700	2700	2700
	W	0.151	0.153	0.158	0.167	0.180	0.182	0.182	0.182
0.25	F_W	3000	3030	3120	3300	3570	3600	3600	3600
	W	0.202	0.204	0.210	0.222	0.240	0.242	0.242	0.242
0.3125	F_W	3750	3787	3900	4125	4463	4500	4500	4500
	W	0.253	0.255	0.263	0.278	0.300	0.303	0.303	0.303
0.375	F_W	4500	4545	4680	4950	5355	5400	5400	5400
	W	0.303	0.306	0.315	0.333	0.361	0.364	0.364	0.364
0.50	F_W	6000	6060	6240	6600	7140	7200	7200	7200
	W	0.404	0.408	0.420	0.444	0.481	0.485	0.485	0.485

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TABLE 4-13.5J

Y = 5 BASIC V_p = 12000 psi

ALLOWABLE TENSILE WELD UNIT FORCE Fw (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_c	β	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
0.1875	F_W	1875	1894	1950	2062	2231	2494	2700	2700
	W	0.126	0.127	0.131	0.139	0.150	0.168	0.182	0.182
0.25	F_W	2500	2525	2600	2750	2975	3325	3600	3600
	W	0.168	0.170	0.175	0.185	0.20	0.224	0.242	0.242
0.3125	F_W	3125	3156	3250	3437	3719	4156	4500	4500
	W	0.210	0.212	0.219	0.231	0.250	0.280	0.303	0.303
0.375	F_W	3750	3787	3900	4125	4463	4988	5400	5400
	W	0.253	0.255	0.263	0.278	0.300	0.336	0.364	0.364
0.50	F_W	5000	5050	5200	5500	5950	6650	7200	7200
	W	0.337	0.340	0.350	0.370	0.401	0.448	0.485	0.485

TABLE 4-13.6

ALLOWABLE TENSILE WELD UNIT FORCE Fw (lb/in)

ALLOWABLE FILLET WELD SIZE W (IN)

t_c	$0.8 < \beta < 1.0$		$\beta = 1.0$	
	Fw (lb/in)	W (in)	Fw (lb/in)	W (in)
0.1875	2700	0.182	4050	0.273
0.25	3600	0.242	5400	0.364
0.3125	4500	0.303	6750	0.455
0.375	5400	0.364	8100	0.546
0.5	7200	0.485	10800	0.727

SIDE WALL CRIPPLING
NO INCREASE IN ALLOWABLE

EXAMPLE.

WELD TS 8×8×3/8 TO TS 10×10×3/8

$\beta = 0.8 \quad \eta = 0.8$

$$F_W = t_c \times 0.4 F_Y = 0.375 \times 0.4 \times 36000 = 5400 \#/\text{in}$$

$$W = \frac{F_W}{S_s \times 0.707} = \frac{5400}{0.707 \times 21000} = 0.364$$

WELD TS 10×10×3/8 TO TS 10×10×3/8

$\beta = 1.0 \quad \eta = 1.0 \quad Q_f = 1.0$

$$F_W = t_c \, 0.6 F_Y = 0.375 \times 0.6 \times 36000 = 8100 \#/\text{in}$$

$$W = \frac{8100}{0.707 \times 21000} = 0.546$$

TABLE 4-13. 7A

$\gamma = 16$ BASIC $V_p = 3750$

ALLOWABLE TENSILE WELD UNIT FORCE F_W (lb/IN)

ALLOWABLE FILLET WELD SIZE W (IN)

t_c \ η	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	1322	1406	1498	1582	1673	1758
	0.089	0.095	0.10	1.07	0.113	0.118
0.25	1762	1875	1997	2109	2231	2344
	0.119	0.126	0.134	0.142	0.150	0.158
0.3125	2203	2344	2496	2637	2789	2930
	0.148	0.158	0.168	0.178	0.188	0.197
0.375	2644	2812	2995	3164	3347	3517
	0.178	0.189	0.202	0.213	0.225	0.237
0.50	3525	3750	3994	4219	4463	4688
	0.237	0.253	0.269	0.284	0.301	0.316

EXAMPLE.

WELD TS 10"×8"×3/8" TO TS 12×12×3/8

$\beta = \frac{10}{12} = 0.833$ $\eta = 0.66 \approx 0.6$ $Q_\beta = 1.25(1+\eta) = 2.0$

$F_W = t_c Q_\beta Q_f \frac{F_Y}{0.6\gamma}$; $Q_f = 1.0$

$F_W = 0.375 \times 2 \times 1.0 \times \frac{36000}{0.6 \times 16} = 2812$ #/in

$W = \frac{F_W}{0.707 \times S_s} = \frac{2812}{0.707 \times 21000} = 0.189$

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CALCULATION SHEET

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TABLE 4-13.78

$\gamma = 14$ BASIC $V_p = 4286$

ALLOWABLE TENSILE WELD UNIT FORCE F_w (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_c \ η	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	1511	1607	1712	1808	1913	2009
	0.102	0.108	0.115	0.122	0.129	0.135
0.25	2014	2143	2282	2411	2550	2678
	0.136	0.144	0.154	0.162	0.172	0.180
0.3125	2518	2679	2853	3013	3188	3348
	0.170	0.180	0.192	0.203	0.215	0.226
0.375	3022	3214	3423	3616	3825	4018
	0.203	0.217	0.231	0.244	0.258	0.271
0.50	4029	4286	4564	4822	5100	5357
	0.271	0.289	0.307	0.325	0.344	0.361

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TABLE 4-13.7C

$\gamma = 13.3$ BASIC $V_p = 4501$

ALLOWABLE TENSILE WELD UNIT FORCE F_w (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_e \ η	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	1587	1688	1797	1899	2009	2109
	0.107	0.114	0.121	0.128	0.135	0.142
0.25	2115	2250	2397	2532	2678	2813
	0.142	0.152	0.161	0.171	0.180	0.189
0.3125	2644	2813	2996	3165	3348	3516
	0.178	0.189	0.202	0.213	0.225	0.237
0.375	3173	3376	3595	3798	4017	4220
	0.214	0.228	0.242	0.256	0.271	0.284
0.50	4231	4501	4794	5069	5356	5626
	0.285	0.303	0.323	0.341	0.361	0.379

TABLE 4-13.7D

$\gamma = 12$ BASIC $V_p = 5000$

ALLOWABLE TENSILE WELD UNIT FORCE F_w (lb/in)

ALLOWABLE FILLE WELD SIZE

t_e \ η	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	1762	1875	1997	2109	2231	2344
	0.119	0.126	0.134	0.142	0.150	0.158
0.25	2350	2500	2662	2812	2975	3125
	0.158	0.168	0.179	0.189	0.20	0.210
0.3125	2937	3125	3328	3516	3719	3906
	0.198	0.210	0.224	0.237	0.25	0.263
0.375	3525	3750	3994	4219	4463	4688
	0.237	0.253	0.269	0.284	0.301	0.316
0.50	4700	5000	5325	5625	5950	6250
	0.317	0.337	0.359	0.379	0.40	0.42

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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TABLE 4-13.7E

$\gamma = 10.67$ BASIC $V_P = 5623$ psi

ALLOWABLE TENSILE WELD UNIT FORCE F_W (lb/in)

ALLOWABLE FILLET WELD SIZE W (IN)

t_e \ η	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	1982	2109	2246	2372	2509	2636
	0.133	0.142	0.151	0.160	0.169	0.177
0.25	2643	2811	2994	3164	3346	3514
	0.178	0.189	0.202	0.213	0.225	0.237
0.3125	3303	3514	3742	3954	4182	4393
	0.222	0.237	0.252	0.266	0.282	0.296
0.375	3964	4217	4491	4744	5018	5272
	0.267	0.284	0.302	0.32	0.338	0.355
0.50	5286	5623	5988	6326	6691	7029
	0.356	0.379	0.403	0.426	0.451	0.473

TABLE 4-13.7F

$\gamma = 10$ BASIC $V_P = 6000$ psi
BUT $Q_i\, Q_B\, V_P \leq 0.4 F_Y$

ALLOWABLE TENSILE WELD UNIT FORCE F_W (lb/in)

ALLOWABLE FILLET WELD SIZE W (IN)

t_c \ Ω	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	2115	2250	2396	2531	2677	2700
	0.142	0.151	0.161	0.170	0.180	0.182
0.25	2820	3000	3195	3375	3570	3600
	0.19	0.202	0.215	0.227	0.24	0.242
0.3125	3525	3750	3994	4219	4463	4500
	0.237	0.253	0.269	0.284	0.301	0.303
0.375	4230	4500	4793	5063	5355	5400
	0.285	0.303	0.323	0.341	0.361	0.364
0.50	5640	6000	6390	6750	7140	7200
	0.380	0.404	0.430	0.455	0.481	0.485

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TABLE 4-13.7G

$\gamma = 9.33$ BASIC $V_P = 6431$ psi

BUT $Q_f Q_\beta V_P \leq 0.4 F_Y$

ALLOWABLE TENSILE WELD UNIT FORCE F_W (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_c \ η	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	2267	2412	2568	2700	2700	2700
	0.153	0.162	0.173	0.182	0.182	0.182
0.25	3022	3215	3424	3600	3600	3600
	0.203	0.217	0.231	0.242	0.242	0.242
0.3125	3778	4019	4281	4500	4500	4500
	0.254	0.271	0.288	0.303	0.303	0.303
0.375	4534	4823	5137	5400	5400	5400
	0.305	0.325	0.346	0.364	0.364	0.364
0.50	6045	6431	6849	7200	7200	7200
	0.407	0.433	0.461	0.485	0.485	0.485

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TABLE 4-13.7H

$\gamma = 8$

BASIC $V_P = 7500$
BUT $2 f Q_B V_P \leq 0.4 F_Y$

ALLOWABLE TENSILE WELD UNIT FORCE F_W (lbs/in)
ALLOWABLE FILLET WELD SIZE W (in)

t_e \ η	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	2644	2700	2700	2700	2700	2700
	0.178	0.182	0.182	0.182	0.182	0.182
0.25	3525	3600	3600	3600	3600	3600
	0.237	0.242	0.242	0.242	0.242	0.242
0.3125	4406	4500	4500	4500	4500	4500
	0.297	0.303	0.303	0.303	0.303	0.303
0.375	5287	5400	5400	5400	5400	5400
	0.356	0.364	0.364	0.364	0.364	0.364
0.50	7050	7200	7200	7200	7200	7200
	0.475	0.485	0.485	0.485	0.485	0.485

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TABLE 4-13.7I

$\gamma = 6$

BASIC $V_P = 10000$ psi

BUT $Q_f Q_D V_P = 0.4 F_Y$

ALLOWABLE TENSILE WELD UNIT FORCE F_W (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_c \ η	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	2700	2700	2700	2700	2700	2700
	0.182	0.182	0.182	0.182	0.182	0.182
0.25	3600	3600	3600	3600	3600	5600
	0.242	0.242	0.24	0.242	0.242	0.242
0.3125	4500	4500	4500	4500	4500	4500
	0.303	0.303	0.303	0.303	0.303	0.303
0.375	5400	5400	5400	5400	5400	5400
	0.364	0.364	0.364	0.364	0.364	0.364
0.50	7200	7200	7200	7200	7200	7200
	0.485	0.485	0.485	0.485	0.485	0.485

TABLE 4-13.7J

$\gamma = 5$ BASIC $V_p = 12000$ psi
BUT $Q_s Q_f V_p \leq 0.4 F_Y$

ALLOWABLE TENSILE WELD UNIT FORCE F_W (lb/in)
ALLOWABLE FILLET WELD SIZE W (in)

t_c \ η	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	2700	2700	2700	2700	2700	2700
	0.182	0.182	0.182	0.182	0.182	0.182
0.25	3600	3600	3600	3600	3600	3600
	0.242	0.242	0.242	0.242	0.242	0.242
0.3125	4500	4500	4500	4500	4500	4500
	0.303	0.303	0.303	0.303	0.303	0.303
0.375	5400	5400	5400	5400	5400	5400
	0.364	0.364	0.364	0.364	0.364	0.364
0.50	7200	7200	7200	7200	7200	7200
	0.485	0.485	0.485	0.485	0.485	0.485

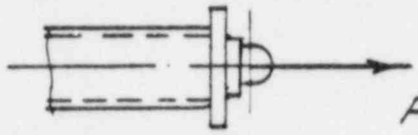
NOTE: "FW" AND "W" REPRESENT THE MAIN MEMBER CAPACITY ONLY, AND THEREFORE SHOWN FOR REFERENCE ONLY.

THIS TABLE IS NOT INCLUDED IN CPPP-7 ATT. 4-13

REF

TUBE END PLATE WITH REAR BRACKET ATTACHMENT

FOR THE STRUT OR SNUBBER WHICH IS IN LINE WITH THE TUBE AXIS, REQUIRED PLATE THICKNESS CAN BE CHECKED PER TABLE 4-13.8



FOR THE TUBE SECTIONS WHICH ARE NOT INCLUDED IN THE TABLE USE THE FORMULA PROVIDED BELOW.

Uniform over central rectangular area (At center) Max $\sigma = \sigma_b = \frac{\beta W}{t^2}$ where $W = w a_1 b_1$

b_1/b \ a_1/b	a = b: 0	0.2	0.4	0.6	0.8	1.0	a = 1.4b: 0	0.2	0.4	0.8	1.2	1.4	a = 2b: 0	0.4	0.8	1.2	1.6	2.0
0		1.82	1.38	1.12	0.93	0.76		2.0	1.55	1.12	0.84	0.75		1.64	1.20	0.97	0.78	0.64
0.2	1.82	1.28	1.08	0.90	0.76	0.63	1.78	1.43	1.23	0.95	0.74	0.64	1.73	1.51	1.03	0.84	0.68	0.57
0.4	1.39	1.07	0.84	0.72	0.62	0.52	1.39	1.13	1.00	0.80	0.62	0.55	1.32	1.08	0.88	0.74	0.60	0.50
0.6	1.12	0.90	0.72	0.60	0.52	0.43	1.10	0.91	0.82	0.68	0.55	0.47	1.04	0.90	0.76	0.64	0.54	0.44
0.8	0.92	0.76	0.62	0.51	0.42	0.36	0.90	0.76	0.68	0.57	0.45	0.40	0.87	0.76	0.63	0.54	0.44	0.38
1.0	0.76	0.63	0.52	0.42	0.35	0.30	0.75	0.62	0.57	0.47	0.38	0.33	0.71	0.61	0.53	0.45	0.38	0.30

FOR THE SKEWED STRUT (SNUBBER) USE METHOD DISCRIBED IN CPPP-7 ATT 4-15 TO EVALUATE THE PLATE STRESS.

FOR ALL CASES THE METHOD DISCRIBED IN SECTION 3.6 SHELL BE USED TO EVALUATE THE PLATE. CONSERVATIVELY TABLES 4-13.SA - 4-13.SJ MAY BE USED.

EXAMPLE.

BRACKET 1 1/8 × 2 WELDED TO THE END PLATE 4×4

$a_1/b = 2:4 = 0.5 \quad b_1/b = 1.125:4 = 0.28 \quad \beta = 0.92$

$$t = \sqrt{\frac{\beta W}{\sigma}} = \sqrt{\frac{0.92 \times 2700}{27000}} = 0.31$$

$W = 2700^{\#} \quad \sigma = 0.75 F_y = 27000$ psi

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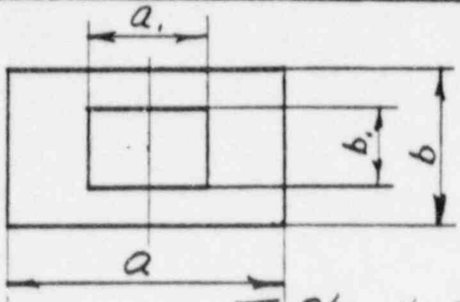
REF

REQUIRED END PLATE THICKNESS FOR REAR BRACKET WELDED TO THE END PLATE.



a_1 - LONG SIDE OF BRACKET
b_1 - SHORT SIDE OF BRACKET
a, b - TUBE DIMENSIONS
W - RATED BRACKET LOAD
β - COEFFICIENT FROM THE TABLE

$$\sigma = \frac{\beta W}{t^2} \leq \sigma_{ALL}$$

TABLE 4-13.8

$$\sigma_{ALL} = 0.75 F_Y = 27000 \text{ psi}$$

BRACKET SIZE RATED LOAD	PLATE SIZE	a/b	a_1/b	b_1/b	β	t REQ'D
1 1/8 × 2	3 × 3	1.0	0.67	0.38	0.72	0.27
2700 #	4 × 4	1.0	0.5	0.28	0.920	0.31
1 1/2 × 3	4 × 4	1.0	0.75	0.38	0.66	0.35
4960 #	5 × 5	1.0	0.60	0.30	0.81	0.39
2 1/4 × 3 1/2	4 × 4	1.0	0.88	0.56	0.50	0.38
8000 #	5 × 5	1.0	0.70	0.45	0.64	0.44
	6 × 6	1.0	0.58	0.38	0.75	0.47
3 × 4 1/2	5 × 5	1.0	0.9	0.6	0.47	0.52
15100 #	6 × 6	1.0	0.75	0.5	0.59	0.59
	8 × 8	1.0	0.56	0.38	0.78	0.65
7 × 7	10 × 10	1.0	0.7	0.7	0.5	0.79
33500 #	12 × 12	1.0	0.58	0.58	0.61	0.87
10 × 10	12 × 12	1.0	0.83	0.83	0.40	0.87
50600 #	14 × 14	1.0	0.71	0.71	0.5	0.97
127000 # 12 1/2 × 12 1/2	14 × 4	1.0	0.89	0.89	0.36	1.28

NOTE: PLATE WIDTH IS EQUAL TO THE TUBE WIDTH

REF

STIFFENER REQUIREMENTS FOR I SHAPE BEAM USED IN PIPE SUPPORT.

1. FLANGE BENDING.

a) CALCULATE EFFECTIVE SECTION MODULUS

$$S = \frac{[B + 2(e - K_1)]t^2}{6}$$

B - WIDTH OF ATTACHMENT ALONG THE BEAM WEB.
K - (SEE PG. 78)

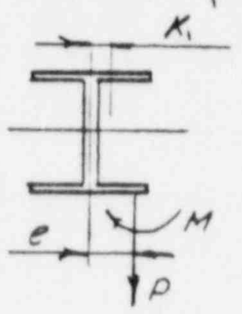
b) CALCULATE BENDING STRESS

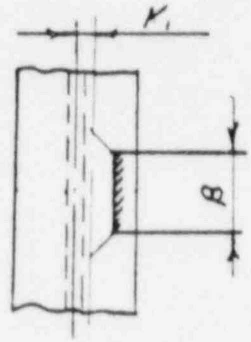
$$\sigma = \frac{M}{S}$$

NO STIFFENER PLATE REQUIRED IF $\sigma < 0.75\,S_y$

c) DETERMINING OF MOMENT "M"

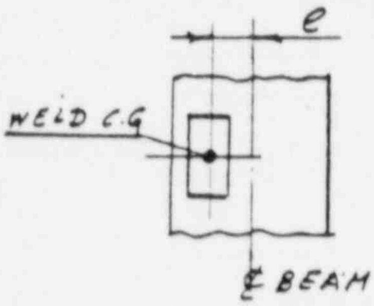
$$M = M + P(e - K_1)$$





d) DETERMINING "e" AND "P"

ATTACHMENT IS LOCATED ON ONE SIDE OF THE CENTERLINE OF THE BEAM.



e - DISTANCE BETWEEN ℄ OF THE BEAM AND C.G OF THE ATTACHMENT WELD.

P - VERTICAL DESIGN LOAD

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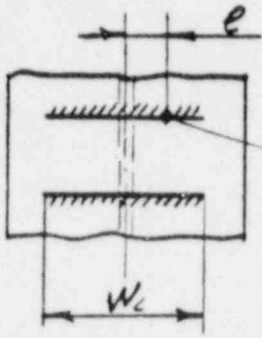
REF

1.) ATTACHMENT IS LOCATED ON BOTH SIDES OF THE CENTER LINE OF THE BEAM

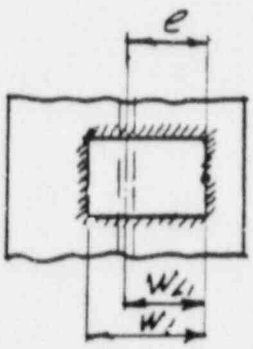


$$e = \frac{W_L}{4}$$

CENTER OF WELD SEGMENT ON ONE SIDE OF BEAM ℄

P = 1/2 OF VERTICAL DESIGN LOAD.

2)

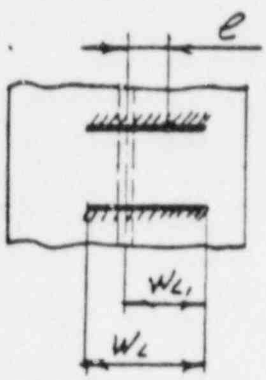


e - THE LONGEST DISTANCE BETWEEN CENTER OF FAR EDGE OF THE WELD LOCATED ON ONE SIDE OF THE BEAM WEB AND ℄ OF THE WEB

P = 1/2 OF VERTICAL DESIGN LOAD.

$e = W_{L1}$

3)



e - THE LONGEST DISTANCE BETWEEN C.G. OF THE WELD LOCATED ON ONE SIDE OF THE BEAM WEB AND ℄ OF THE WEB

$e = W_{L1}/2$

$$P = \frac{W_{L1}}{W_L} \times \left(\text{VERTICAL DESIGN LOAD} \right)$$

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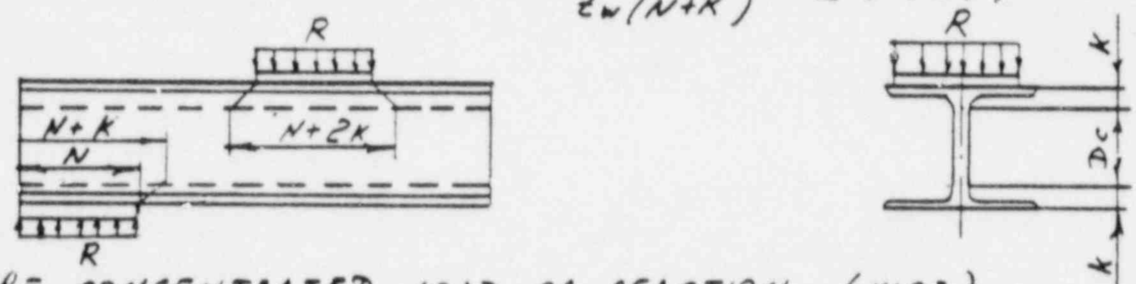
3.6.2.1 WEB CRIPPLING OF I-SHAPED BEAM.

WEBS OF BEAMS AND WELDED PLATE GIRDERS SHALL BE PROPORTIONED SUCH THAT THE COMPRESSIVE STRESS AT THE WEB TOE OF FILLETS RESULTING FROM CONCENTRATED LOADS NOT SUPPORTED BY BEARING STIFFENERS, SHALL NOT EXCEED THE VALUE OF $0.75 S_Y$.

THE GOVERNING FORMULAS SHALL BE

a) FOR INTERIOR LOADS: $\frac{R}{t_w(N+2K)} \leq 0.75 F_Y$

b) FOR END-REACTIONS: $\frac{R}{t_w(N+K)} \leq 0.75 F_Y$



R = CONCENTRATED LOAD OR REACTION (KIPS)

t_w = THICKNESS OF WEB (IN)

N = LENGTH OF BEARING (NOT LESS THAN K FOR END REACTION) (IN)

K = DISTANCE FROM OUTER FACE OF FLANGE TO WEB TOE OF FILLET (IN)

D_c = WEB DEPTH CLEAR OF FILLETS.

F_Y = MINIMUM YIELD STRESS

FOR THE INTERIOR LOADS PRODUCED BY PIPE, "N" THE BEARING LENGTH MAY BE ASSUMED TO EQUAL TO ZERO.

IF AFTER CHECKING EQUATIONS "a" OR "b" IT IS FOUND THAT STIFFENER PLATE ARE REQUIRED, THEY SHALL BE PROVIDED PER AISC SECTION 1.10.5.1

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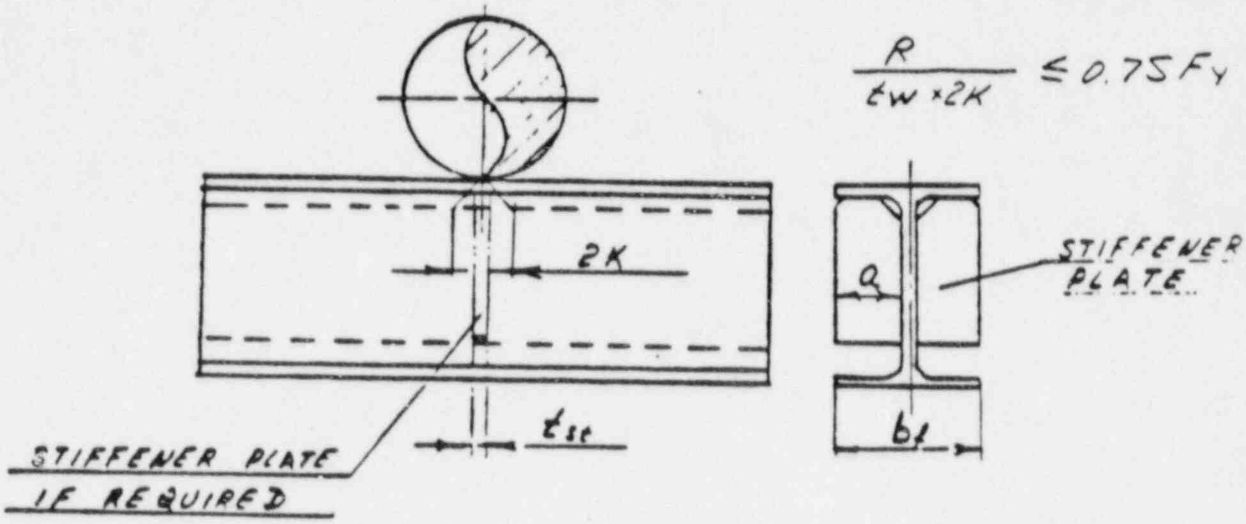
3.6.3.1 WEB CRIPPLING DUE TO PIPE BEARING LOAD.

$$\frac{R}{t_w \times 2K} \le 0.75 F_Y$$



IF AFTER CHECKING EQUATION "a" IT IS FOUND THAT STIFFENER PLATE ARE REQUIRED, THEY SHALL BE PROVIDED PER AISC SECTION 1.10.5.1 THE FOLLOWING FORMULA MAY BE USED TO CHOOSE THE TRIAL SIZE FOR REQUIRED STIFFENER PLATE

$$\frac{a}{t_{st}} < \frac{95}{\sqrt{S_Y}} \quad \text{(PER AISC 1.9.1.2)}$$

$$2a = b_f - t_w$$

$$t_w \le t_{st} \le t_f$$

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3.7 LOCAL TUBE STRESS DUE TO PIPE BEARING LOAD

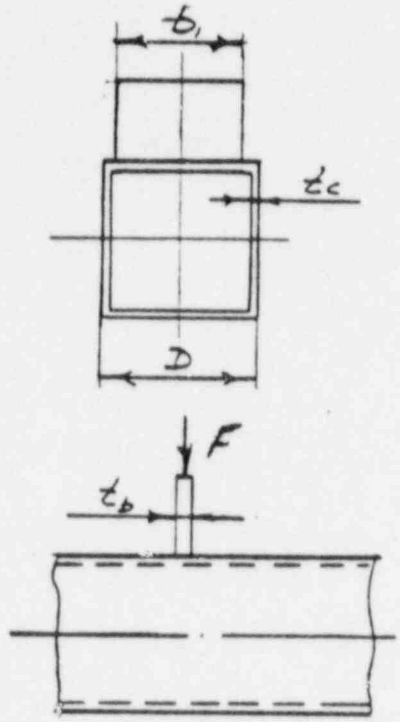

FIG. 1
PLATE ATTACHED TO THE TUBE.

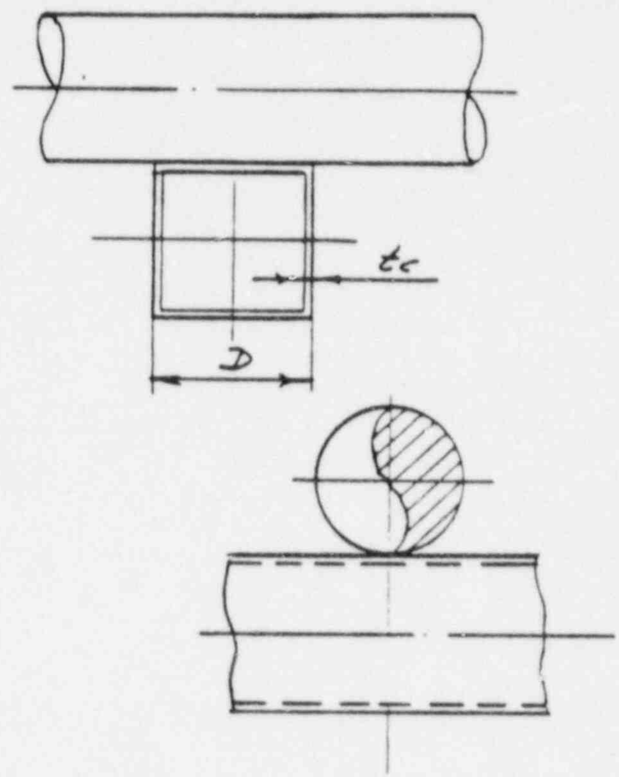

FIG 2.
PIPE SUPPORTED BY TUBE.

3.7.1 PUNCHING SHEAR OF CHORD DUE TO FORCE "F."

6 $$F = 2(t_b + b_1)\frac{F_Y}{\sqrt{3}}\,t_c \qquad \left(\text{WHERE } \frac{F_Y}{\sqrt{3}} - \text{SHEAR YIELD STRESS}\right)$$

BY COMPARISON FIG. 1 AND FIG 2.

$$t_b = 0 \qquad b_1 = D$$

∴ PUNCHING SHEAR DUE TO BEARING LINE LOAD

$$F = 2D\,t_c\,\frac{F_Y}{\sqrt{3}}$$

F − FORCE LIMITED YIELD OF CHORD

REF

USING 0.6 F_Y FOR NORMAL AND UPSET LOAD CONDITION, IS USED IN ORDER TO BE CONSISTENT WITH THE METHOD USED IN REF 6.

$$F = 2Dt_c \frac{0.6\,F_Y}{\sqrt{3}}$$

FOR $F_Y = 36000$ psi

$$F = Dt_c \frac{2 \times 0.6 \times 36000}{\sqrt{3}} = 24942\ Dt_c$$

TUBE SIZE \ CHORD THK.	3/16	1/4	3/8	1/2
2 × 2	9328	12471	18707	24942
3 × 3	13992	18707	28060	37413
4 × 4	18656	24942	37413	49884
5 × 5	23321	31178	46766	62355
6 × 6	27984	37413	56120	74826
7 × 7	32649	43649	65472	87297
8 × 8	37313	49884	74826	99768
10 × 10	46641	62355	93533	124710
12 × 12	55969	74826	112239	149652
14 × 14	65298	87297	130945	174594

BASED ON THE ABOVE RESULTS CONCLUSION MAY BE MADE, THAT TUBE LOCAL STRESS DUE TO PIPE BEARING LOAD NEEDS NOT TO BE CHECKED FOR PIPE SUPPORT MEMBERS

REF

3.7.2 CHORD SIDE WALL CRIPPLING AND BUCLING.

$$F = 2\sigma_K t_c \left(\frac{a_x}{\sin\theta} + 5t_c \right) \frac{1}{\sin\theta}$$

σ_K - BUCLING CRITICAL STRESS.

$\sigma_K = 36000\,psi$ FOR THE TUBE SECTIONS USED IN PIPE SUPPORT

a_x MAY BE EQUAL TO ZERO.
a_x — LENGTH OF ATTACHED MEMBER ALONG THE TUBE AXIS.

ALLOWABLE FORCE DUE TO PIPE BEARING LOAD.

$$F = 2\sigma_K t_c \times 5t_c \frac{1}{\sin\theta}$$

BY COMPARISION THE ABOVE FORMULA WITH THE ALLOWABLE FORCE DUE TO PUNCHING SHEAR IT IS CLEAR THAT CAPACITY DUE TO PUNCHING SHEAR IS SMALLER AND THEREFORE CHORD SIDE WALL CRIPPLING AND BUCKLING DOES NOT NEED TO BE CHECKED FOR PIPE SUPPORT MEMBERS.

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BOLT NUTS BEARING AGAINST TUBE STEEL WALLS

Nuts used in cinched U-bolt application and/or threaded rod or bolt in Richmond Insert / Tube Connections exert load locally against tube wall. Stresses thus induced around the hole shall be evaluated so as to ensure no local failure exists. The following steps may be used to evaluate the adequacy of the washer plate (if exists) or the tube wall:

a) Calculate U-bolt load, P_A, for each leg or axial load in the threaded rod or bolt in Richmond Insert application, including preload if any.

b) Find F_A, the capacity of washer plate or tube wall if no washer plate for the tube size used, from Table 4-13.9A thru 4-13.9J.

c) Compare the values of P_A versus F_A:

— If $P_A < F_A$, no local failure exists.

— If $P_A > F_A$ and there is washer plate, multiply F_A by a factor of $\left(\frac{t_1^3 + t_2^3}{t_1^3}\right)$ to obtain the total capacity of washer plate and tube wall. Again no local failure exists if P_A is less than the factored F_A. NOTE: t_1 IS THE THICKNESS OF THE THINNER OF THE TS WALL OR WASHER PLATE.

See the following pages for the factor

d) Use appropriate increases for F_A for emergency and faulted connections as allowed by the Code.

e) Reduce F_A if ambient temperature is above 100°F. The reduction factor is $\frac{F_{yt}}{F_y}$.

where F_{yt} = Base metal yield strength @ elevated temp.
F_y = Base metal yield strength @ 100°F

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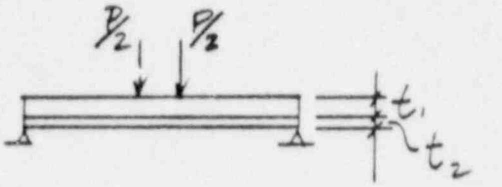
Justification of the multiplier $\left(\frac{t_1^3 + t_2^3}{t_1^3}\right)$



} NOTE: t_1 IS THE THICKER OF THE TUBE OR PL

Neglecting friction between the washer plate & tube ched the deflected cure should have the same curvature

i.e. $$\frac{1}{\rho} = \frac{M_1}{EI_1} = \frac{M_2}{EI_2}$$

$$\frac{M_1}{M_2} = \frac{I_1}{I_2}$$

$$\frac{\sigma_1 S_1}{\sigma_2 \cdot S_2} = \frac{I_1}{I_2}$$

$$\frac{\sigma_1 \cdot \frac{I_1 \cdot 2}{t_1}}{\sigma_2 \cdot \frac{I_2 \cdot 2}{t_2}} = \frac{I_1}{I_2}$$

$$\therefore \frac{\sigma_1}{\sigma_2} = \frac{t_1}{t_2}$$

WHERE M_1; σ_1; I_1; S_1 — , STRESS, MOMENT OF INERTIA AND SECTION MODULAS OF THINNER SECTION

M_2; σ_2; I_2; S_2 — MOMENT, STRESS, MOMENT OF INERTIA AND SECTION MODULAS OF THICKER SECTION

Also total $M = M_1 + M_2$

$$= \sigma_1 \cdot S_1 + \sigma_2 \cdot S_2$$

$$= \sigma_1 S_1 + \sigma_1 \cdot \frac{t_2}{t_1} \cdot S_2$$

$$= \sigma_1 \left[S_1 + \frac{t_2}{t_1} \cdot S_2 \right]$$

$$= \sigma_1 \left[\frac{b t_1^2}{6} + \frac{t_2}{t_1} \times \frac{b t_2^2}{6} \right]$$

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$$M = \sigma_1 \cdot \frac{b}{6}\left[t_1^2 + \frac{t_2^3}{t_1}\right]$$

$$= \sigma_1 \cdot \frac{b}{6} \cdot \frac{t_1^2}{t_1^2}\left[t_1^2 + \frac{t_2^3}{t_1}\right]$$

$$= M_1 \cdot \frac{1}{t_1^2}\left[\frac{t_1^3 + t_2^3}{t_1}\right]$$

$$= M_1\left[\frac{t_1^3 + t_2^3}{t_1^3}\right]$$

Therefore, total capacity of washer plate and tube chord is equal to the CAPACITY OF THE THINNER SECTION multiplied by the factor of $\left(\frac{t_1^3 + t_2^3}{t_1^3}\right)$

THE CAPACITY OF THE TOTAL SECTION IS THEREFORE LIMITED BY σ_1 (STRESS IN THINNER SECTION) EQUAL TO 27 ksi (.75 Sy).

THE TOTAL CAPACITY CAN BE DETERMINED BY MULTIPLYING THE ABOVE FACTOR BY THE TABULATED CAPACITY OF THE THICKER SECTION INDEPENDENT OF THE THINNER SECTION

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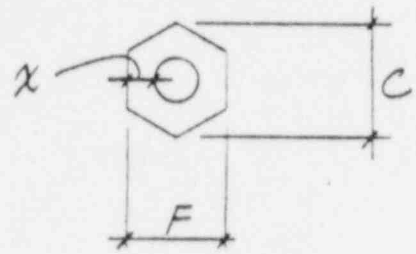
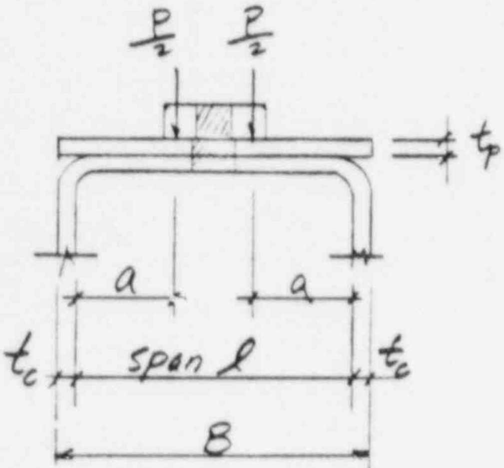
CAPACITY OF WASHER ℄ AND/OR TUBE STEEL WALL DUE TO U-BOLT NUT BEARING — A CONSERVATIVE APPROACH

NUT DIM. FOR BOLT DIA. $d = F \times C$



BOLT HOLE, $H = d + \frac{1}{8}$ (d = BOLT DIA)

$$x = \frac{1}{2}(F - H)$$



$$a = \frac{1}{2}(l - H - x) = \frac{1}{2}[l - (H + x)]$$

$$M = \frac{P}{2} \cdot a = \frac{Pa}{2}$$

$$S = \frac{(B - H)\,t_p^2}{6} \quad \text{(PLATE SECTION MODULUS)}$$

$$27 = \frac{M}{S} = \frac{\frac{Pa}{2}}{S}$$

or $$P_{all} = \frac{54 \cdot S}{a}$$ PER U-BOLT LEG OR PER HOLE

Results for span $l = B - 2t_c$, see Tables 4-13 9A ~ 9J

Results for span $l = B - 4t_c$, see Tables 4-13 10A ~ 10J

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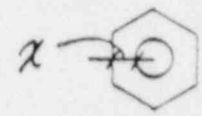
<u>EXAMPLE:</u>

TS 3 × 3 × 1/4

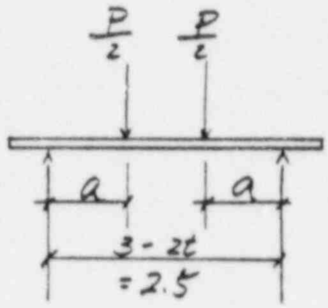
NO WASHER PL

U-BOLT : 3/4"ϕ   NUT SIZE : $1\frac{1}{4}$" × $1\frac{7}{16}$



$x = \frac{1}{2}(1.25 - 0.875)$

$= 0.1875$



$a = \frac{1}{2}(2.5 - 0.875 - 0.1875) \doteq 0.72"$

$S = \frac{(3-0.875)(0.25)^2}{6} = 0.022$

$M = \frac{P}{2} \times 0.72 = 0.36\,P$

$27 = \frac{0.36\,P}{0.022}$

$P_{all} = 1.65^k = 1650^{\#}$ per LEG

└ SHOWN IN THE TABLE 4-13.9C

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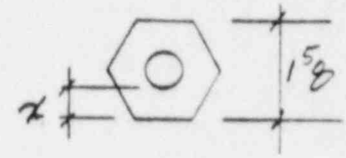
EXAMPLE:

TS 4 × 4 × ½

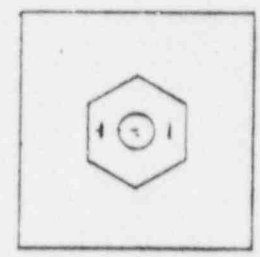
WASHER ℄ : ½" (4" × 4")

U-BOLT : 1"φ   NUT SIZE = 1⅝ × 1⅞



$x = (1.625 - 1.125)/2$
$= 0.25''$

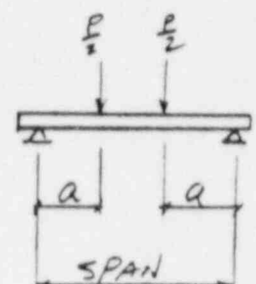
$\sigma = \frac{M}{S}$



$M = \frac{P}{2} \cdot a = \frac{P}{2} \times 0.8125'' = 0.406P$

$S = \frac{(4-1.125)(0.5)^2}{6} \cong 0.12^{in}$

$\sigma = 27^{ksi}$



or $27 = \frac{0.406P}{0.12}$

$\therefore P_{all} = 7.98^{kip} \approx 8000^{\#}$ PER LEG

↑

Shown in Table 4-13.9E

$a = \frac{1}{2}(3 - 1.125 - 0.25)$
$= 0.8125''$

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TABLE 4-13.9A (Span $\ell = B - 2t_c$)

U-BOLT SIZE: $\frac{1}{2}$" φ

ALLOWABLE CAPACITY OF WASHER PLATE OR TUBE WALL, F_A LB					
TUBE SIZE	WASHER ℓ THICKNESS				
WIDTH x THICKNESS	1/4"	5/16"	1/2"	3/4"	1"
2 x 1/4	2010	3140	8040	18,090	32,160
3 x 1/4	1,534	2396	6136	13,806	24,544
3 x 5/16	1,660	2593	6638	14,935	26,552
4 x 1/2	1,700	2655	6798	15,295	27,192

NOTES:

1. WASHER PLATE IS ASSUMED OF SQUARE SHAPE WITH SIDE DIMENSION SAME AS TUBE WIDTH.
2. IF NO WASHER PLATE EXISTS. THE TABULATED VALUES REPRESENT THE TUBE WALL CAPACITY FOR THE CORRESPONDING THICKNESSES.

TABLE 4-13.9B (Span $l = B - 2t_c$)

U-BOLT SIZE: $\frac{5}{8}$" ϕ

ALLOWABLE CAPACITY OF WASHER PLATE OR TUBE WALL, F_A LB			
TUBE SIZE	WASHER ℘ THICKNESS		
WIDTH x THICKNESS	¼"	½"	1"
2 x ¼	2,340	9360	37,440
3 x ¼	1,552	6208	24,832
4 x ½	1,737	6950	27,800

NOTES:

1. WASHER PLATE IS ASSUMED OF SQUARE SHAPE WITH SIDE DIMENSION SAME AS TUBE WIDTH.
2. IF NO WASHER PLATE EXISTS, THE TABULATED VALUES REPRESENT THE TUBE WALL CAPACITY FOR THE CORRESPONDING THICKNESS.

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TABLE 4-13.9C (span $l = B - 2t_c$)

U-BOLT SIZE: 3/4" φ

ALLOWABLE CAPACITY OF WASHER PLATE OR TUBE WALL, FA LB			
TUBE SIZE	WASHER PL THICKNESS		
WIDTH x THICKNESS	1/4"	1/2"	1"
2 x 1/4	2945	11,780	47,120
3 x 1/4	1,650	6600	26,400
4 x 1/2	1,828	7312	29,248

NOTES:

1. WASHER PLATE IS ASSUMED OF SQUARE SHAPE WITH SIDE DIMENSION SAME AS TUBE WIDTH.
2. IF NO WASHER PLATE EXISTS, THE TABULATED VALUES REPRESENT THE TUBE WALL CAPACITY FOR THE CORRESPONDING THICKNESS.

TABLE 4-13.9D (span $l = B - 2t_c$)

U-BOLT SIZE: 7/8" φ

ALLOWABLE CAPACITY OF WASHER PLATE OR TUBE WALL, FA (LB)						
TUBE SIZE	WASHER ℄ THICKNESS					
WIDTH x THICKNESS	3/16"	1/4"	3/8"	1/2"	3/4"	1"
3 x 1/4	997	1,772	3,987	7,088	15,948	28,352
3½ x 3/16	843	1,499	3,372	5,995	13,488	23,979
4 x 1/4	825	1,468	3,303	5,872	13,212	23,488
4 x 3/8	926	1,647	3,705	6,587	14,820	26,346
4 x 1/2	1,055	1,875	4,219	7,500	16,875	30,000
6 x 1/4	738	1,312	2,952	5,248	11,808	20,992
6 x 3/8	790	1,404	3,159	5,616	12,636	22,464
8 x 1/2	759	1350	3037	5400	12,150	21,600

NOTES:

1. WASHER PLATE IS ASSUMED OF SQUARE SHAPE WITH SIDE DIMENSION SAME AS TUBE WIDTH.
2. IF NO WASHER PLATE EXISTS, THE TABULATED VALUES REPRESENT THE TUBE WALL CAPACITY FOR THE CORRESPONDING THICKNESS.

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TABLE 4-13.9E (span $\ell = B - 2t_c$)

U-BOLT SIZE: 1"φ

ALLOWABLE CAPACITY OF WASHER PLATE OR TUBE WALL, F_A LB						
TUBE SIZE	WASHER PLATE THICKNESS					
WIDTH x THICKNESS	1/4"	5/16"	3/8"	1/2"	3/4"	1"
3 x 1/4	1873	2927	4215	7493	16860	29973
4 x 1/4	1525	2382	3431	6099	13723	24396
4 x 3/8	1723	2693	3878	6894	15510	27574
4 x 1/2	2000	3125	4500	8000	18000	32000
5 x 3/8	1524	2380	3428	6094	13712	24376
5 x 1/2	1675	2617	3768	6699	15072	26794
6 x 3/8	1409	2202	3171	5637	12682	22546
6 x 1/2	1510	2360	3398	6042	13593	24166
8 x 1/2	1381	2158	3108	5525	12431	22100
10 x 1/2	1311	2048	2950	5244	11799	20976

NOTES:

1. WASHER PLATE IS ASSUMED OF SQUARE SHAPE WITH SIDE DIMENSION SAME AS TUBE WIDTH
2. IF NO WASHER PLATE EXISTS, THE TABULATED VALUES REPRESENT THE TUBE WALL CAPACITY FOR THE CORRESPONDING THICKNESS

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TABLE 4-13.9F (span $\ell = B - 2t_c$)

U-BOLT SIZE : $1\frac{1}{2}''\phi$

ALLOWABLE CAPACITY OF WASHER PLATE OR TUBE WALL, F_A LB						
TUBE SIZE	WASHER PLATE THICKNESS					
WIDTH x THICKNESS	1/4"	5/16"	3/8"	1/2"	3/4"	1"
4 x 1/4	1,800	2,813	4,050	7200	16,200	28,800
4 x 3/8	2,143	3,348	4,821	8,572	19,286	34,286
4 x 1/2	2,700	4,219	6,075	10,800	24,300	43,200
5 x 3/8	1,680	2,625	3,780	6,720	15,120	26,880
5 x 1/2	1,890	2,953	4,253	7,560	17,010	30,240
6 x 3/8	1512	2362	3,401	6046	13,603	24,184
6 x 1/2	1,643	2,566	3,696	6,570	14,783	26,280
8 x 1/2	1431	2236	3,220	5,724	12,879	22,896
10 x 1/2	1350	2109	3038	5400	12,150	21,600

NOTES:

1. WASHER PLATE IS ASSUMED OF SQUARE SHAPE WITH SIDE DIMENSION SAME AS TUBE WIDTH.
2. IF NO WASHER PLATE EXISTS, THE TABULATED VALUES REPRESENT THE TUBE WALL CAPACITY FOR THE CORRESPONDING THICKNESS.

TABLE 4-13.9G (Span $l = B - 2t_c$)

U-BOLT SIZE : $1\frac{1}{4}$" ϕ

ALLOWABLE CAPACITY OF WASHER PLATE OR TUBE WALL, FA LB				
TUBE SIZE	WASHER PL THICKNESS			
WIDTH x THICKNESS	3/8"	1/2"	3/4"	1"
6 x 3/8	3,276	5,824	13,104	23,296

TABLE 4-13.9H (Span $l = B - 2t_c$)

U-BOLT SIZE : 2" ϕ

ALLOWABLE CAPACITY OF WASHER PLATE OR TUBE WALL, FA LB				
TUBE SIZE	WASHER PL THICKNESS			
WIDTH x THICKNESS	3/8"	1/2"	3/4"	1"
8 x 1/2	3,451	6,136	13,806	24,544

NOTES:

1. WASHER PLATE IS ASSUMED OF SQUARE SHAPE WITH SIDE DIMENSION SAME AS TUBE WIDTH.
2. IF NO WASHER PLATE EXISTS, THE TABULATED VALUES REPRESENT THE TUBE WALL CAPACITY FOR THE CORRESPONDING THICKNESS

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TABLE 4-13.9I (span $l = B - 2t_c$)

U-BOLT SIZE: $2\frac{1}{2}$" φ

ALLOWABLE CAPACITY OF WASHER PLATE OR TUBE WALL, F_A LB				
TUBE SIZE	WASHER ℄ THICKNESS			
WIDTH × THICKNESS	3/8"	1/2"	3/4"	1"
$7\frac{1}{2} \times \frac{1}{2}$	3,806	6,766	15,223	27,064

TABLE 4-13.9J (span $l = B - 2t_c$)

U-BOLT SIZE: $2\frac{3}{4}$" φ

ALLOWABLE CAPACITY OF WASHER PLATE OR TUBE WALL, F_A LB				
TUBE SIZE	WASHER ℄ THICKNESS			
WIDTH × THICKNESS	1/2"	3/4"	1"	
$6 \times \frac{1}{2}$	9,750	21,937	39,000	
$8 \times \frac{1}{2}$	6,687	15,045	26,817	

NOTES:

1. WASHER PLATE IS ASSUMED OF SQUARE SHAPE WITH SIDE DIMENSION SAME AS TUBE WIDTH.
2. IF NO WASHER PLATE EXISTS, THE TABULATED VALUES REPRESENT THE TUBE WALL CAPACITY FOR THE CORRESPONDING THICKNESS.

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TABLE 4-13.10A (Span $l = B - 4t_c$)

U-BOLT SIZE : $\frac{1}{2}$" φ

ALLOWABLE CAPACITY OF WASHER PLATE OR TOP CHORD OF TUBE, F_a					
TUBE SIZE	WASHER PL THICKNESS				
WIDTH × THICKNESS	1/4"	5/16"	1/2"	3/4"	1"
2 × 1/4	6187	9668	24750	43200*	57600*
3 × 1/4	2137	3340	8550	19237	34200
3 × 5/16	2672	4175	10687	24047	42750
4 × 1/2	3037	4746	12150	27337	48600

* Limited by shear capacity based on $0.4F_y$

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TABLE 4-13.10B (Span $l = B - 4t_c$)

U-BOLT SIZE: $\frac{5}{8}\phi$

ALLOWABLE CAPACITY OF WASHER PLATE OR TOP CHORD OF TUBE, F_A LB			
TUBE SIZE	WASHER PL THICKNESS		
WIDTH x THICKNESS	1/4"	1/2"	1"
2 x 1/4	14400*	28,800*	57,600*
3 x 1/4	2314	9255	37021
4 x 1/2	3342	13368	53485

*Limited by shear capacity based on $0.4 F_y$.

TABLE 4-13.10C (Span $l = 4t_c$)

U-BOLT SIZE: 3/4" ϕ

ALLOWABLE CAPACITY OF WASHER PLATE OR TOP CHIRD OF TUBE, F_A LB			
TUBE SIZE	WASHER PL THICKNESS		
WIDTH x THICKNESS	1/4"	1/2"	1"
2 x 1/4	N/A	N/A	N/A
3 x 1/4	2,550	10,200	40,800
4 x 1/2	3,750	15,000	60,000

← Wall Crippling controls (note beside the 2 x 1/4 row)

TABLE 4-13.10D (Span l = B - 4tc)

U-BOLT SIZE: 7/8" φ

ALLOWABLE CAPACITY OF WASHER PLATE OR TOP CHORD OF TUBE, F_A LB						
TUBE SIZE	WASHER ℄ THICKNESS					
WIDTH x THICKNESS	3/16"	1/4"	3/8"	1/2"	3/4"	1"
3 x 1/4	1,620	2880	6480	11,520	25,920	46,080
3 1/2 x 3/16	1033	1,836	4,132	7346	16,530	29,387
4 x 1/4	1065	1,894	4,263	7579	17,052	30,315
4 x 3/8	1481	2634	5,926	10,536	23,707	42,146
4 x 1/2	2,430	4,320	9,720	17280	38,880	69,120
6 x 1/4	836	1,487	3,347	5,950	13,388	23,801
6 x 3/8	964	1,714	3,857	6,857	15,428	27,428
8 x 1/2	926	1,647	3,705	6,588	14,823	26,353

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TABLE 4-13.10E (span $l = B - 4t_c$)

U-BOLT SIZE: 1"φ

ALLOWABLE CAPACITY OF WASHE PLATE OR TOP CHORD OF TUBE, FA_{LB}						
TUBE SIZE	WASHER PLATE THICKNESS					
WIDTH x THICKNESS	1/4"	5/16"	3/8"	1/2"	3/4"	1"
3 x 1/4	3375	5,273	7,593	13,500	30,375	54,000
4 x 1/4	1,990	3110	4,478	7,961	17,913	31,846
4 x 3/8	2,875	4,492	6,468	11,500	25,875	46,000
4 x 1/2	5,175	8,085	11,643	20,700	46,575	82,800
5 x 3/8	2,051	3,205	4,615	8,205	18,463	32,823
5 x 1/2	2,682	4,192	6,036	10,730	24,144	42,923
6 x 3/8	1,755	2,742	3,948	7,020	15,795	28,080
6 x 1/2	2,089	3,264	4,700	8,357	18,803	33,428
8 x 1/2	1,672	2,613	3,762	6,689	15,050	26,756
10 x 1/2	1,507	2,355	3,391	6,028	13,563	24,113

TABLE 4-13.10F (span $l = B - 4t_c$)

U-BOLT SIZE: $1\frac{1}{2}$" φ

ALLOWABLE CAPACITY OF WASHER PLATE OR TOP CHORD OF TUBE $F_{A_{GB}}$						
TUBE SIZE	WASHER PLATE THICKNESS					
WIDTH × THICKNESS	1/4"	5/16"	3/8"	1/2"	3/4"	1"
4 × 1/4	2,671	4,175	6011	10,687	24,046	42,750
4 × 3/8	5,343	8,349	12,023	21,375	48,093	85,500
4 × 1/2	N/A	N/A	N/A	N/A	N/A	N/A
5 × 3/8	2,531	3,955	5,695	10,125	22,781	40,500
5 × 1/2	3,797	5,932	8,543	15,187	34,172	60,750
6 × 3/8	1,968	3,076	4,429	7,875	17,718	31,500
6 × 1/2	2,461	3,845	5,537	9844	22,148	39,375
8 × 1/2	1,793	2,801	4034	7,172	16,137	28,687
10 × 1/2	1,570	2,453	3,533	6,281	14,133	25,125

N/A : Crippling of tube wall controls.

TABLE 4-13.10G (Span $l = B - 4t_c$)

U-BOLT SIZE : $1\frac{1}{4}$" ϕ

ALLOWABLE CAPACITY OF WASHER PLATE OR TOP CHORD OF TUBE, F_A LB				
TUBE SIZE	WASHER PLATE THICKNESS			
WIDTH x THICKNESS	3/8"	1/2"	3/4"	1"
6 x 3/8	4,162	7,400	16,650	29,600

TABLE 4-13.10H (Span $l = B - 4t_c$)

U-BOLT SIZE : 2" ϕ

ALLOWABLE CAPACITY OF WASHER PLATE OR TOP CHORD OF TUBE, F_A LB				
TUBE SIZE	WASHER PLATE THICKNESS			
WIDTH x THICKNESS	3/8"	1/2"	3/4"	1"
8 x 1/2	4,406	7,833	17,625	31,333

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TABLE 4-13.10 I (Span $l = B - 4t_c$)

U-BOLT SIZE : $2\frac{1}{2}"\phi$

ALLOWABLE CAPACITY OF WASHER PLATE OR TOP CHORD OF TUBE, F_A LB				
TUBE SIZE	WASHER PL THICKNESS			
WIDTH x THICKNESS	3/8"	1/2"	3/4"	1"
7½ x ½	5,484	9,750	21,937	39,000

TABLE 4-13.10 J (Span $l = B - 4t_c$)

U-BOLT SIZE : $2\frac{3}{4}"\phi$

ALLOWABLE CAPACITY OF WASHER PLATE OR TOP CHORD OF TUBE, F_A LB				
TUBE SIZE	WASHER PL THICKNESS			
WIDTH x THICKNESS	1/2"	3/4"	1"	
6 x ½	32,143	72,321	128,571	
8 x ½	9,461	21,288	37,846	

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REF.

LUG-TO-TUBE STEEL LOCAL STRESS

1. BY INSPECTION OF THE LUG LENGTH (ℓ_1) AND THE TUBE RADIUS (R), IT IS APPARENT THAT WHEN $\ell_1 < R$ THE FORCE IS TRANSFERRED THROUGH THE TUBE SIDE WALLS. WHEN $\ell_1 > R$, IT CAN BE ASSUMED THAT AFTER LOAD APPLICATION THE TOP CHORD WILL DEFLECT AND THE FORCE WILL TRANSFER THROUGH THE SIDE WALL.

2. THE BUCKLING CAPACITY OF THE TUBE STEEL SECTION (SIDE WALL BUCKLING) IS DETERMINED BY THE FOLLOWING EQUATION:

6 $$F = \hat{\sigma}_k (B + 5t_c) t_c \quad \text{(CONS.)}$$

FOR 70°F, $\hat{\sigma}_k$ = 36000 psi NOTE: B ≡ LUG WIDTH

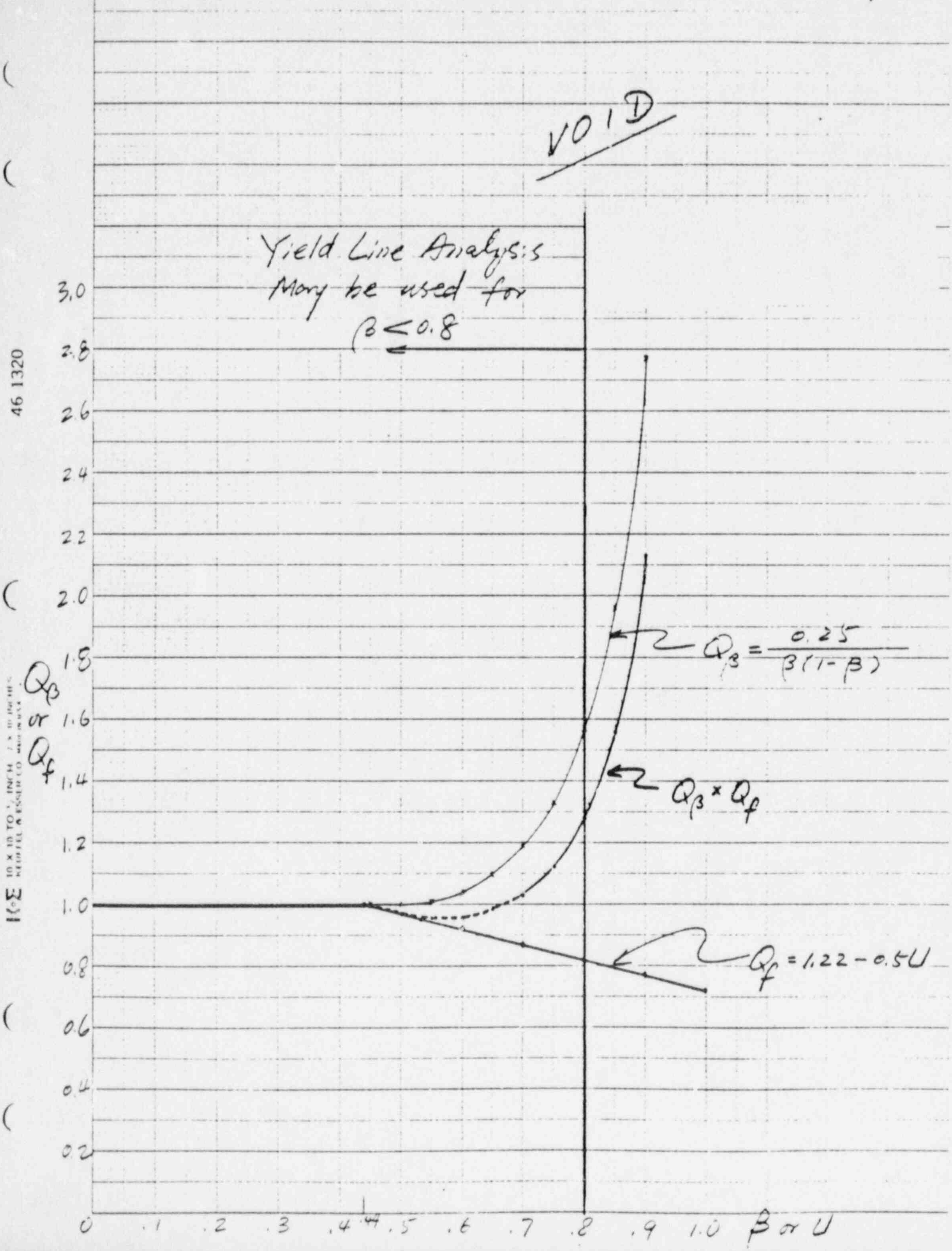
WITH B = 0 (POINT OR LINE CONTACT)

$$F = \hat{\sigma}_k 5 t_c^2$$

3. THE FOLLOWING TABLE CALCULATES THE CAPACITIES FOR VARIOUS TUBE STEEL WALL THICKNESSES:

TABLE 4-13.11

TUBE STEEL THICK (IN)	3/16	1/4	5/16	3/8	1/2	5/8
ALLOWABLE LOAD (LBS)	6328	11250	17578	25312	45,000	70,312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Yield Line Analysis May be used for β ≤ 0.8
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Qβ or Qf
Qβ = 0.25 / β(1-β)
Qβ × Qf
Qf = 1.22 - 0.5U
0
.1
.2
.3
.4
.44
.5
.6
.7
.8
.9
1.0
β or U

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1B. FOR MATCHED TUBE CONNECTION ($\beta = 1.0$) — ALL AROUND WELDS

(Results are shown in Tables 4-13.2A ~ 4-13.2G)

PER SEC. 10.5.1.1 OF AWS CODE, ALLOWABLE STATIC CAPACITY FOR LOADS NORMAL TO THE MAIN MEMBER SHALL BE TAKEN AS THE SUM OF F_1 AND F_2 AS FOLLOWS:

(1) ALONG THE SIDES, WEB CRIPPLING CAPACITY OF THE MAIN MEMBER

$$F_1 = 2 t_c a_x (0.6 Q_f F_y)$$

(2) ALONG THE HEEL AND TOE. PUNCHING SHEAR (TAKEN AS SINGLE SHEAR) IN ACCORDANCE WITH 10.5.1, EXCEPT

$$Q_\beta = 1.25(1+\eta) \quad \text{for } \eta < 1.0$$

$$Q_\beta = 2.5 \quad \text{for } \eta \geq 1.0$$

WHERE $\eta = a_x / D$

THUS $F_2 = 2 t_c b \left[Q_\beta \cdot Q_f \cdot \frac{F_y}{0.6 \gamma} \right]$

$$F = F_1 + F_2$$

$$= 1.2\, t_c Q_f F_y \left[\frac{a}{0.6} + \frac{t_c Q_\beta}{0.18} \right]$$

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EXA: CAPACITY FOR THE JOINT OF TS 5×5×1/4 (MAIN MEMBER) AND TS 5×5×t (BRANCH MEMBER) WITH U = 0.7

$\eta = \frac{5}{5} = 1.0 \quad Q_\beta = 2.5 \quad Q_f = 1.22 - 0.5U = 1.22 - 0.5\times0.7 = 0.87$

$$\therefore F = 1.2\, t_c Q_f F_y \left[\frac{a}{\sin\theta} + \frac{t_c Q_\beta}{0.18}\right]$$

$$= 1.2\times0.25\times36000\, Q_f \left[\frac{5}{\sin 90^\circ} + \frac{0.25\times2.5}{0.18}\right]$$

$$= 10800\, Q_f [5 + 3.472]$$

$$= 10800\times0.87\,(8.472)$$

$$= 79603^{\#}$$

$\approx 79^{kips}$ (SHOWN IN THE TABLE)

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EXA IF BRANCH MEMBER : TS 5×3×t

MAIN MEMBER : TS 5×5×1/4 AND U = 0.7

THEN $\eta = \frac{3}{5} = 0.6 \quad Q_\beta = 1.25(1+\eta) = 2.0 \quad Q_f = 0.87$

THEREFORE

$$F = 1.2\, t_c Q_f F_y \left[\frac{a}{\sin\theta} + \frac{t_c Q_\beta}{0.18}\right]$$

$$= 1.2\times0.25\times0.87\times36000 \left[\frac{3}{\sin 90} + \frac{0.25\times2.0}{0.18}\right]$$

$$= 54288^{\#}$$

$\approx 54^{kips}$. (SHOWN IN THE TABLE)

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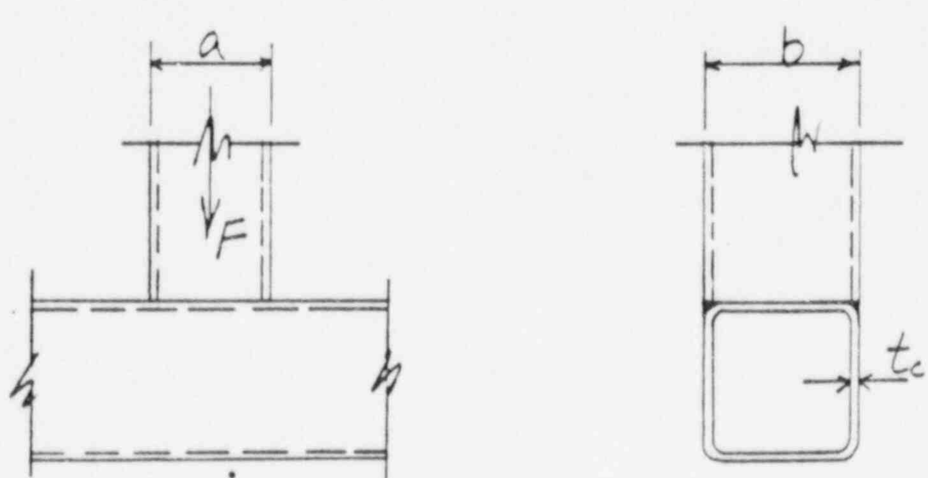
Tables 4-13.2A ~ 4-13.2G are to be used for matched Tube Connection ($\beta = 1.0$) — welded all around.

$TS\ 10 \times 10 \times t_c$ TABLE 4-13.2A

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER (KIPS)								
$t_{c\ IN}$	a_{IN}	$U \leq 0.44$	$U = 0.5$	$U = 0.6$	$U = 0.7$	$U = 0.8$	$U = 0.9$	$U = 1.0$
1/4	10	145	141	133	126	119	112	104
	6	94	92	87	82	77	73	68
3/8	10	246	239	226	214	202	190	177
	6	164	159	151	143	135	126	118
1/2	10	366	355	336	318	300	282	263
	6	249	242	229	217	204	192	179
5/8	10	504	489	464	438	413	388	363
	6	349	339	321	304	286	269	251



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STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

ATTACHMENT 'A1'

Do. 1.5

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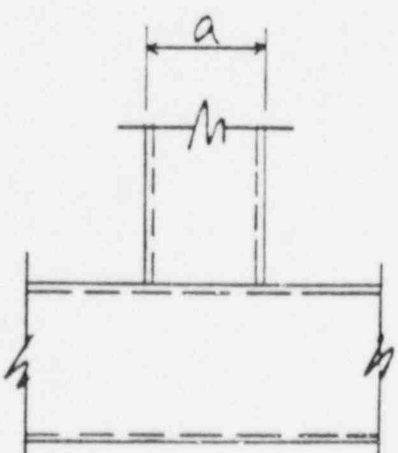
TABLE 4-13.2B

TS 8 × 8 × t_c

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER (KIPS)								
t_c, IN	a, IN	U ≤ 0.44	U = 0.5	U = 0.6	U = 0.7	U = 0.8	U = 0.9	U = 1.0
1/4	8	124	120	114	107	101	95	89
	6	97	94	90	85	80	75	70
3/8	8	214	207	197	186	175	165	154
	6	171	166	157	149	140	131	123
1/2	8	322	313	297	280	264	248	232
	6	261	253	240	227	214	201	188
5/8	8	450	437	414	392	369	347	324
	6	367	356	338	319	301	282	364



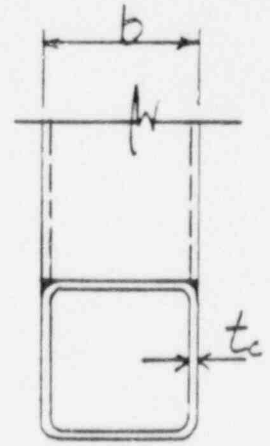


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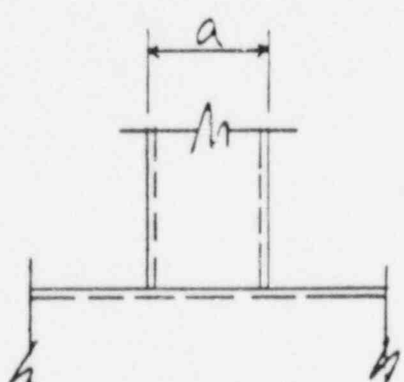
TABLE 4-13.2C

TS 6 × 6 × t_c

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER (Kips)								
$t_{c,IN}$	a_{IN}	$U \le 0.44$	$U=0.5$	$U=0.6$	$U=0.7$	$U=0.8$	$U=0.9$	$U=1.0$
1/4	6	102	99	94	89	84	79	73
	4	74	72	68	65	61	57	53
5/16	6	139	135	128	121	114	107	100
	4	103	99	94	89	84	79	74
3/8	6	181	176	167	158	149	140	131
	4	135	131	124	117	110	104	97
1/2	6	279	271	257	243	229	215	201
	4	211	205	194	184	173	163	152



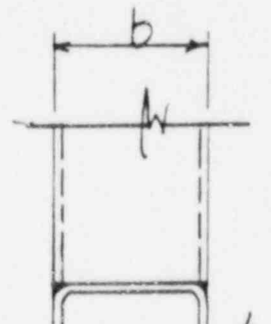


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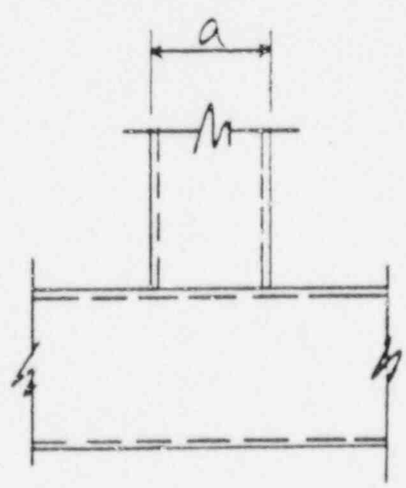
TABLE 4-13.2D

TS 5 × 5 × t_c

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER (KIPS)								
t_c IN	a IN	U ≤ 0.44	U = 0.5	U = 0.6	U = 0.7	U = 0.8	U = 0.9	U = 1.0
1/4	5	91	89	84	79	75	70	66
	3	62	60	57	54	51	48	45
5/16	5	126	122	116	109	103	97	91
	3	87	85	80	76	72	67	63
3/8	5	165	160	152	144	135	127	119
	3	116	112	107	101	95	89	83
1/2	5	258	250	237	224	211	198	186
	3	184	179	170	161	151	142	133



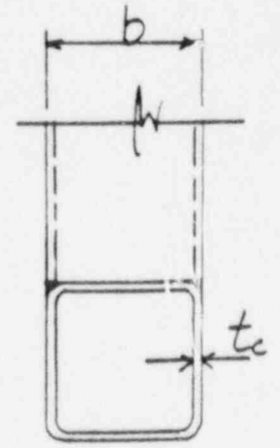


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TABLE 4-13.2E

TS 4 × 4 × t_c

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER (KIPS)								
$t_{c\,IN}$	a_{IN}	U≤0.44	U=0.5	U=0.6	U=0.7	U=0.8	U=0.9	U=1.0
3/16	4	53	52	49	46	44	41	38
	2	32	31	29	28	26	24	23
1/4	4	81	78	74	70	66	62	58
	2	50	48	46	43	41	38	36
5/16	4	112	109	103	98	92	87	81
	2	71	69	65	62	58	54	51
3/8	4	149	144	137	130	122	115	107
	2	95	93	88	83	78	74	69
1/2	4	236	229	217	205	194	182	170
	2	155	151	143	135	128	120	112

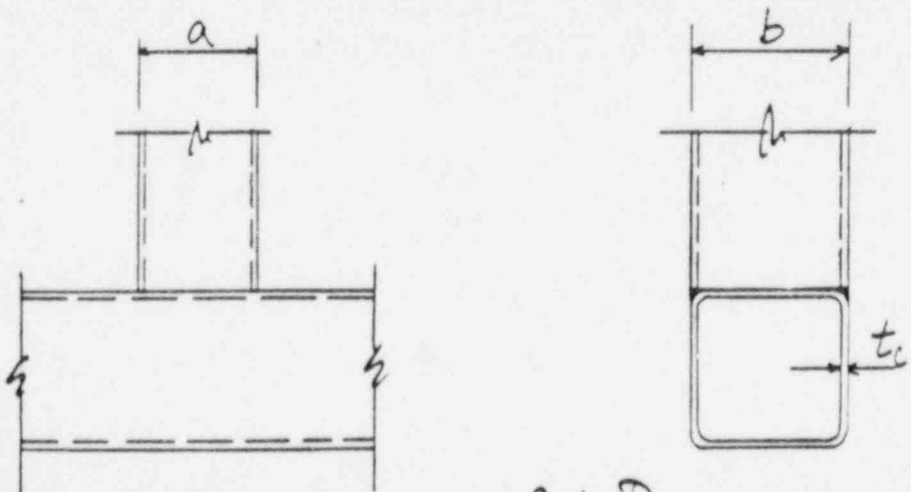

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TABLE 4-13.2F

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TS 3 × 3 × t_c

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER (KIPS)								
t_c IN.	a IN.	U ≤ 0.44	U = 0.5	U = 0.6	U = 0.7	U = 0.8	U = 0.9	U = 1.0
3/16	3	45	44	42	39	37	35	33
	2	34	33	31	29	28	2[illegible]	24
1/4	3	70	68	64	61	57	54	50
	2	53	51	48	46	43	41	38

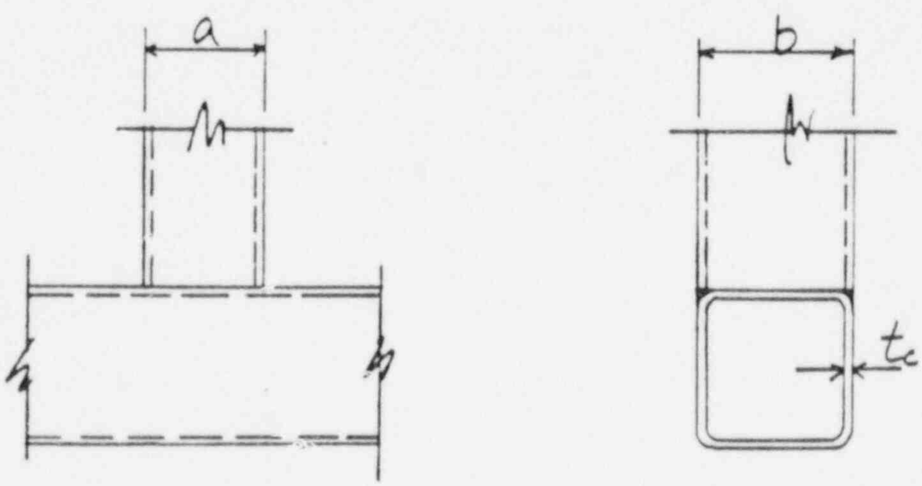

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TABLE 4-13.2G

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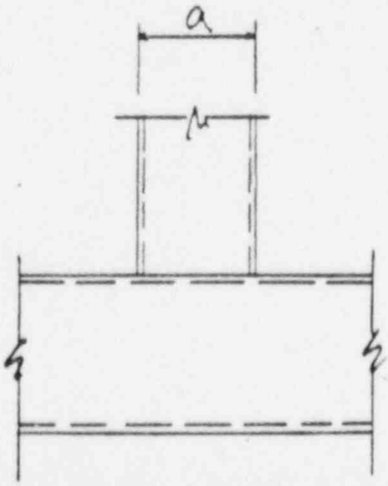
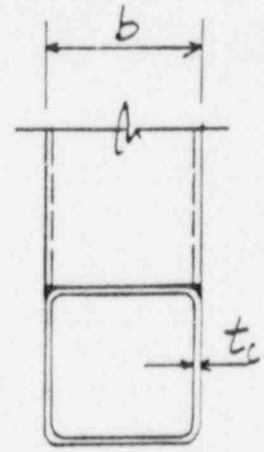
TS 2 × 2 × t_c

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER

t_c IN	a IN	U≤0.44	U=0.5	U=0.6	U=0.7	U=0.8	U=0.9	U=1.0
3/16	2	37	36	34	32	30	29	27
1/4	2	59	57	54	51	48	45	42





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1C. FOR STEPPED TUBE CONNECTIONS ($\beta > 0.8$ or $\beta > \eta$)
(Results shown in Tables 4-13.3A ~ 3E) (joint is of all-aroundweld)
PER SEC. 10.5.1.3. THE ALLOWABLE STATIC CAPACITY FOR LOADS NORMAL TO THE MAIN MEMBER SHALL BE COMPUTED IN ACCORDANCE WITH 10.5.1 BUT SHALL NOT EXCEED THE SUM OF $F_1 + F_2$.

$$F_1 = 2t_c a_x (0.4F_y)$$

$$F_2 = 2t_c b \left[Q_\beta \cdot Q_f \cdot \frac{F_y}{0.6 \gamma} \right]$$

VOID

$$F = F_1 + F_2 = 2t_c a_x (0.4F_y) + 2t_c b \left[Q_\beta \cdot Q_f \times \frac{F_y}{0.6 \gamma} \right]$$

$$= 0.8 t_c F_y \left[a + \frac{\beta t_c Q_\beta Q_f}{0.12} \right]$$

EXAMPLE: TS 4 x 4 x t (BRANCH MEMBER) TO TS 5 x 5 x 1/4 (MAIN MEMBER)

$\eta = 4/5 = 0.8 \quad Q_\beta = 1.25(1+0.8) = 2.25$

$$F = 0.8 t_c F_y \left[a + \frac{\beta t \cdot Q_\beta Q_f}{0.12} \right]$$

$$= 0.8 \times 0.25 \times 36000 \left[4 + \frac{0.8 \times 0.25 \times 2.25 \times Q_f}{0.12} \right]$$

$$= 7200 [4 + 3.75 Q_f] \qquad \text{FOR } U = 0.5$$

$$= 7200 [4 + 3.75 \times 0.97] \qquad Q_f = 1.22 - 0.5 \times 0.5 = 0.97$$

$= 54990^{\#} \approx 55^{KIPS}$ (SHOWN IN THE TABLE)

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

A 5010.65 ATTACHMENT 'A1' PG. 1.1

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Tables 4-13.3A ~ 3E are to be used for stepped tube connections ($0.8 < \beta < 1.0$) — welded all around.

TABLE 4-13.3A

MAIN MEMBER: TS 5×5×t_c

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER (Kips)

t_c IN.	BRANCH MEMBER	$U \le 0.44$	$U = 0.5$	$U = 0.6$	$U = 0.7$	$U = 0.8$	$U = 0.9$	$U = 1.0$
3/16	TS4×4	37	36	35	35	34	33	32
	TS4×2	23	22	22	21	20	20	19
1/4	TS4×4	56	55	54	52	51	50	48
	TS4×2	35	35	34	33	32	31	30
5/16	TS4×4	78	77	75	73	71	68	66
	TS4×2	51	50	48	47	45	43	42
3/8	TS4×4	104	102	99	96	93	90	87
	TS4×2	69	67	65	63	60	58	56
1/2	TS4×4	166	162	157	152	146	141	135
	TS4×2	113	110	106	102	98	93	89

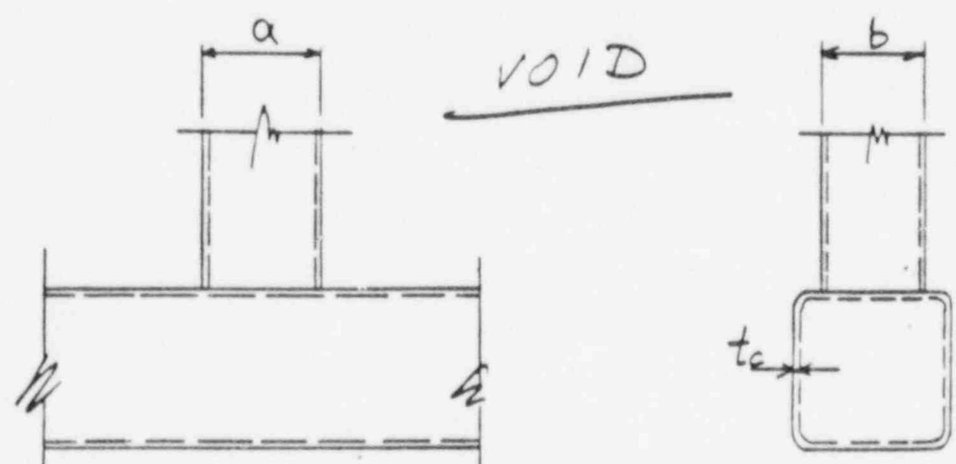

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TABLE 4-13.3B

VOID

MAIN MEMBER : TS 6 × 6 × t_c

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER (KIPS)								
t_c IN.	BRANCH MEMBER	U ≤ 0.44	U = 0.5	U = 0.6	U = 0.7	U = 0.8	U = 0.9	U = 1.0
1/4	TS 5×5	64	63	62	60	59	58	56
	TS 5×3	45	44	43	42	40	39	38
5/16	TS 5×5	89	87	85	83	81	79	76
	TS 5×3	63	62	60	58	56	55	53
3/8	TS 5×5	117	115	112	109	106	102	99
	TS 5×3	84	82	80	77	75	72	70
1/2	TS 5×5	184	181	175	169	164	158	156
	TS 5×3	135	132	128	123	118	114	109

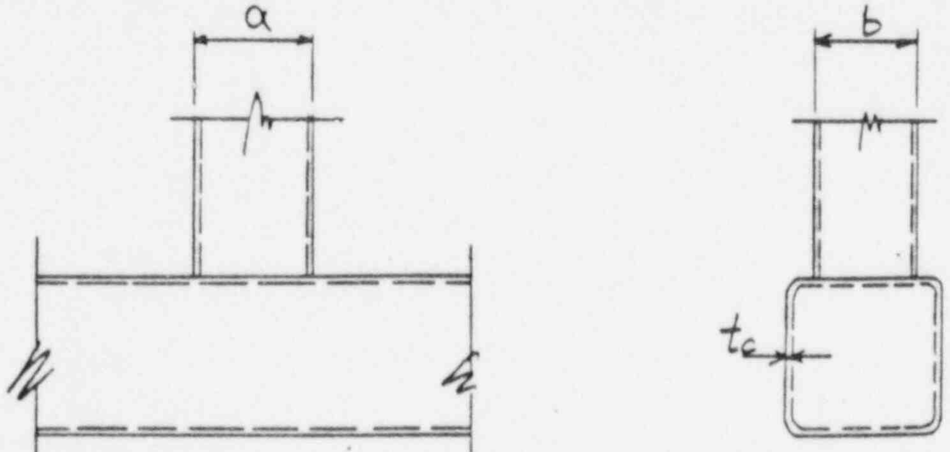

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TABLE 4-13.3C

VOID

MAIN MEMBER: TS 8 × 8 × t_c

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER (KIPS)

t_c IN.	BRANCH MEMBER	U ≤ 0.44	U = 0.5	U = 0.6	U = 0.7	U = 0.8	U = 0.9	U = 1.0
1/4	TS 7×7	81	80	79	77	76	74	73
	TS 7×5	63	62	62	59	58	57	55
5/16	TS 7×7	111	110	107	105	102	100	98
	TS 7×5	87	85	83	81	79	77	75
3/8	TS 7×7	145	143	139	136	132	129	125
	TS 7×5	114	112	109	106	103	100	97
1/2	TS 7×7	224	220	214	208	202	196	189
	TS 7×5	179	175	170	165	159	154	149
5/8	TS 7×7	318	312	303	293	283	274	264
	TS 7×5	257	252	243	235	227	218	210

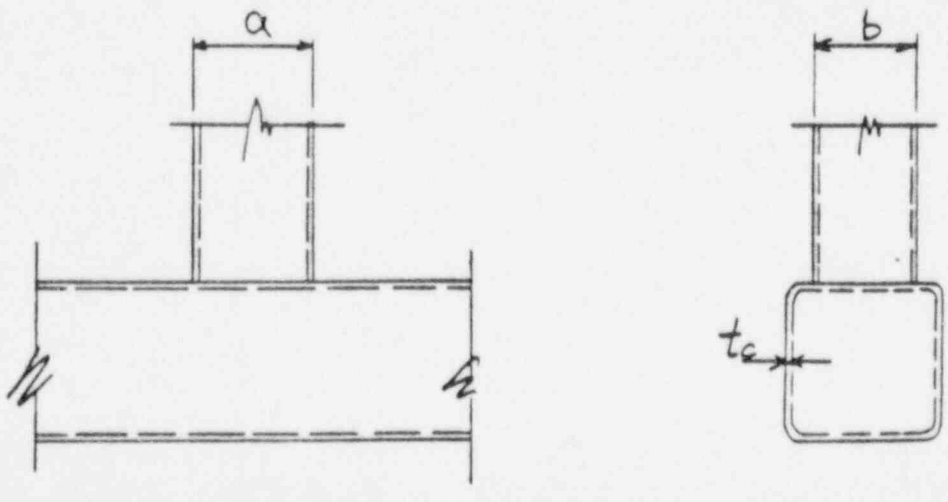

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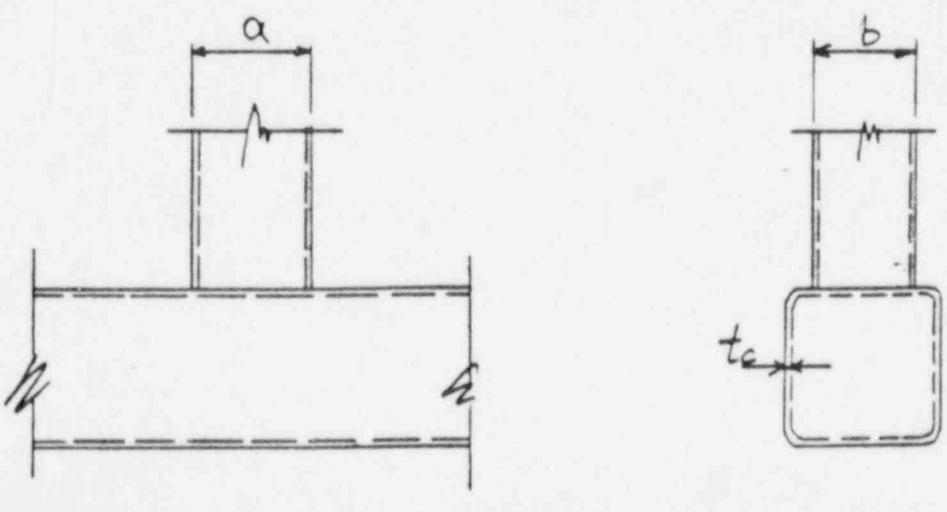
TABLE 4-13.3D

VOID

MAIN MEMBER: TS 10 x 10 x t_c

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER (KIPS)

t_c IN.	BRANCH MEMBER	U ≤ 0.44	U = 0.5	U = 0.6	U = 0.7	U = 0.8	U = 0.9	U = 1.0
1/4	TS8x8	85	84	82	81	80	78	77
	TS8x6	67	66	65	64	63	62	60
3/8	TS8x8	147	145	142	139	136	133	130
	TS8x6	119	117	114	112	109	106	104
1/2	TS8x8	223	220	215	209	204	198	193
	TS8x6	182	180	175	170	165	160	156
5/8	TS8x8	313	308	299	291	282	274	266
	TS8x6	258	253	250	239	231	223	216



STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

A 5010 65 ATTACHMENT 'A1' PG 1.16

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 41
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TABLE 4-13.3E

VOID

MAIN MEMBER: TS 12 x 12 x t_c

ALLOWABLE LOADS, F, NORMAL TO THE MAIN MEMBER (KIPS)

t_c IN.	BRANCH MEMBER	U ≤ 0.44	U = 0.5	U = 0.6	U = 0.7	U = 0.8	U = 0.9	U = 1.0
1/4	TS10x10	101	100	98	97	95	94	93
	TS10x6	67	66	65	64	62	61	60
3/8	TS10x10	172	170	167	164	161	158	154
	TS10x6	118	116	113	111	108	105	103
1/2	TS10x10	258	255	249	244	238	232	226
	TS10x6	180	177	173	168	163	159	154
5/8	TS10x10	359	353	345	336	327	318	309
	TS10x6	254	250	243	235	228	221	213

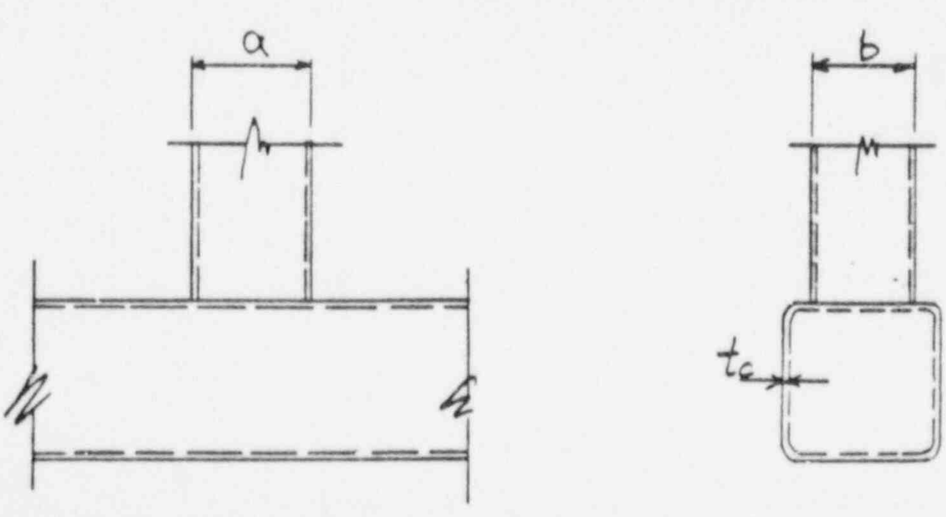

TABLE 4.13.4B VOID

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET 1½" × 3" × ½" H = 2" F = 4960 lb

TUBE SIZE AND THICKNESS	LOAD TYPE "A"			LOAD TYPE "B"		
	‖	=	□	‖	=	□
* TS 2×2×1/4	1.0	1.0	1.0	0.37	0.51	1.0
* TS 3×3×1/4	1.0	1.0	1.0	0.23	0.71	1.0
TS 4×4×3/16	0.7	1.0	1.0	—	0.45	0.52
TS 4×4×1/4	1.0	1.0	1.0	0.14	0.80	0.94
TS 4×4×5/16	1.0	1.0	1.0	0.22	1.0	1.0
TS 4×4×3/8	1.0	1.0	1.0	0.32	1.0	1.0
TS 4×4×1/2	1.0	1.0	1.0	0.54	1.0	1.0
TS 5×5×3/16	0.51	1.0	1.0	—	0.36	0.42
TS 5×5×1/4	0.9	1.0	1.0	0.11	0.64	0.76
TS 5×5×3/8	1.0	1.0	1.0	0.35	1.0	1.0
TS 5×5×1/2	1.0	1.0	1.0	0.45	1.0	1.0
TS 6×6×3/16	0.42	0.85	1.0	—	0.30	0.35
TS 6×6×1/4	0.75	1.0	1.0	—	0.53	0.63
TS 6×6×5/16	1.0	1.0	1.0	0.15	0.83	0.98
TS 6×6×3/8	1.0	1.0	1.0	0.21	1.0	1.0
TS 6×6×1/2	1.0	1.0	1.0	0.38	1.0	1.0
TS 8×8×1/4	0.57	1.0	1.0	—	0.40	0.47
TS 8×8×3/8	1.0	1.0	1.0	0.16	0.9	1.0
TS 8×8×1/2	1.0	1.0	1.0	0.28	1.0	1.0
TS 10×10×3/8	1.0	1.0	1.0	[illegible]	0.7?	0.84
TS 10×10×1/2	1.0	1.0	1.0	0.23	1.0	1.0
TS 10×10×5/8	1.0	1.0	1.0	0.35	1.0	1.0
TS 12×12×3/8	0.85	1.0	1.0	0.11	0.60	0.71
TS 12×12×1/2	1.0	1.0	1.0	0.19	1.0	1.0
TS 14×14×1/2	1.0	1.0	1.0	0.16	0.91	1.0

TABLE 4-13 4C

VOID

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET 2 1/4 × 3 1/2 × 3/4 H = 2.5" F = 8000 LB

	TUBE SIZE AND THICKNESS	LOAD TYPE "A"			LOAD TYPE "B"		
		∥	=	□	∥	=	□
	TS 2×2×1/4	1.0	1.0	1.0	0.43	1.0	1.0
*	TS 3×3×1/4	1.0	1.0	1.0	0.28	0.69	1.0
*	TS 4×4×3/16	0.59	1.0	1.0	—	0.35	0.49
*	TS 4×4×1/4	1.0	1.0	1.0	0.16	0.58	0.87
*	TS 4×4×5/16	1.0	1.0	1.0	0.25	0.83	1.0
*	TS 4×4×3/8	1.0	1.0	1.0	0.36	1.0	1.0
*	TS 4×4×1/2	1.0	1.0	1.0	0.61	1.0	1.0
	TS 5×5×3/16	0.47	0.74	1.0	—	0.3-	0.38
	TS 5×5×1/4	0.84	1.0	1.0	0.13	0.54	0.69
*	TS 5×5×3/8	1.0	1.0	1.0	0.28	1.0	1.0
*	TS 5×5×1/2	1.0	1.0	1.0	0.51	1.0	1.0
	TS 6×6×3/16	0.4	0.62	1.0	—	0.25	0.32
	TS 6×6×1/4	0.70	1.0	1.0	0.11	0.45	0.58
	TS 6×6×5/16	1.0	1.0	1.0	0.16	0.71	0.89
	TS 6×6×3/8	1.0	1.0	1.0	0.23	1.0	1.0
	TS 6×6×1/2	1.0	1.0	1.0	0.42	1.0	1.0
	TS 8×8×1/4	0.53	0.82	1.0	—	0.34	0.43
	TS 8×8×3/8	1.0	1.0	1.0	0.17	0.76	0.97
	TS 8×8×1/2	1.0	1.0	1.0	0.32	1.0	1.0
	TS 10×10×3/8	0.95	1.0	1.0	0.14	0.61	0.78
	TS 10×10×1/2	1.0	1.0	1.0	0.25	1.0	1.0
	TS 10×10×5/8	1.0	1.0	1.0	0.39	1.0	1.0
	TS 12×12×3/8	0.79	1.0	1.0	0.12	0.51	0.65
	TS 12×12×1/2	1.0	1.0	1.0	0.21	0.90	1.0
	TS 14×14×1/2	1.0	1.0	1.0	0.18	0.77	0.99

VOID

TABLE 4-13.4D

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET: 3 × 4 1/2 × 1.0 H = 3 3/16 F = 15700 LB

	TUBE SIZE AND THICKNESS	LOAD TYPE 'A'			LOAD TYPE 'B'		
		‖	=	□	‖	=	□
	TS 3×3×1/4	1.0	1.0	1.0	0.32	0.88	1.0
*	TS 4×4×3/16	0.53	0.56	1.0	—	0.25	0.44
*	TS 4×4×1/4	0.88	0.95	1.0	0.15	0.4	1.0
*	TS 4×4×5/16	1.0	1.0	1.0	0.23	0.58	1.0
*	TS 4×4×3/8	1.0	1.0	1.0	0.33	0.73	1.0
*	TS 4×4×1/2	1.0	1.0	1.0	0.42	1.0	1.0
*	TS 5×5×3/16	0.33	0.47	1.0	—	0.21	0.27
*	TS 5×5×1/4	0.6	0.79	1.0	—	0.33	0.5
*	TS 5×5×3/8	1.0	1.0	1.0	0.21	0.78	1.0
*	TS 5×5×1/2	1.0	1.0	1.0	0.37	1.0	1.0
	TS 6×6×3/16	0.27	0.4	0.67	—	0.17	0.22
	TS 6×6×1/4	0.47	0.72	1.0	—	0.31	0.4
*	TS 6×6×5/16	0.74	1.0	1.0	0.12	0.48	0.62
*	TS 6×6×3/8	1.0	1.0	1.0	0.17	0.69	0.89
*	TS 6×6×1/2	1.0	1.0	1.0	0.30	1.0	1.0
	TS 8×8×1/4	0.35	0.54	0.9	—	0.23	0.30
	TS 8×8×3/8	0.8	1.0	1.0	0.12	0.51	0.67
	TS 8×8×1/2	1.0	1.0	1.0	0.23	0.92	1.0
	TS 10×10×3/8	0.64	0.97	1.0	0.1	0.41	0.54
	TS 10×10×1/2	1.0	1.0	1.0	0.18	0.73	0.95
	TS 10×10×5/8	1.0	1.0	1.0	0.28	1.0	1.0
	TS 12×12×3/8	0.54	0.80	1.0	—	0.39	0.45
	TS 12×12×1/2	0.95	1.0	1.0	0.15	0.61	0.80
	TS 14×14×1/2	0.81	1.0	1.0	0.13	0.52	0.68

VOID

TABLE 4-13.4E

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET 7×7×1.0 H = 4" F = 33500 LB

TUBE SIZE AND THICKNESS	LOAD TYPE "A"			LOAD TYPE B		
	‖	=	□	‖	=	□
TS 6×6×3/16	0.62	0.62	1.0	0.18	0.42	1.0
TS 6×6×1/4	1.0	1.0	1.0	0.31	0.74	1.0
TS 6×6×5/16	1.0	1.0	1.0	0.49	1.0	1.0
TS 6×6×3/8	1.0	1.0	1.0	0.7	1.0	1.0
TS 6×6×1/2	1.0	1.0	1.0	1.0	1.0	1.0
TS 8×8×1/4	0.92	0.92	1.0	0.25	0.61	1.0
* TS 8×8×3/8	1.0	1.0	1.0	0.58	1.0	1.0
* TS 8×8×1/2	1.0	1.0	1.0	1.0	1.0	1.0
TS 10×10×3/8	0.84	0.84	1.0	0.24	0.56	0.78
TS 10×10×1/2	1.0	1.0	1.0	0.42	0.99	1.0
TS 10×10×5/8	1.0	1.0	1.0	0.65	1.0	1.0
TS 12×12×3/8	0.61	0.61	1.0	0.17	0.41	0.56
TS 12×12×1/2	1.0	1.0	1.0	0.3.	0.71	1.0
TS 14×14×1/2	0.90	0.90	1.0	0.25	0.59	0.83

EXAMPLE

BRACKET 7"×7"×1 H = 4" F = 33500 LB

TUBE 10×10×3/8

$\beta = 0.7 \quad \gamma = 13.33 \quad \eta = 0.7$

LOAD TYPE "A" (‖ TYPE WELD)

$F_w = F/C = 33500 \div 14 = 2393\ \#/"$ $\qquad Q_\beta = \frac{0.25}{0.7(1-0.7)} = 1.19$

$V_p' = F_W/t_e = 2393 \div 0.375 = 6381\ psi$

$V_p = \frac{F_y}{0.6\gamma} Q_\beta Q_f = \frac{36000}{0.6 \times 13.3} \times 1.19 \times 1.0 = 5370\ psi$

$K = \frac{V_p}{V_p'} = \frac{4511}{6381} = 0.84$ (SEE NUMBER IN THE TABLE)

TABLE 4-13.4F VOID

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET 10 x 10 x 1½ H = 5¼" F = 50600 LB

TUBE SIZE AND THICKNESS	LOAD TYPE "A"			LOAD TYPE "B"		
	‖	=	□	‖	=	□
TS 8x8x1/4	0.74	0.74	1.0	0.22	0.51	1.0
TS 8x8x3/8	1.0	1.0	1.0	0.5	1.0	1.0
TS 8x8x1/2	1.0	1.0	1.0	0.9	1.0	1.0
TS 10x10x3/8	1.0	1.0	1.0	0.5	1.0	1.0
TS 10x10x1/2	1.0	1.0	1.0	0.9	1.0	1.0
TS 10x10x5/8	1.0	1.0	1.0	1.0	1.0	1.0
TS 12x12x3/8	1.0	1.0	1.0	0.39	0.88	1.0
TS 12x12x1/2	1.0	1.0	1.0	0.68	1.0	1.0
TS 14x14x1/2	1.0	1.0	1.0	0.31	0.71	1.0

TABLE 4-13.4G

VOID

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET 12½" × 12½" × 2" H = 8" F = 123000 LB

TUBE SIZE AND THICKNESS	LOAD TYPE "A"			LOAD TYPE "B"		
	||	=	□	||	=	□
TS 10×10×3/8	0.69	0.69	1.0	0.17	0.42	1.0
TS 10×10×1/2	1.0	1.0	1.0	0.31	0.76	1.0
TS 10×10×5/8	1.0	1.0	1.0	0.50	1.0	1.0
TS 12×12×3/8	0.69	0.69	1.0	0.17	0.42	1.0
TS 12×12×1/2	1.0	1.0	1.0	0.31	0.76	1.0
TS 14×14×1/2	1.0	1.0	1.0	0.25	0.64	1.0

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TABLE 4-13.7F

$\gamma = 10$ BASIC $V_p = 6000$

ALLOWABLE TENSILE WELD UNIT FORCE Fw (lb/in)

ALLOWABLE FILLET WELD SIZE W (IN)

t_c \ Ω	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	2115	2260	2396	2537	2677	2812
	0.142	0.151	0.161	0.170	0.180	0.189
0.25	2820	3000	3195	3375	3570	3750
	0.19	0.202	0.215	0.227	0.24	0.253
0.3125	3525	3750	3994	4219	4463	4688
	0.237	0.253	0.269	0.284	0.301	0.316
0.375	4230	4500	4793	5063	5355	5625
	0.285	0.303	0.323	0.341	0.361	0.380
0.50	5640	6000	6390	6750	7140	7500
	0.380	0.404	0.430	0.455	0.481	0.505

VOID

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TABLE 4-13.7G

$\gamma = 9.33$ BASIC $V_p = 6431$

ALLOWABLE TENSILE WELD UNIT FORCE F_W (lb/in)
ALLOWABLE FILLET WELD SIZE W (in)

t_e \ η	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	2267	2412	2568	2713	2870	3014
	0.153	0.162	0.173	0.183	0.193	0.203
0.25	3022	3215	3424	3617	3826	4019
	0.203	0.217	0.231	0.244	0.258	0.271
0.3125	3778	4019	4281	4522	4783	5024
	0.254	0.271	0.288	0.305	0.322	0.338
0.375	4534	4823	5137	5426	5740	6029
	0.305	0.325	0.346	0.365	0.387	0.406
0.50	6045	6431	6849	7235	7653	8039
	0.407	0.433	0.461	0.487	0.515	0.541

VOID

A 5010 65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO. 15454	DIVISION & GROUP NZ(C)	CALCULATION NO. GENX-023	OPTIONAL TASK CODE	PAGE 88

TABLE 4-13.7H

$\gamma = 8$ BASIC $V_p = 7500$

ALLOWABLE TENSILE WELD UNIT FORCE Fw(lb/in)
ALLOWABLE FILLET WELD SIZE W(in)

t_c \ Ω	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	2644	2812	2995	3164	3347	3517
	0.178	0.189	0.202	0.213	0.225	0.237
0.25	3525	3750	3994	4219	4463	4688
	0.237	0.253	0.269	0.284	0.301	0.316
0.3125	4406	4687	4992	5273	5578	5859
	0.297	0.316	0.336	0.355	0.376	0.395
0.375	5287	5625	5991	6328	6694	7031
	0.356	0.379	0.403	0.426	0.451	0.474
0.50	7050	7500	7987	8437	8925	9375
	0.475	0.505	0.538	0.568	0.601	0.631

VOID

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

ATTACHMENT 'A1' PG 1.26

A 5010 65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO. 15454	DIVISION & GROUP NZ(C)	CALCULATION NO. GENX-023	OPTIONAL TASK CODE	PAGE 89

TABLE 4-13.7I

$\gamma = 6$ BASIC V_p = 10000 psi

ALLOWABLE TENSILE WELD UNIT FORCE F_w (lb/in)

ALLOWABLE FILLET WELD SIZE W (in)

t_e \ Ω	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	3525	3750	3994	4050	4050	4050
	0.237	0.253	0.269	0.273	0.273	0.273
0.25	4700	5000	5325	5400	5400	5400
	0.317	0.337	0.359	0.364	0.364	0.364
0.3125	5875	6250	6656	6750	6750	6750
	0.396	0.421	0.448	0.455	0.455	0.455
0.375	7050	7500	7987	8100	8100	8100
	0.475	0.505	0.538	0.546	0.546	0.546
0.50	9400	10000	10650	10800	10800	10800
	0.633	0.673	0.717	0.7	0.7	0.7

VOID

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 90
15454	NE(C)	GENX-023		

TABLE 4-13.7J

$\gamma = 5$ BASIC V_p = 12000 psi

ALLOWABLE TENSILE WELD UNIT FORCE F_w (lb/in)
ALLOWABLE FILLET WELD SIZE W (in)

t_e \ Ω	0.50	0.60	0.70	0.80	0.90	1.0
0.1875	4230	4500	4793	5063	5355	5625
	0.285	0.303	0.323	0.341	0.361	0.379
0.25	5640	6000	6390	6750	7140	7500
	0.379	0.404	0.430	0.455	0.481	0.505
0.3125	7050	7500	7987	8437	8925	9375
	0.475	0.505	0.538	0.568	0.601	0.631
0.375	8460	9000	9585	10125	10710	11250
	0.570	0.606	0.645	0.682	0.721	0.758
0.50	11280	12000	12780	13500	14280	15000
	0.760	0.808	0.861	0.909	0.962	1.010

NOTE: "Fw" AND "W" REPRESENT THE MAIN MEMBER CAPACITY ONLY, AND THEREFORE SHOWN FOR REFERENCE ONLY.

THIS TABLE IS NOT INCLUDED IN CPPP-7 ATT. 4-13

VOID

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 93
15454	NZ(C)	GENX-023		

REF

STIFFENER REQUIREMENTS FOR I SHAPE BEAM USED IN PIPE SUPPORT.

1. FLANGE BENDING.

a) CALCULATE EFFECTIVE SECTION MODULUS

$$S = \frac{(B + 2K)\, t_f^2}{6}$$

B - WIDTH OF ATTACHMENT ALONG THE BEAM WEB.

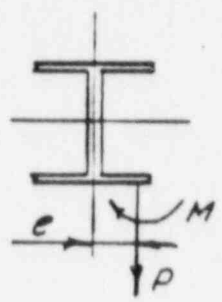
b) CALCULATE BENDING STRESS

$$\sigma = \frac{M}{S}$$

NO STIFFENER PLATE REQUIRED IF $\sigma < 0.75\, S_Y$

c) DETERMINING MOMENT M

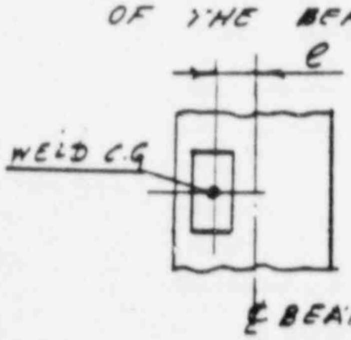
$$M = M + P \times e$$



VOID

d) DETERMINING "e" AND "P"

ATTACHMENT IS LOCATED ON ONE SIDE OF THE CENTERLINE OF THE BEAM.



e - DISTANCE BETWEEN ℄ OF THE BEAM AND C.G OF THE ATTACHMENT WELD.

P - VERTICAL DESIGN LOAD

TABLE 4-13.4A

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET 1 1/8 × 2 × 3/8 H=1.5 F=2700#

TUBE SIZE AND THICKNESS	LOAD TYPE A			LOAD TYPE B		
	‖	=	□	‖	=	□
* TS 2×2×1/4	1.0	1.0	1.0	0.37	1.0	1.0
TS 3×3×1/4	1.0	1.0	1.0	0.26	1.0	1.0
TS 4×4×3/16	0.87	1.0	1.0	0.1	0.55	0.69
TS 4×4×1/4	1.0	1.0	1.0	0.19	1.0	1.0
TS 4×4×5/16	1.0	1.0	1.0	0.3	1.0	1.0
TS 4×4×3/8	1.0	1.0	1.0	0.45	1.0	1.0
TS 4×4×1/2	1.0	1.0	1.0	0.75	1.0	1.0
TS 5×5×3/16	0.7	1.0	1.0	—	0.44	0.55
TS 5×5×1/4	1.0	1.0	1.0	0.16	0.79	1.0
TS 5×5×3/8	1.0	1.0	1.0	0.35	1.0	1.0
TS 5×5×1/2	1.0	1.0	1.0	0.62	1.0	1.0
TS 6×6×3/16	0.58	1.0	1.0	—	0.37	0.46
TS 6×6×1/4	1.0	1.0	1.0	0.13	0.66	0.82
TS 6×6×5/16	1.0	1.0	1.0	0.20	1.0	1.0
TS 6×6×3/8	1.0	1.0	1.0	0.29	1.0	1.0
TS 6×6×1/2	1.0	1.0	1.0	0.52	1.0	1.0
TS 8×8×1/4	0.78	1.0	1.0	0.1	0.5	0.61
TS 8×8×3/8	1.0	1.0	1.0	0.22	1.0	1.0
TS 8×8×1/2	1.0	1.0	1.0	0.39	1.0	1.0
TS 10×10×3/8	1.0	1.0	1.0	0.18	0.89	1.0
TS 10×10×1/2	1.0	1.0	1.0	0.31	1.0	1.0
TS 10×10×5/8	1.0	1.0	1.0	0.49	1.0	1.0
TS 12×12×3/8	1.0	1.0	1.0	0.15	0.74	0.92
TS 12×12×1/2	1.0	1.0	1.0	0.26	1.0	1.0
TS 14×14×1/2	1.0	1.0	1.0	0.22	1.0	1.0

TABLE 4.13.4B

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET 1½" × 3" × ½"   H = 2"   F = 4960 lb

TUBE SIZE AND THICKNESS	LOAD TYPE "A"			LOAD TYPE "B"		
	‖	=	□	‖	=	□
* TS 2×2×1/4	1.0	1.0	1.0	0.37	0.51	1.0
* TS 3×3×1/4	1.0	1.0	1.0	0.23	0.71	1.0
TS 4×4×3/16	0.64	1.0	1.0	—	0.45	0.52
TS 4×4×1/4	1.0	1.0	1.0	0.14	0.80	0.94
TS 4×4×5/16	1.0	1.0	1.0	0.22	1.0	1.0
TS 4×4×3/8	1.0	1.0	1.0	0.32	1.0	1.0
TS 4×4×1/2	1.0	1.0	1.0	0.54	1.0	1.0
TS 5×5×3/16	0.51	1.0	1.0	—	0.36	0.42
TS 5×5×1/4	0.9	1.0	1.0	0.11	0.64	0.76
TS 5×5×3/8	1.0	1.0	1.0	0.25	1.0	1.0
TS 5×5×1/2	1.0	1.0	1.0	0.45	1.0	1.0
TS 6×6×3/16	0.42	0.85	1.0	—	0.50	0.35
TS 6×6×1/4	0.75	1.0	1.0	—	0.53	0.63
TS 6×6×5/16	1.0	1.0	1.0	0.15	0.83	0.98
TS 6×6×3/8	1.0	1.0	1.0	0.21	1.0	1.0
TS 6×6×1/2	1.0	1.0	1.0	0.38	1.0	1.0
TS 8×8×1/4	0.57	1.0	1.0	—	0.40	0.47
TS 8×8×3/8	1.0	1.0	1.0	0.16	0.9	1.0
TS 8×8×1/2	1.0	1.0	1.0	0.28	1.0	1.0
TS 10×10×3/8	1.0	1.0	1.0	0.13	0.72	0.84
TS 10×10×1/2	1.0	1.0	1.0	0.23	1.0	1.0
TS 10×10×5/8	1.0	1.0	1.0	0.35	1.0	1.0
TS 12×12×3/8	0.85	1.0	1.0	0.11	0.60	0.71
TS 12×12×1/2	1.0	1.0	1.0	0.19	1.0	1.0
TS 14×14×1/2	1.0	1.0	1.0	0.16	0.91	1.0

TABLE 4-13 4C

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET 2 1/4 x 3 1/2 x 3/4 H = 2.5" F = 8000 LB

TUBE SIZE AND THICKNESS	LOAD TYPE "A"			LOAD TYPE "B"		
	‖	=	□	‖	=	□
TS 2x2x1/4	1.0	1.0	1.0	0.31	1.0	1.0
* TS 3x3x1/4	1.0	1.0	1.0	0.28	0.69	1.0
* TS 4x4x3/16	0.59	1.0	1.0	—	0.35	0.49
* TS 4x4x1/4	1.0	1.0	1.0	0.16	0.58	0.87
* TS 4x4x5/16	1.0	1.0	1.0	0.25	0.83	1.0
* TS 4x4x3/8	1.0	1.0	1.0	0.36	1.0	1.0
* TS 4x4x1/2	1.0	1.0	1.0	0.61	1.0	1.0
TS 5x5x3/16	0.47	0.74	1.0	—	0.3-	0.38
TS 5x5x1/4	0.84	1.0	1.0	0.13	0.54	0.69
* TS 5x5x3/8	1.0	1.0	1.0	0.28	1.0	1.0
* TS 5x5x1/2	1.0	1.0	1.0	0.51	1.0	1.0
TS 6x6x3/16	0.4.	0.62	1.0	—	0.25	0.32
TS 6x6x1/4	0.70	1.0	1.0	0.11	0.45	0.58
TS 6x6x5/16	1.0	1.0	1.0	0.16	0.71	0.89
TS 6x6x3/8	1.0	1.0	1.0	0.23	1.0	1.0
TS 6x6x1/2	1.0	1.0	1.0	0.42	1.0	1.0
TS 8x8x1/4	0.53	0.82	1.0	—	0.34	0.43
TS 8x8x3/8	1.0	1.0	1.0	0.17	0.76	0.97
TS 8x8x1/2	1.0	1.0	1.0	0.32	1.0	1.0
TS 10x10x3/8	0.95	1.0	1.0	0.14	0.61	0.78
TS 10x10x1/2	1.0	1.0	1.0	0.25	1.0	1.0
TS 10x10x5/8	1.0	1.0	1.0	0.39	1.0	1.0
TS 12x12x3/8	0.79	1.0	1.0	0.12	0.51	0.65
TS 12x12x1/2	1.0	1.0	1.0	0.21	0.90	1.0
TS 14x14x1/2	1.0	1.0	1.0	0.18	0.77	0.99

TABLE 4-13.4D

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET: 3 × 4 1/2 × 1.0 H = 3 3/16 F = 15700 LB

TUBE SIZE AND THICKNESS	LOAD TYPE 'A'			LOAD TYPE 'B'		
	∥	=	□	∥	=	□
TS 3×3×1/4	1.0	1.0	1.0	0.21	0.88	1.0
* TS 4×4×3/16	0.53	0.56	1.0	—	0.25	0.44
* TS 4×4×1/4	0.88	0.95	1.0	0.15	0.4	1.0
* TS 4×4×5/16	1.0	1.0	1.0	0.23	0.58	1.0
* TS 4×4×3/8	1.0	1.0	1.0	0.33	0.73	1.0
* TS 4×4×1/2	1.0	1.0	1.0	0.42	1.0	1.0
* TS 5×5×3/16	0.33	0.47	1.0	—	0.21	0.27
* TS 5×5×1/4	0.6	0.79	1.0	—	0.33	0.5
* TS 5×5×3/8	1.0	1.0	1.0	0.21	0.78	1.0
* TS 5×5×1/2	1.0	1.0	1.0	0.37	1.0	1.0
TS 6×6×3/16	0.27	0.4	0.67	—	0.17	0.22
TS 6×6×1/4	0.47	0.72	1.0	—	0.31	0.4
* TS 6×6×5/16	0.74	1.0	1.0	0.12	0.48	0.62
* TS 6×6×3/8	1.0	1.0	1.0	0.17	0.69	0.89
* TS 6×6×1/2	1.0	1.0	1.0	0.30	1.0	1.0
TS 8×8×1/4	0.35	0.54	0.9	—	0.23	0.30
TS 8×8×3/8	0.8	1.0	1.0	0.12	0.51	0.67
TS 8×8×1/2	1.0	1.0	1.0	0.23	0.92	1.0
TS 10×10×3/8	0.64	0.97	1.0	0.1	0.41	0.54
TS 10×10×1/2	1.0	1.0	1.0	0.18	0.73	0.95
TS 10×10×5/8	1.0	1.0	1.0	0.28	1.0	1.0
TS 12×12×3/8	0.54	0.80	1.0	—	0.39	0.45
TS 12×12×1/2	0.95	1.0	1.0	0.15	0.61	0.80
TS 14×14×1/2	0.81	1.0	1.0	0.13	0.52	0.68

TABLE 4-13.4E

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET 7×7×1.0 H = 4" F = 33500 LB

TUBE SIZE AND THICKNESS	LOAD TYPE "A"			LOAD TYPE B		
	‖	=	□	‖	=	□
TS 6×6×3/16	0.62	0.62	1.0	0.18	0.42	1.0
TS 6×6×1/4	1.0	1.0	1.0	0.31	0.74	1.0
TS 6×6×5/16	1.0	1.0	1.0	0.45	1.0	1.0
TS 6×6×3/8	1.0	1.0	1.0	0.54	1.0	1.0
TS 6×6×1/2	1.0	1.0	1.0	0.72	1.0	1.0
TS 8×8×1/4	0.92	0.92	1.0	0.25	0.61	1.0
* TS 8×8×3/8	1.0	1.0	1.0	0.58	1.0	1.0
* TS 8×8×1/2	1.0	1.0	1.0	0.96	1.0	1.0
TS 10×10×3/8	0.84	0.84	1.0	0.24	0.56	0.78
TS 10×10×1/2	1.0	1.0	1.0	0.42	0.99	1.0
TS 10×10×5/8	1.0	1.0	1.0	0.65	1.0	1.0
TS 12×12×3/8	0.61	0.61	1.0	0.17	0.41	0.56
TS 12×12×1/2	1.0	1.0	1.0	0.3	0.71	1.0
TS 14×14×1/2	0.90	0.90	1.0	0.25	0.59	0.83

EXAMPLE

BRACKET 7"×7"×1" H = 4" F = 33500 LB

TUBE 10×10×3/8

$\beta = 0.7 \quad \gamma = 13.33 \quad \eta = 0.7$

LOAD TYPE "A" (‖ TYPE WELD)

$F_w = F/\ell = 33500 : 14 = 2393$ #/in

$Q_\beta = \frac{0.25}{0.7(1-0.7)} = 1.19$

$V_p' = F_w/t_e = 2393 : 0.375 = 6381$ psi

$V_p = \frac{F_y}{0.6\,\gamma} Q_\beta Q_f = \frac{36000}{0.6 \times 13.3} \times 1.19 \times 1.0 = 5370$ psi

$K = \frac{V_p}{V_p'} = \frac{4511}{6381} = 0.84$ (SEE NUMBER IN THE TABLE)

TABLE 4-13.4F

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET 10×10×1½ H=5¼" F = 50600 lb

TUBE SIZE AND THICKNESS	LOAD TYPE "A"			LOAD TYPE "B"		
	‖	=	□	‖	=	□
TS 8×8×¼	0.74	0.74	1.0	0.22	0.51	1.0
TS 8×8×3/8	1.0	1.0	1.0	0.5	1.0	1.0
TS 8×8×½	1.0	1.0	1.0	0.69	1.0	1.0
TS 10×10×3/8	1.0	1.0	1.0	0.5	1.0	1.0
TS 10×10×½	1.0	1.0	1.0	0.86	1.0	1.0
TS 10×10×5/8	1.0	1.0	1.0	1.0	1.0	1.0
TS 12×12×3/8	1.0	1.0	1.0	0.39	0.88	1.0
TS 12×12×½	1.0	1.0	1.0	0.82	1.0	1.0
TS 14×14×½	1.0	1.0	1.0	0.31	0.71	1.0

TABLE 4-13.4G

K_I - RATIO OF DESIGN LOAD TO THE RATED BRACKET LOAD

BRACKET 12½" × 12½" × 2" H=8" F= 123000 LB

TUBE SIZE AND THICKNESS	LOAD TYPE "A"			LOAD TYPE "B"		
	‖	=	□	‖	=	□
TS 10×10×3/8	0.69	0.69	1.0	0.17	0.42	1.0
TS 10×10×1/2	1.0	1.0	1.0	0.29	0.73	1.0
TS 10×10×5/8	1.0	1.0	1.0	0.37	0.91	1.0
TS 12×12×3/8	0.69	0.69	1.0	0.17	0.42	1.0
TS 12×12×1/2	1.0	1.0	1.0	0.31	0.76	1.0
TS 14×14×1/2	1.0	1.0	1.0	0.25	0.64	1.0

Job No. 15454

Chrono File R2.1.15
Job Book

STONE & WEBSTER ENGINEERING CORPORATION

COMANCHE PEAK STEAM ELECTRIC STATION
UNIT 1 J.O. No. 15454
TELEPHONE MEMORANDUM

Time 10:00 AM
Date 5/21/86
Incoming
Outgoing

Between R. READ/ E. OGDEN of SWEC and P. W. MARSHALL of SHELL OIL

Subject INTERPRETATION OF 1985 AWS D1.1 SECTION 10.5

THE JOB BOOK NUMBER MUST BE PLACED IN UPPER RIGHT

SUMMARY

$\beta < 0.8$ JOINT CAPACITY IS LIMITED BY SECTION 10.5.1 AS CALCULATED SEPARATELY

$0.8 < \beta$ JOINT CAPACITY IS LIMITED BY THE LESSER OF THE CAPACITIES PER SECTIONS 10.5.1 AND 10.5.1.3 WITH F_2 CALCULATED IN 10.5.1.1(2) FURTHER LIMITED BY ALLOWABLE V_{pc} 0.4Fy

$\beta = 1.0$ JOINT CAPACITY IS CALCULATED PER SECTION 10.5.1.1 WITH F_2 CALCULATED IN 10.5.1.1.(2) LIMITED BY ALLOWABLE V_{pc} 0.4 Fy

SECTION 10.5.1.7 ~~REQUIRES~~ RECOMMENDS A 1/3 DECREASE IN ALLOWABLES FOR CRITICAL CONNECTIONS AS DEFINED IN SECTION 10.5.1.7

Action Required: SWEC TO REVISE CPPP-7 ATTACHMENT 4-13 TO COMPLY WITH THE ABOVE CODE INTERPRETATION

Action Assigned: E. EVANS.

COPIES TO:

✓	RPKlause	✓	JAchacoso
✓	KYChu		TYChang
✓	AWChan		CButt
✓	RWrucke	✓	E.EVANS
		✓	T.TSAI

$\frac{1}{3}$ DEC ATTACH 3A
PAGE 3.2

10:00 AM
P. MARSHAL
R. READ
F. OGDEN ✓

REDUNDANT OR NON CRITICAL

10.5.1.7 $\frac{1}{3}$ DECREASE	

MATCHED CONNECTIONS: →