ATTACHMENT 1.1

"CL1BIC" Computer Program For ASME Section III Class 1 Area Reinforcement Analysis For Certain Branch Connection Types Of The CATAWBA Nuclear Power Station

Prepared For

DU.E POWER COMPANY

Prepared By

EDS NUCLEAR INC.

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EDS NUCLEAR INC.

REPORT APPROVAL COVER SHEET

Client: Duke Power Company

Project: Catawba Nuclear Plant Job Number: 0930910

Report Title: "CL1BIC" Computer Program For ASME Section III Class 1 Area Reinforcement Analysis For Certain Branch Connections of the CATAWBA Nuclear Power Plant

Report Number: PAD-77-117 Rev. 2

The work described in this Report was performed in accordance with the EDS Nuclear Quality Assurance Program. The signatures below verify the accuracy of this Report and its compliance with applicable quality assurance requirements.

Prepared By: Vincent Yee Date: October 31, 1977

Reviewed By: John T. Prawlucki Date: November 30, 1977

Approved By: C. J. Rossler Date: November 30, 1977

REVISION RECORD

Rev. No.	Prepared	Reviewed	Approved	Approval Date	Revision
1	John T. Prawlucki	Vincent Yee	C. J. Rossler	2/10/77	Misc. Revisions
2	Vincent Yee	William R. Read	C. J. Rossler	3/22/78	Misc. Revisions

Revision 1

Revision includes the following items:

a) Tables have been revised to show the design pressures for the SWB being used on 8" run pipe which is permitted by MDG-ES-2.

b) Tables have been revised to include notes which define the reasons for not including certain components.

c) The back-up hand calculations have been revised to match program calculation techniques.

d) Revised program listing has been included.

Revision 2

Revision includes the following items:

a) Table 2.2 has been revised to include the pressure values for the following in addition to the values already shown:

1) SWB fittings for run pipe sizes of 4", 5", and 6" and branch pipe sizes of 3/4" through 2".

2) SWFOB fittings with run pipe sizes of 4" through 14" and 1" branch pipe size.

3) SWFOB fittings with run pipe sizes of 4" through 6" and 3/4" branch pipe.

ABSTRACT

The piping design criteria of the ASME Code Section III for Class 1 Components requires that design for pressure loading be performed in accordance with the rules of subarticle NB-3640. Paragraph NB-3643 sets forth area reinforcement rules, including calculations, which guarantee the stress limit requirements of NB-3640 are satisfied for branch connections. The purpose of this report is to document and certify the calculations which establish the allowable pressure for various branch configurations of interest to the Catawba Nuclear Station pipe design activity. Additionally, the technical basis, listing, input, and output for the computer program used to develop the allowable pressure values are presented. The program can be used to establish the allowable pressure for other branch configurations which satisfy the configurational restrictions set forth in NB-3643 and as modified in NB-3680 in order to make the stress indices of the Code applicable. Output of the program contains information other than the allowable pressure which will be of interest to the pipe designer.

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NOMENCLATURE

As Specified In		
ASME	Program	
P	PMR	maximum internal design pressure of run, psi
P	PMB	maximum internal design pressure of branch, psi
P	PPP	maximum internal design pressure of branch connection, psi
P	P23	maximum internal design pressure of branch connection, psi (where the 2/3 area restrictions of NB-3643. 3(c)(1)(c) governs)
	PPL	the smaller of PMR and PMB
	PAA	maximum allowable pressure
t_m		minimum required wall thickness
t_r		t_m - a = minimum required thickness of run pipe
t_b		t_m - a = minimum required thickness of branch pipe
	TRM	minimum wall thickness of run pipe
	TBM	minimum wall thickness of branch pipe
	TFM	minimum wall thickness of fitting
T_r	RTM	nominal wall thickness of run pipe
	TBA	nominal wall thickness of branch pipe
T_b	TFA	nominal wall thickness of fitting
a	A	an additional thickness to provide for corrosion
y	Y	= .4
S_m	SMR	maximum allowable stress intensity caused by internal pressure at the design temperature for the - run pipe
S_m	SMF	maximum allowable stress intensity caused by internal pressure at the design temperature for the - fitting
S_m	SMB	maximum allowable stress intensity caused by internal pressure at the design temperature for the - branch pipe
r_2	RZM	minimum - transition radius between branch (fitting) and run pipe

NOMENCLATURE

As Specified In		
ASME	Program	
r_2	RZM	minimum - transition radius between branch (fitting) and run pipe
r_2	RZR	required - transition radius between branch (fitting) and run pipe for a design pressure of 2500 psi
L_A	DLA	half width of reinforcement zone measured along the mid-surface of the run pipe
L_N	XLN	limit of reinforcement measured normal to run pipe wall
r_m	RFAA	mean radius of the branch (fitting)
R_m	RRA	mean radius of the run pipe
r^1_m	RBAA	mean radius of the branch pipe
D_o	DRO	outside diameter of run pipe
D_o	DBO	outside diameter of branch pipe
D_o	DFO	outside diameter of fitting
d	DRI	inside diameter of run pipe based on minimum wall thickness
d	DBI	inside diameter of branch pipe based on minimum wall thickness
d	DFI	inside diameter of fitting based on minimum wall thickness
d	DFIA	inside diameter of fitting based on nominal wall thickness

1.0 INTRODUCTION

The ASME Boiler and Pressure Vessel Code Section III requires that pipe intersections be properly designed for pressure. This report is intended to be a design aid which determines qualified branch connection fitting types based upon specified design parameters in ASME Class 1 (Duke Power Company Class A) piping systems and verifies that these fittings satisfy the area reinforcement requirements of subsection NB-3643, based on the design temperature, design pressure, size, schedule, corrosion allowance, and material parameters of the run and branch pipes.

2.0 BRANCH CONNECTION PRESSURE DESIGN TABLES

Tables 2.1 through 2.3 contain the allowable design pressures for those Class 1 branch connections involving socket welding fittings. Each table is for a given design temperature and run, branch, and fitting material combination which is presented at the top of the table. The table is composed of a matrix of maximum allowable pressure for a given run pipe to branch pipe size with fitting type as a subparameter. Along the left hand side of the table are listed the ten run pipe sizes and associated schedules which are specified for Duke Class A piping in reference 7. The allowable pressure for each run pipe is also listed and may be used to establish what controls the branch connection (fitting, run or branch) allowable pressures. The branch pipe size, associated schedule, and allowable pressure are listed along the top row. The minimum stress intensity and corrosion allowance values used to develop the allowable pressures are shown at the top of the table.

These three tables are intended to be used by design personnel to verify that the piping design criteria of subarticle NB-3640 of the ASME Boiler and Pressure Vessel Code Section III are satisfied. The version of the Code used is the 1974 Edition with addenda through summer of 1974, which is the Code of Record for the Catawba Nuclear Power Station. The fitting configurations used to construct the branch connections considered are presented in Figures 2.1 through 2.3. Actual fitting nominal dimensions were utilized in preparing the report with suitable allowance taken for the metal removed when the fitting is shaped to fit the run pipe. It should be noted that the limits set forth in Figure 2.2 for Special Welding Boss branch connection configurations have been included in establishing the values contained herein. The restriction on thickness of run pipe is related to fabricability. While similar restrictions may apply to half coupling and special welding flow orifice boss branch connections, they are not noted in the Figures or contained in the values presented herein. Therefore, it is the responsibility of the designer to verify the combination of fitting and run pipe is fabricable.

3.0 DESIGN AND ANALYSIS PROCEDURE

3.1 ASME Criteria

ASME Boiler and Pressure Vessel Code Section III NB-3643 specifies pressure design requirements for branch connections. This subsection establishes general requirements, defines branch connections, and discusses reinforcement requirements and calculations. A summary of this subsection is provided below.

3.1.1 Satisfying Area Reinforcement Requirements

NB-3643 requires that reinforcement be provided "in an amount and distribution so that the requirements for the area of reinforcement are satisfied for all planes through the center of the opening and normal to the surface of the run pipe." The area of reinforcement shall not be less than

$$A_{req} = d\, t_r \ (in^2)$$

for a branch connection normal to the surface of the run pipe. This is the area of the minimum thickness pipe for the pressure that is removed by the hole.

3.1.2 Branch Connections Not Requiring Reinforcement

Per NB-3643.3(b), reinforcement need not be provided under the following conditions:

(a) A single opening has a diameter not exceeding $0.2\sqrt{R_m\, T_r}$ or if there are two or more openings within any circle of diameter $2.5\sqrt{R_m\, T_r}$ but the sum of the diameters of such unreinforced openings shall not exceed $0.25\sqrt{R_m\, T_r}$.

(b) No two unreinforced openings shall have their centers closer to each other, measured on the inside wall of the run pipe, than the sum of their diameters.

(c) No unreinforced opening shall have its center closer than $2.5\sqrt{R_m\, T_r}$ to the edge of any other locally stressed area.

Since these three conditions are all layout dependent, it is assumed the designer checks these conditions prior to finalizing the location of the connections. The program prints out values of $\sqrt{R_m T_r}$ to aid the designer in checking these conditions.

3.1.3 Cross-Sectional Area Available for Reinforcement

The area available for reinforcement is the sum of the contributing areas A_1, A_2, and A_3, as shown in Figures 3.1 for the socket welding fitting (6000# socket-welded half coupling (B16.11), special welding boss (MDG-ES-2, -3) and special welding flow orifice boss (MC-1684-00.00) attached to the run pipe. The areas available for compensation are:

A_1 - excess wall in branch (half each side)
A_2 - weld metal (half each side)
A_3 - excess wall in run (half each side)

The "thicknesses" of these areas are dependent on the t_r and t_b values determined in the straight pipe pressure design calculations for the run and branch pipes.

3.1.4 Effective Length of Reinforcement on the Run

NB-3643.3(c) defines the "limits of reinforcement measured along the mid-surface of the nominal wall thickness of the run pipe," i.e. the effective length along the run, as

$$L_A = \max (d,\ r + T_r + T_b).$$

In addition, two thirds of the required reinforcement shall be provided within a limit the greater of

$$r + 0.5\sqrt{R_m T_r}$$

$$r + T_r + T_b$$

3.1.5 Effective Length of Reinforcement on the Branch

NB-3643.3(c) defines the "limits" of reinforcement measured normal to the wall of the run pipe, i.e. effective length along the branch, as

$$L_N = 0.5\sqrt{r_m T_b} + 0.5\, r_2$$

For the purposes of these calculations L_N shall not exceed the

laying height of the fitting in question. Laying heights are tabulated in Table 4.1 Input Data Used for Generated Design Table.

It was determined that the reduction in available laying height (due to cutting of the fitting to fit the contour of the run pipe) did not affect the L_N value. The calculated value was always smaller than the reduced available laying height of the socket welded half coupling.

3.1.6 Stress Index Restrictions on Branch Connections

Section III places certain restrictions on branch connections in order to assure the validity of the stress indices of NB-3686. Special indices must be developed independently for branch connections which do not meet these criteria. Note that (c) must be confirmed from the layout scheme.

(a) Reinforcing area requirements of NB-3643 must be met.

(b) Axis of the branch pipe must be normal to the surface of the run pipe wall.

(c) The arc distance measured between the center of adjacent branches along the surface of the run pipe must not be less than three times the sum of their inside radii in the longitudinal direction and must not be less than twice the sum of their radii along the circumference of the run pipe.

(d) The ratio of run pipe near radius to run pipe nominal thickness must not exceed 50, i.e.

$$\frac{R_r}{T_r} \leq 50$$

(e) The ratio of branch pipe mean radius to run pipe mean radius may not exceed one-half, i.e.

$$\frac{r_m^1}{R_r} \leq 0.5$$

(f) The inside corner radius is greater than one-tenth of the run pipe nominal thickness and less than one-half the run pipe nominal thickness, i.e.

$$0.1\ T_r < r_1 < 0.5\ T_r$$

(g) The outer radius is not less than the larger of one-half the run pipe nominal thickness or one-half the branch pipe nominal thickness, i.e.

$$r_2 \geq \max (0.5\ T_b,\ 0.5\ T_r)$$

3.2 Duke Criteria

3.2.1 Code Of Record

The Code of Record is ASME Boiler and Pressure Vessel Code Section III-NB, 1974 edition, with addenda through summer of 1974.

3.2.2 Types of Intersections Considered

This manual covers reinforcement area calculations and stress index determination for all combinations of the following parameters:

(a) Fitting Sizes

Five 6000# socket-welded half couplings: 3/4", 1", 1-1/4", 1-1/2", and 2"

Six special welding bosses: 1/2", 3/4", 1", 1-1/4", 1-1/2", and 2"

Three special welding flow orifice bosses: 1/2", 3/4", 1".

(b) Pipe Sizes

Seven schedule 160 pipes: 2", 2-1/2", 3", 4", 5", 6", and 8"

Three schedule 140 pipes: 10", 12", and 14"

(c) Materials

Pipe:	SA-376	TP304
	SA-312	TP304
	SA-316	TP316
Fitting:	SA-182	F304

(d) Design Conditions

Three temperatures: 600°F, 650°F, and 700°F.

3.2.3 Design Manual Assumptions

The following assumptions are made regarding the various types of fittings used for form the branch connection:

(a) The angle of attachment is 90^{o}.

(b) All welds are full penetration welds as required by ASME.

(c) Fitting to pipe combinations which fail to satisfy the requirements of NB-3683 are noted and design pressures are not provided.

3.2.4 Nomenclature

A list of nomenclature showing relevant symbology and cross references ASME and computer program parameters is provided on page 5 of this report.

4.0 INPUT DATA

4.1 Data Used for Generated Tables

Numerical data used to develop the design tables in this report comes from the sources listed in the section 7.0 references.

4.1.1 Data for Fittings

Cross-sectional data for the three fittings considered on this report are listed in Figures 2.1 through 2.3. Reference for the special welding boss is MDG Engineering Standard MDG-ES-2 (Revision 0) and MDG-ES-3 (Revision 1). Details for the 1/2", 3/4" and 1" special welding flow orifice bosses are taken from CN-1680-3 (Rev. 2), -4 (Rev. 2) and -46 (Rev. 0), respectively. Half coupling dimensions come from ANSI B16.11 (1973). Material data for SA-182 F304 is from NA Appendix I of ASME BPVC Section III (1974) and is listed in Table 4.2 at design temperatures of 600°F, 650°F and 700°F.

4.1.2 Data for Piping

ANSI B36.19 is the source of cross-sectional data for both run pipes and branch pipes. Figures 2.1 through 2.3 lists the values used for outside diameter and nominal wall thickness. Minimum wall thickness is taken to be 7/8-ths of the nominal wall thickness based upon the ANSI Standard.

Design stress intensity values for SA-376 TP304, SA-312 TP304, and SA-376 TP316 are listed in Table 4.2 for design temperatures of 600°F, 650°F, and 700°F. The listed S_m values are exact for the 304 materials and are slightly conservative for SA-376 TP316.

4.1.3 Miscellaneous Data

The applied corrosion allowance of 0.00 inch is specified in reference 8.0. All calculations are performed for right angle (90°) branch-to-run intersections. Section III specifies a value of 0.4 for Y.

4.2 Input Data Development for Additional Tables

Application of the CLIBIC program requires that data be prepared for pipes and fittings under appropriate design conditions. Computer input card decks must be prepared according to the following guidelines. Data "types" noted in the guidelines are:

I	Interger	Integer data only, right-justified in the card column data fields
R	Real	Data may contain decimal values and may appear anywhere in the card column data field
A	Alphanumeric	Test data. Any characters may appear anywhere in the card column data field

Control Parameters Card - first card of the data deck:

Col.	Type	Units	Data
1-5	I		Number of fitting cards.
6-10	I		Number of branch pipe cross-section cards.
11-15	I		Numer of run pipe cross-section cards.
16-20	I		Number of fitting material data sets.
21-25	I		Number of pipe material data sets.

Miscellaneous Data Card - one card which specifies the following information:

Col.	Type	Units	Data
1-10	F	in	Corrosion allowance.
11-20	F	deg	Branch-to-run intersection angle.
21-30	F		Y (typically 0.4).
31-35	I		Stress index flag. If non-zero, stress indices will be calculated using the formulas given in Table NB-3682.2-1.

Fitting Data - one pair of cards for each fitting to be analyzed:

Card One

Col.	Type	Units	Data
1-5	I		Fitting number. Must be sequential beginning with 1.
6-15	A		Branch size (3/4 in., 1 in., etc.).
16-25	A		Fitting Type (SWB, 6000 SWHC, etc.).
26-35	R	in.	Outside diameter.
36-45	R	in.	Nominal thickness of body.
46-55	R	in.	Minimum thickness of body.
56-65	R	in.	Laying height, from run pipe surface to bottom of fitting socket.
66-70	I		Enter 1 if fitting is any kind of special welding boss. Program checks for run pipe OD $\leq$8.625 in. and run pipe $t_n \leq 0.5$ in.
71-75	I		Cross-section number of branch pipe attached to this fitting.
76-80	I		Material set number of branch pipe attached to this fitting.

Card Two

Col.	Type	Units	Data
1-20			Blank

Branch Pipe Data - one card for each branch cross-section:

Col.	Type	Units	Data
1-5	I		Branch cross-section number. Must be sequential, beginning with 1.
6-15	A		Pipe size (3/4 in., 1 in., etc.).
16-15	A		Pipe schedule (SCH 160, XXS, etc.).
26-35	R	in.	Outside diameter.
36-45	R	in.	Nominal wall thickness.
46-55	R	in.	Minimum wall thickness. If blank or zero, will default to 0.875 (t_{nom}).

Run Pipe Data - one card for each run cross-section:

Col.	Type	Units	Data
1-5	I		Run cross-section number. Must be sequential, beginning with 1.
6-15	A		Nominal pipe size.
16-15	A		Pipe schedule (SCH 160, XXS, etc.)
26-35	R	in.	Outside diameter.
36-45	R	in.	Nominal wall thickness.
46-55	R	in.	Minimum wall thickness. If blank or zero, will default to 0.875 (t_{nom}).

Fitting Material Data - one card for each fitting material followed by the appropriate number of cards specifying applicable material names.

Col.	Type	Units	Data
1-5	I		Fitting material data set number. Must be sequential, beginning with 1.
6-15	R	psi	Stress intensity, S_m.
16-25	R	^oF	Design temperature.
26-30	I		Number of applicable material names which follow.

Applicable Fitting Material Names - number of cards as specified in col. 26-30 above to identify the material data set:

Col.	Type	Units	Data
1-5	A		Blank
6-80	A		Material name (SA-376 TP304, etc.)

Piping Material Data - one card for each piping material followed by the appropriate number of cards specifying applicable material names:

Col.	Type	Units	Data
1-5	I		Piping material data set number. Must be sequential, beginning with 1.
6-15	R	psi	Stress intensity, S_m.
16-25	R	^oF	Design temperature.
26-30	I		Number of applicable material names which follow.

Applicable Piping Material Names - number of cards as specified in col. 26-30 above to identify the material data set:

Col.	Type	Units	Data
1-5			Blank
6-80	A		Material name (SA-375 TP304, etc.)

5.0 PROGRAM OUTPUT DESCRIPTION

A listing of all the data input into the program is initially provided to the user. The area reinforcement results are then presented in a tabular format for each run pipe size, schedule, and temperature input.

Appendix B contains the computer output in a tabular form. Pipe and fitting material are listed at the top of the page. The run pipe size, schedule, average wall thickness, minimum wall thickness, stress intensity, and maximum allowable pressure are for the specific run pipe shown. The first column lists the branch size, the second lists the fitting type, the third lists the nominal wall thickness of the fitting, the fourth lists the minimum wall thickness of the fitting, the fifth lists the allowable design pressure for the branch connection (with no increase in r_2), the sixth lists the design temperature, the seventh lists the limits of reinforcement, L_A, measured along the mid-surface of the nominal wall thickness of the run pipe, the eighth lists the limits of reinforcement, L_N, measured normal to the wall of the run pipe, the ninth lists the minimum, r_2, the tenth lists the required r_2 value for a design pressure of 2,500 psi, the eleventh lists values of $\sqrt{R_m \times T_r}$ used to check spacing criteria, and the last column lists the maximum allowable pressure of the branch pipe.

6.0 SAMPLE PROBLEMS

Enclosed are six sample problems which serve as verification of the program. Each problem was performed using hand calculations and CLIBIC.

7.0 REFERENCES

1. ASI B16.11-1973 Forged Steel Fittings Socket-Welding and Threaded.

2. ASI B36.19.

3. Duke Power Co. MDG Engineering Standard No. MDG-ES-2 Rev. 0 General Details Special Welding Boss.

4. Duke Power Co. MDG Engineering Standard No. MDG-ES-3 Rev. 1 Application Details Special Welding Boss.

5. Duke Power Co. Drawing MC-1684-00.00 Rev. 2 Special Welding Flow Orifice Boss.

6. ASME Boiler and Pressure Vessel Code Section III 1974 Edition with Addenda through Summer of 1974.

7. Duke Power Co. Specification CNS-1206.00-2.2 Rev. 7 Specification for the Procurement of Power Piping.

8. Duke Power Co. Specification CNS-1206.02-1.0 Rev. 1 Design Specification, ASME Section III, Class 1 Piping.

Additional References for McGuire

1. ASME Boiler and Pressure Vessel Code Section III 1971 Edition with Addenda through Winter of 1971.

2. Duke Power Co. Specification MCS-1206.00-2.2 Rev. 28 Specification for the Procurement of Power Piping Systems Materials and Components.

3. Duke Power Co. Specification MCS-1206.02-1.0 Rev. 7 Catawba Nuclear Station, Design Specification, ASME Section III, Class 1 Piping.

4. Duke Power Co. Drawing CN-1680-3 Rev. 2 Special Welding Flow Orifice Boss.

5. Duke Power Co. Drawing CN-1680-4 Rev. 2 Special Welding Flow Orifice Boss.

6. Duke Power Co. Drawing CN-1680-46 Rev. 0 Special Welding Flow Orifice Boss.

Data Sheet for Sample Problem - 1

Design Conditions		Nomenclature
Design Pressure (psig)	To be determined	P
Design Temperature (^{o}F)	700.	T
Duke Piping System Classification	A	
Temperature Factor	.4	y

Branch

Nominal Size (in.) and Schedule	$\frac{1}{2}$" SCH 160	
Nominal Wall Thickness (in)	.187	T_b
Minimum Wall Thickness (in)	.164	t_{mb}
Outside Diameter (in)	.840	D_{ob}
Corrosion Allowance (in)	0.0	a
Material	SA 376 TP 316	
Design Stress Intensity, S_m (psi)	16,300.	S_m

Fitting

Fitting Discription	$\frac{1}{2}$" SWB	
Nominal Wall Thickness (in)	.531	T_f
Minimum Wall Thickness (in)	.499	t_{mf}
Outside Diameter (in)	1.5	D_{of}
Maximum Laying Height of Fitting (in)	.654	L_N (max)
Corrosion Allowance (in)	0.0	a
Material	SA 182 F 304	
Design Stress Intensity, S_m(psi)	15,900.	S_m

Run Pipe

Nominal Size (in) and Schedule	14" SCH 140	
Nominal Wall Thickness (in)	1.25	T_r
Minimum Wall Thickness (in)	1.094	t_{mr}
Outside Diameter (in)	14.0	D_{or}
Corrosion Allowance (in)	0.0	a
Material	SA 376 TP 316	
Design Stress Intensity, S_m (psi)	16,300.	S_m

ITEM: Case Number One 1" SWB on 14" SCH 140		CLIENT: Duke Power Company	
		PROJECT: Catawba	
		JOB NO.	
BY JTP	DATE 11-30-77	CKD. VKY	DATE 11/30/77
ITEM NO.		SHT. 1 OF 2	

1. NB-3643.3 (b) REQUIREMENT

$d_f \leq .2\sqrt{R_m T_r}$ NO AREA REINFORCEMENT REQUIRED

$d_f = D_{of} - 2T_f = 1.5 - 2(.531) = .438$ IN.

$R_m = (D_{of} - T_r)/2 = (14.0 - 1.25)/2 = 6.375$

$.2\sqrt{R_m T_r} = .2\sqrt{(6.375)(1.25)} = .565 > .438$ IN

∴ NO AREA REINFORCEMENT REQUIRED FOR THIS COMBINATION

2. NB-3686.1 (e) REQUIREMENT

$\frac{r'_m}{R_m} \leq .5$ CODE STRESS INDICES MAY BE USED

$r'_m = (D_{ob} - T_b)/2 = (.84 - .187)/2 = .326$

$R_m = 6.375$

$r'_m/R_m = .0512 < .5$

∴ CODE STRESS INDICES MAY BE USED

PROGRAM "90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE" DEFAULTS TO SMALLER MAXIMUM ALLOWABLE PRESSURE OF RUN PIPE OR FITTING TYPE AND REQUIRED R_2 DEFAULTS TO GREATER OF $T_b/2$ OR $T_r/2$.

ITEM CASE NUMBER ONE 1/2" SWB ON 14" SCH 160				CLIENT DUKE POWER COMPANY	
				PROJECT CATAWBA	
				JOB NO.	
BY JTP	DATE 11-30-77	CKD VK-f	DATE 11/30/77	ITEM NO.	SHT. 2 OF 2

Data Sheet for Sample Problem - 2

Design Conditions		Nomenclature
Design Pressure (psig)	To be determined	P
Design Temperature (^{o}F)	600.	T
Duke Piping System Classification	A	
Temperature Factor	.4	y

Branch

Nominal Size (in.) and Schedule	2" SCH 160	
Nominal Wall Thickness (in)	.343	T_b
Minimum Wall Thickness (in)	.300	t_{mb}
Outside Diameter (in)	2.375	D_{ob}
Corrosion Allowance (in)	0.0	a
Material	SA 376 TP 304	
Design Stress Intensity, S_m (psi)	16,400.	S_m

Fitting

Fitting Discription	6,000 #SWHC	
Nominal Wall Thickness (in)	.735	T_f
Minimum Wall Thickness (in)	.725	t_{mf}
Outside Diameter (in)	3.159	D_{of}
Maximum Laying Height of Fitting (in)	1.625	L_N (max)
Corrosion Allowance (in)	0.0	a
Material	SA 182 F 304	
Design Stress Intensity, S_m(psi)	16,400.	S_m

Run Pipe

Nominal Size (in) and Schedule	4" SCH 160	
Nominal Wall Thickness (in)	.531	T_r
Minimum Wall Thickness (in)	.465	t_{mr}
Outside Diameter (in)	4.5	D_{or}
Corrosion Allowance (in)	0.0	a
Material	SA 376 TP 304	
Design Stress Intensity, S_m (psi)	16,400.	S_m

ITEM: Case Number Two 2" 6,000 #HC on 4" SCH 160		CLIENT: Duke Power Company	
		PROJECT: Catawba	
		JOB NO.	
BY JTP	DATE 11-30-77 CKD VKY DATE 11/30/77	ITEM NO.	SHT. 1 OF 2

1. NB-3643.3(b) REQUIREMENT

$d_f \leq .2\sqrt{R_m T_r}$ NO AREA REINFORCEMENT REQUIRED

$d_f = D_{of} - 2T_f = 3.159 - 2(.735) = 1.689$

$R_m = (D_{or} - T_r)/2 = (4.500 - .531)/2 = 1.985$

$.2\sqrt{R_m T_r} = .2\sqrt{(1.985)(.531)} = .205 < 1.689$

∴ AREA REINFORCEMENT REQUIRED FOR THIS CONDITION

2. NB-3686.1(e) REQUIREMENT

$\frac{r'_m}{R_m} \leq 0.5$ CODE STRESS INDICES MAY BE USED

$r'_m = (D_{ob} - T_b)/2 = (2.375 - .343)/2 = 1.016$

$R_m = 1.985$

$r'_m / R_m = .512 > .5$

∴ CODE STRESS INDICES MAY NOT BE USED

PROGRAM WILL NOT PROVIDE DESIGN PRESSURES FOR COMBINATIONS THAT EXCEED THE $r'_m/R_m \leq 0.5$ REQUIREMENT SINCE THIS COULD RESULT IN THE NEED TO DEVELOP SPECIAL STRESS INDICES.

ITEM CASE NUMBER TWD-2" 6000# HL ON 4" SCH 160			CLIENT DUKE POWER COMPANY
			PROJECT CATAWBA
			JOB NO.
BY JTP	DATE 11-30-77	CKD VKT	DATE 11/30/77
			ITEM NO.
			SHT 2 OF 2

Data Sheet for Sample Problem - 3

Design Conditions		Nomenclature
Design Pressure (psig)	To be determined	P
Design Temperature (^{o}F)	650.	T
Duke Piping System Classification	A	
Temperature Factor	.4	y

Branch

Nominal Size (in.) and Schedule	3/4" SCH 160	
Nominal Wall Thickness (in)	.218	T_b
Minimum Wall Thickness (in)	.191	t_{mb}
Outside Diameter (in)	1.05	D_{ob}
Corrosion Allowance (in)	0.0	a
Material	SA 376 TP 304	
Design Stress Intensity, S_m (psi)	16,100.	S_m

Fitting

Fitting Discription	3/4" SWFOB	
Nominal Wall Thickness (in)	.688	T_f
Minimum Wall Thickness (in)	.656	t_{mf}
Outside Diameter (in)	1.75	D_{of}
Maximum Laying Height of Fitting (in)	.794	L_N (max)
Corrosion Allowance (in)	0.0	a
Material	SA 182 F 304	
Design Stress Intensity, S_m(psi)	16,100.	S_m

Run Pipe

Nominal Size (in) and Schedule	6" SCH 160	
Nominal Wall Thickness (in)	.718	T_r
Minimum Wall Thickness (in)	.628	t_{mr}
Outside Diameter (in)	6.625	D_{or}
Corrosion Allowance (in)	0.0	a
Material	SA 376 TP 304	
Design Stress Intensity, S_m (psi)	16,100.	S_m

ITEM: Case Number Three 3/4" SWFOB on 6" SCH 160		CLIENT: Duke Power Company	
		PROJECT: Catawba	
		JOB NO.	
BY JTP	DATE 11-30-77 CKD VKY DATE 11/30/77	ITEM NO.	SHT 1 OF 5

1. NB-3643.3(b) REQUIREMENT

$d_f \leq .2\sqrt{R_m T_r}$ NO AREA REINFORCEMENT REQUIRED

$d_f = D_{of} - 2T_f = 1.750 - 2(.688) = .374$

$R_m = (D_{or} - T_r)/2 = (6.625 - .718)/2 = 2.954$

$.2\sqrt{(2.954)(.718)} = .291 < .374$

∴ AREA REINFORCEMENT REQUIRED FOR THIS COMBINATION

2. NB-3686.1(e) REQUIREMENT

$\frac{r'_m}{R_m} \leq 0.5$ CODE STRESS INDICES MAY BE USED

$r'_m = (D_{ob} - T_b)/2 = (1.05 - .218)/2 = .416$

$R_m = 2.954$

$r'_m / R_m = .141 < .5$

∴ CODE STRESS INDICES MAY BE USED

3. MAXIMUM STRAIGHT PIPE AND FITTING PRESSURE

$P = \frac{2S_m(t_m - a)}{D_o - 2Y(t_m - a)}$ EQUATION (2) FROM NB-3641.1

FOR 6" SCH 160 AT 650°F AND MATERIAL SA-376 TP304

$S_m = 16,100$ PSI

$P = \frac{2(16,100\ PSI)(.628 - 0)}{6.625 - 2(.4)(.628 - 0)} = 3303$ PSI VS PROGRAM VALUE OF 3304 PSI.

ITEM CASE NUMBER THREE - 3/4" SW/FOB ON 6" SCH 160		CLIENT DUKE POWER COMPANY	
		PROJECT CATAWBA	
		JOB NO.	
BY JTP	DATE 11-30-77	CKD VKJ	DATE 11/30/77
ITEM NO.		SHT 2 OF 5	

3. CON'T.

FOR 3/4" SV/FOB AT 600° F AND MATERIAL SA-182 F304

$S_m = 16{,}100$ PSI

$D_{ob} = 1.050$ $\quad t_{mb} = .191$ FOR CONNECTING 3/4" SCH 160 PIPE

$$P = \frac{2(16{,}100\ PSI)(.191-0)}{1.050 - 2(.4)(.191-0)} = 6855$$ VS. PROGRAM VALUE OF 6844 PSI

∴ RUN PIPE WALL THICKNESS IS LIMITING

MINIMUM THICKNESS OF SV/FOB REQUIRED IS

$$t_m = \frac{Pd + 2a(S_m + PY)}{2(S_m + PY - P)}$$ EQUATION (3) FROM NB-3641.1

$d = D_{of} - 2(t_{mf}) = 1.75 - 2(.656) = .438$

$$t_m = \frac{3304(.438) + 0}{2(16{,}100 + .4(3304) - 3304)} = .0512$$

4. LIMITS OF REINFORCEMENT

RUN PIPE

L_A = GREATER OF $\begin{cases} d_f = D_{of} - 2(T_f) = .374 \\ \frac{d_f}{2} + T_r + T_f = .187 + .718 + .688 = 1.593 \end{cases}$

$L_A = 1.593$ VS PROGRAM VALUE OF 1.593

BRANCH PIPE

$L_N = .5\sqrt{r_m T_f} + .5 r_2$

$r_m = (D_{of} - T_f)/2 = (1.75 - .688)/2 = .531$

ITEM CASE NUMBER THREE				CLIENT DUKE POWER COMPANY	
				PROJECT CATAWBA	
				JOB NO.	
BY JTP	DATE 11-30-77	CKD VKT	DATE 11/30/77	ITEM NO.	SHT 3 OF 5

MINIMUM r_2 = GREATER OF $\begin{cases} T_f/2 = .688/2 = .344 \\ T_r/2 = .718/2 = .359 \end{cases}$

$r_2 = .359$ VS PROGRAM VALUE OF .359

$L_N = .5\sqrt{(.531)(.688)} + .5(.359)$

$= .482$ VS PROGRAM VALUE OF .482

5. AREA REQUIRED, A_{REQ}, VERSUS AREA AVAILABLE

$A_{REQ} = d\, t_{mr}\,(2 - \sin\alpha)$

$= .438\,(.628)(2 - \sin 90) = .275\ IN^2$

$A_1 + A_2 = 2\,L_N\,(T_f - t_m) = 2\,(.482)(.688 - .0512) = .613$

$A_3 = (2\,L_A - d_F)\,(T_r - t_m) = (2\,(1.593) - .374)\,(.718 - .718) = 0.0$

DESIGN PRESSURE HAS BEEN SELECTED SUCH THAT THE RUN PIPE HAS NO ADDITIONAL REINFORCEMENT AREA AVAILABLE.

$A_{REQ} \leq A_1 + A_2 + A_3$

6. 90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE

SINCE THE AVAILABLE AREA IS GREATER THAN THE REQUIRED AREA THE PROGRAM WILL PRINT OUT AN ALLOWABLE DESIGN PRESSURE EQUAL TO THE RUN PIPE PRESSURE OF 3304 PSI

ITEM CASE NUMBER THREE				CLIENT DUKE POWER COMPANY	
				PROJECT CATAWBA	
				JOB NO.	
BY JTP	DATE 11-30-77	CKD. VKT	DATE 11/30/77	ITEM NO.	SHT 4 OF 5

7. MAXIMUM POSSIBLE PRESSURE AND REQUIRED R_2

SINCE THE AVAILABLE AREA IS GREATER THAN THE REQUIRED AREA THE CONNECTION IS DESIGNED FOR THE MAXIMUM POSSIBLE PRESSURE WHICH IS THAT OF THE RUN PIPE PRESSURE OF 3304 PSI. THE R_2 VALUE REQUIRED FOR A DESIGN PRESSURE OF 2500 DEFAULTS TO THE MINIMUM RADIUS ASSOCIATED WITH THE STRESS INDICES, i.e., THE .359 IN. CALCULATED IN 4.

ITEM CASE NUMBER THREE				CLIENT DUKE POWER COMPANY	
				PROJECT CATAWBA	
				JOB NO.	
BY JTP	DATE 11-30-77	CKD. VKY	DATE 11/30/77	ITEM NO.	SHT 5 OF 5

Data Sheet for Sample Problem - 4

Design Conditions		Nomenclature
Design Pressure (psig)	To be determined	P
Design Temperature (^{o}F)	700.	T
Duke Piping System Classification	A	
Temperature Factor	.4	y

Branch

Nominal Size (in.) and Schedule	2" SCH 160	
Nominal Wall Thickness (in)	.343	T_b
Minimum Wall Thickness (in)	.300	t_{mb}
Outside Diameter (in)	2.375	D_{ob}
Corrosion Allowance (in)	0.0	a
Material	SA 376 TP 304	
Design Stress Intensity, S_m (psi)	15,900.	S_m

Fitting

Fitting Discription	2" SWB	
Nominal Wall Thickness (in)	.969	T_f
Minimum Wall Thickness (in)	.937	t_{mf}
Outside Diameter (in)	3.625	D_{of}
Maximum Laying Height of Fitting (in)	1.341	L_N (max)
Corrosion Allowance (in)	0.0	a
Material	SA 182 F 304	
Design Stress Intensity, S_m(psi)	15,900.	S_m

Run Pipe

Nominal Size (in) and Schedule	8" SCH 160	
Nominal Wall Thickness (in)	.906	T_r
Minimum Wall Thickness (in)	.793	t_{mr}
Outside Diameter (in)	8.625	D_{or}
Corrosion Allowance (in)	0.0	a
Material	SA 376 TP 304	
Design Stress Intensity, S_m (psi)	15,900.	S_m

ITEM: Case Number Four 2" SWB on 8" SCH 160		CLIENT: Duke Power Company	
		PROJECT: Catawba	
		JOB NO.	
BY JTP	DATE 11-30-77 CKD. VK-Y DATE 11/30/77	ITEM NO.	SHT. 1 OF 5

1. NB-3643.3(b) REQUIREMENT

$d_f \leq .2\sqrt{R_m T_r}$ NO AREA REINFORCEMENT REQUIRED

$d_f = D_{of} - 2T_f = 3.625 - 2(.969) = 1.687$

$R_m = (D_{or} - T_r)/2 = [8.625 - .906]/2 = 3.859$

$.2\sqrt{(3.859)(.906)} = .374 < 1.687$

∴ AREA REINFORCEMENT REQUIRED FOR THIS COMBINATION

2. NB-3686.1(c) REQUIREMENT

$\frac{r'_m}{R_m} \leq 0.5$ CODE STRESS INDICES MAY BE USED

$r'_m = (D_{ob} - T_b)/2 = (2.375 - .343)/2 = 1.016$

$R_m = 3.859$

$\frac{r'_m}{R_m} = .263 \leq 0.5$

∴ CODE STRESS INDICES MAY BE USED

3. MAXIMUM STRAIGHT PIPE AND FITTING PRESSURE

$P = \frac{2Sm(t_m - a)}{D_o - 2Y(t_m - a)}$ EQUATION (2) FROM NB-3641

FOR 8" SCH 160 AT 700° F AND MATERIAL SA-376 TP304

$Sm = 15,900$ PSI

$P = \frac{2(15,900)(.793 - 0)}{8.625 - 2(.4)(.793 - 0)} = 3156$ VS. PROGRAM VALUE OF 3155

ITEM CASE NUMBER FOUR - 2" SWB ON 8" SCH 160			CLIENT DUKE POWER CO.
			PROJECT CATAWBA
			JOB NO.
BY VKT	DATE 11/30/11	CKD. JTP	DATE 11/30/11
			ITEM NO.
			SHT. 2 OF 5

3. CON'T.

FOR 2" SVIB AT 700°F AND MATERIAL SA-182 F304

$S_m = 15{,}900$ PSI.

$D_{ob} = 2.375$ $t_{mb} = .300$ FOR CONNECTING 2" SCH 160 PIPE

$$P = \frac{2(15900\ \text{PSI})(.300-0)}{2.375 - 2(.4)(.300-0)} = 4468 \text{ VS. PROGRAM VALUE OF } 4470$$

∴ RUN PIPE WALL THICKNESS IS LIMITING

MINIMUM THICKNESS OF SVIB REQUIRED IS

$$t_m = \frac{Pd + 2a(S_m + YP)}{2(S_m + YP - P)} \quad \text{EQUATION (3) NB-3641}$$

$$d = D_{of} - 2(t_{mf}) = 3.625 - 2(.937) = 1.751$$

$$t_m = \frac{3155(1.751) + 0.0}{2(15{,}900 + .4(3155) - 3155)} = .197$$

4. LIMITS OF REINFORCEMENT

RUN PIPE

$$L_A = \text{GREATER OF} \begin{cases} d_f = D_{of} - 2(T_f) = 3.625 - 2(.969) = 1.687 \\ (d_f/2) + T_r + T_f = .844 + .906 + .969 = 2.719 \end{cases}$$

$L_A = 2.719$ VS PROGRAM VALUE OF 2.719

$XLA = (2L_A - d_f)/2 = (2(2.719) - 1.687)/2 = 1.875$

BRANCH PIPE

$$L_N = .5\sqrt{r_m T_f} + .5 r_2$$

$r_m = (D_{of} - T_f)/2 = (3.625 - .969)/2 = 1.328$

ITEM CASE NUMBER FOUR				CLIENT DUKE POWER CO	
				PROJECT CATAWBA	
				JOB NO.	
BY VKT	DATE 11/30/77	CKD JTP	DATE 11/31/77	ITEM NO.	SHT. 3 OF 5

4. CON'T.

MINIMUM r_2 = GREATER OF $\begin{cases} T_f/2 = .969/2 = .485 \\ T_r/2 = .906/2 = .453 \end{cases}$

$r_2 = .485$ VS. PROGRAM VALUE OF .485

$L_N = .5\sqrt{(1.328)(.969)} + .5(.485)$

$= .8097$ VS PROGRAM VALUE OF .809

5. AREA REQUIRED, A_{REQ}, VERSUS AREA AVAILABLE

$A_{REQ} = d t_r (2 - \sin\alpha)$

$= 1.751 (.793)(2 - \sin 90)$

$= 1.388$

$A_1 + A_2 = 2 L_N (T_F - t_m) = 2(.809)(.969 - .197) = 1.249$

1 $A_3 = 2 X L_A (T_r - t_r) = 2(1.875)(.793 - .793) = 0$

$\therefore$ BRANCH ALLOWABLE DESIGN PRESSURE IS CONTROLLING

6. 90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE

$A_{REQ} = d_F t_r$

$d = 1.751$

$t_m = \dfrac{P d_r + 2a(Sm + YP)}{2(Sm + YP - P)}$

$A_{REQ} = A_1 + A_2 + A_3$

$A_1 + A_2 = 2 L_N (T_F - t_f)$

$= 2 L_N \left[T_F - \left(\dfrac{P d_r + 2a(Sm + YP)}{2(Sm + YP - P)} \right) \right]$

ITEM CASE NUMBER FOUR				CLIENT DUKE POWER CO	
				PROJECT CATAWBA	
REV. 1 △	BY VKT	CKD JTP	DATE 2/6/78	JOB NO.	
BY VKT	DATE 11/30/77	CKD JTP	DATE 11/30/77	ITEM NO.	SHT 4 OF 5

6 CON'T

$$A_3 = 2XL_A(t_{mr} - t_r)$$

$$= 2XL_A\left[t_{mr} - \left(\frac{Pd_r + 2a(Sm + YP)}{2(Sm + YP - P)}\right)\right]$$

$a = 0.0$

$$\frac{d_F Pd_r}{2(Sm+YP-P)} = 2L_N\left[T_F - \frac{Pd_f}{2(Sm+YP-P)}\right] + 2XL_A\left[t_{mr} - \frac{Pd_r}{2(Sm+YP-P)}\right]$$

$$d_F Pd_r = 2L_N[2T_F(Sm+YP-P) - Pd_f] + 2XL_A[2t_{mr}(Sm+YP-P) - Pd_r]$$

$$= 4L_N T_F(Sm+YP-P) - 2L_N Pd_f + 4XL_A t_{mr}(Sm+YP-P) - 2XL_A Pd_r$$

$$= 4L_N T_F Sm + 4L_N T_F YP - 4L_N T_F P - 2L_N Pd_f + 4XL_A t_{mr} Sm$$

$$+ 4XL_A t_{mr} YP - 4XL_A t_{mr} P - 2XL_A Pd_r$$

$$P(d_F d_r - 4L_N T_F Y + 4L_N T_F + 2L_N d_f - 4XL_A t_{mr} Y + 4XL_A t_{mr} + 2XL_A d_r)$$

$$= 4L_N T_F Sm + 4XL_A t_{mr} Sm$$

$$P = \frac{4L_N T_F Sm + 4XL_A t_{mr} Sm}{d_F d_r - 4L_N T_F Y + 4L_N T_F + 2L_N d_f - 4XL_A t_{mr} Y + 4XL_A t_{mr} + 2XL_A d_r}$$

$$= \frac{4Sm(L_N T_F + XL_A t_{mr})}{d_F d_r - 4L_N T_F(Y-1) + 2L_N d_f - 4XL_A t_{mr}(Y-1) + 2XL_A d_r}$$

$$= \frac{4(15900)[(.969)(.809) + (.793)(1.875)]}{(1.751)(7.039) - 4(.809)(.969)(.4-1) + 2(.809)(1.751) - 4(1.875)(.793)(.4-1) + 2(1.875)(7.039)}$$

$= 3.072$ VS. PROGRAM VALUE OF 3072

ITEM CASE NUMBER FOUR				CLIENT DUKE POWER CO.	
				PROJECT CATAWBA	
				JOB NO.	
BY VKT	DATE 11/30/77	CKD JTP	DATE 11/30/77	ITEM NO.	SHT. 5 OF 5

Data Sheet for Sample Problem - 5

Design Conditions		Nomenclature
Design Pressure (psig)	To be determined	P
Design Temperature (^{o}F)	700.	T
Duke Piping System Classification	A	
Temperature Factor	.4	y

Branch		
Nominal Size (in.) and Schedule	2" SCH 160	
Nominal Wall Thickness (in)	.343	T_b
Minimum Wall Thickness (in)	.300	t_{mb}
Outside Diameter (in)	2.375	D_{ob}
Corrosion Allowance (in)	0.0	a
Material	SA 376 TP 304	
Design Stress Intensity, S_m (psi)	15,900.	S_m

Fitting		
Fitting Discription	2" 6,000 #SWHC	
Nominal Wall Thickness (in)	.735	T_f
Minimum Wall Thickness (in)	.725	t_{mf}
Outside Diameter (in)	3.159	D_{of}
Maximum Laying Height of Fitting (in)	1.625	L_N (max)
Corrosion Allowance (in)	0.0	a
Material	SA 182 F 304	
Design Stress Intensity, S_m(psi)	15,900.	S_m

Run Pipe		
Nominal Size (in) and Schedule	12" SCH 140	
Nominal Wall Thickness (in)	1.125	T_r
Minimum Wall Thickness (in)	.984	t_{mr}
Outside Diameter (in)	12.75	D_{or}
Corrosion Allowance (in)	0.0	a
Material	SA 376 TP 304	
Design Stress Intensity, S_m (psi)	15,900.	S_m

ITEM	Case Number Five 2" 6,000 #HC on 12" SCH 140	CLIENT	Duke Power Company
		PROJECT	Catawba
		JOB NO.	
BY JTP	DATE 11-30-77 CKD. VKY DATE 11/30/77	ITEM NO.	SHT. 1 OF 6

1. NB-3643.3(b) REQUIREMENT

$d_f \leq 0.2\sqrt{R_m T_r}$ NO AREA REINFORCEMENT REQUIRED

$d_F = D_{of} - 2T_f = 3.159 - 2(.735) = 1.689$

$R_m = (D_{or} - T_r)/2 = (12.750 - 1.125)/2 = 5.812$

$.2\sqrt{(5.812)(1.125)} = .511 < 1.689$

∴ AREA REINFORCEMENT REQUIRED FOR THIS COMBINATION

2. NB-3686.1(c) REQUIREMENT

$\frac{r'_m}{R_m} \leq 0.5$ CODE STRESS INDICES MAY BE USED

$r'_m = (D_{ob} - T_b)/2 = (2.375 - .343)/2 = 1.016$

$R_m = 5.812$

$\frac{r'_m}{R_m} = .175 < 0.5$

∴ CODE STRESS INDICES MAY BE USED

3. MAXIMUM STRAIGHT PIPE AND FITTING PRESSURE

$$P = \frac{2S_m(t_m - a)}{D_o - 2Y(t_m - a)}$$

FOR 12" SCH 140 AT 700°F AND MATERIAL SA-376 TP304

$S_m = 15{,}900$ PSI

$$P = \frac{2(15900)(.984-0)}{12.750 - 2(.4)(.984-0)} = 2616 \text{ VS. PROGRAM VALUE OF } 2617$$

ITEM CASE NUMBER FIVE - 2" 6000# HC ON 12" SCH 140				CLIENT DUKE POWER CO.	
				PROJECT CATAWBA	
				JOB NO.	
BY VKT	DATE 11/30/77	CKD JTP	DATE 11/30/77	ITEM NO.	SHT. 2 OF 6

3. CON'T.

FOR 2" 6000# HC AT 700°F AND MATERIAL SA-182 F304

$S_m = 15{,}900$ PSI.

$D_o = 2.375$ $t_m = .300$ FOR CONNECTING 2" SCH 160 PIPE

$$P = \frac{2(15{,}900)(.300-0)}{2.375 - 2(.4)(.300-0)} = 4468 \text{ VS. PROGRAM VALUE OF } 4470 \text{ PSI}$$

∴ RUN PIPE WALL THICKNESS IS LIMITING

MINIMUM WALL THICKNESS OF 6000# HC REQUIRED IS

$$t_m = \frac{Pd + 2a(S_m + YP)}{2(S_m + YP - P)}$$

$$d = D_{of} - 2t_{mf} = 3.159 - 2(.725) = 1.709$$

$$t_m = \frac{(2617)(1.709)}{2(15{,}900 + .4(2617) - 2617)} = .1561$$

4. LIMITS OF REINFORCEMENTS

RUN PIPE

$$L_A = \text{GREATER OF} \begin{cases} d_F = D_{of} - 2T_f = 1.689 \\ (d_F/2) + T_r + T_f = .845 + 1.125 + .735 = 2.705 \end{cases}$$

$L_A = 2.705$ VS. PROGRAM VALUE OF 2.705

$$XLA = (2L_A - d_f)/2 = [(2)(2.705) - 1.689]/2 = 1.861$$

BRANCH PIPE

$$L_N = 0.5\sqrt{r_m T_b} + 0.5 r_2$$

$$r_m = (D_{of} - T_f)/2 = (3.159 - .735)/2 = 1.212$$

ITEM CASE NUMBER FIVE				CLIENT DUKE POWER CO.	
				PROJECT CATAWBA	
				JOB NO.	
BY VKT	DATE 11/30/77	CKD JTP	DATE 11/30/77	ITEM NO.	SHT. 3 OF 6

4. CON'T.

$T_f = .735$

r_2 = GREATER OF $\begin{cases} T_f/2 = .735/2 = .368 \\ T_r/2 = 1.125/2 = .563 \end{cases}$

$L_N = 0.5\sqrt{(1.212)(.735)} + 0.5(.562) = .753$ VS PROGRAM VALUE OF .753

5. AREA REQUIRED VERSUS AREA AVAILABLE

$A_{REQ} = d\,t_r\,(2 - \sin\alpha)$

$= 1.709(.984) = 1.682\ IN^2$

$A_1 + A_2 = 2\,L_N\,(T_F - t_m) = 2(.753)(.735 - .156) = .872$

$\triangle 1$ $A_3 = 2\,XLA\,(T_r - t_{mr}) = 2(1.861)(.984 - .984) = 0$

$A_{REQ} > A_1 + A_2 + A_3$

∴ BRANCH ALLOWABLE DESIGN PRESSURE IS CONTROLLING

6. 90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE
(SEE CASE NUMBER FOUR FOR DEVELOPMENT OF EQUATION BELOW)

$$P = \frac{4\,S_m\,(T_F\,L_N + t_{mr}\,XLA)}{d_F d_r - 4\,L_N T_F (Y-1) + 2\,L_N d_f - 4\,XLA\,t_{mr}(Y-1) + 2\,XLA\,d_r}$$

$$= \frac{4\,(15900)[(.735)(.753) + (.984)(1.865)]}{(1.71)(10.78) - 4(.753)(.735)(.4-1) + 2(.753)(1.71) - 4(1.865)(.984)(.4-1) + 2(1.865)(10.78)}$$

$= 2269$ VS. PROGRAM VALUE OF 2269

ITEM CASE NUMBER FIVE				CLIENT DUKE POWER CO.	
				PROJECT CATAWBA	
REV. 1 △	BY VKY	CKD JTP	DATE 2/6/78	JOB NO.	
BY VKY	DATE 11/30/77	CKD. JTP	DATE 1/30/77	ITEM NO.	SHT. 4 OF 6

7. DETERMINE R_2 REQUIRED FOR A DESIGN PRESSURE OF 2500 PSI

$$A_{REQ} = d_f t_r$$

$$t_m = \frac{Pd_r + 2a(S_m + YP)}{2(S_m + YP - P)}$$

$$A_{REQ} = A_1 + A_2 + A_3$$

$$A_1 + A_2 = 2L_N (T_f - t_f)$$

$$= 2[.5\sqrt{r_m T_f} + .5 r_2]\left(T_f - \frac{Pd_f + 2a(S_m + YP)}{2(S_m + YP - P)}\right)$$

1 $$A_3 = 2XLA\,(t_{mr} - t_r)$$

$$= 2XLA\left(t_{mr} - \frac{Pd_r + 2a(S_m + YP)}{2(S_m + YP - P)}\right)$$

$$a = 0.0$$

$$\frac{d_f P d_r}{2(S_m + YP - P)} = 2\left(\tfrac{1}{2}\sqrt{r_m T_f} + \tfrac{1}{2} r_2\right)\left(T_f - \frac{Pd_f}{2(S_m + YP - P)}\right) + 2L_A\left(t_{mr} - \frac{Pd_r}{2(S_m + YP - P)}\right)$$

$$d_f P d_r = 2T_f(S_m + YP - P)(\sqrt{r_m T_f} + r_2) - Pd_f(\sqrt{r_m T_f} + r_2) + 4XL_A\, t_{mr}(S_m + YP - P) - 2XLA\, Pd_r$$

$$2T_f(S_m + YP - P)(\sqrt{r_m T_f} + r_2) - Pd_f(\sqrt{r_m T_f} + r_2) = d_f P d_r + 2XL_A P d_r - 4XL_A t_{mr}(S_m + YP - P)$$

$$(\sqrt{r_m T_f} + r_2)(2T_f(S_m + YP - P) - Pd_f) = d_r P(d_f + 2XL_A) - 4XL_A t_{mr}(S_m + YP - P)$$

$$r_2 = \frac{d_r P(d_f + 2XL_A) - 4XL_A t_{mr}(S_m + YP - P)}{2T_f(S_m + YP - P) - Pd_f} - \sqrt{r_m T}$$

ITEM CASE NUMBER FIVE				CLIENT DUKE POWER CO	
				PROJECT CATAWBA	
REV 1 ⚠	BY VKT	CKD JTP	DATE 2/6/98	JOB NO.	
BY VKT	DATE 11/30/97	CKD JTP	DATE 11/5/97	ITEM NO.	SHT 5 OF 6

7. CON'T.

$$r_2 = \frac{(10.78)(2500)(1.71 + 2(1.865)) - 4(1.865)(.984)(15900 + .4(2500) - 2500}{2(.735)(15900 + .4(2500) - 2500) - 2500(1.71)}$$

$$- \sqrt{(1.212)(.735)}$$

$$= 1.477 \quad \text{VS. PROGRAM VALUE OF } 1.475$$

ITEM CASE NUMBER FIVE				CLIENT DUKE POWER CO.	
				PROJECT CATAWBA	
				JOB NO.	
BY VKT	DATE 11/30/77	CKD. JTP	DATE 11/30/77	ITEM NO.	SHT. 6 OF 6

Data Sheet for Sample Problem - 6

Design Conditions		Nomenclature
Design Pressure (psig)	To be determined	P
Design Temperature (°F)	650.	T
Duke Piping System Classification	A	
Temperature Factor	.4	y

Branch

Nominal Size (in.) and Schedule	3/4" SCH 160	
Nominal Wall Thickness (in)	.218	T_b
Minimum Wall Thickness (in)	.191	t_{mb}
Outside Diameter (in)	1.050	D_{ob}
Corrosion Allowance (in)	0.0	a
Material	SA 312 TP 304	
Design Stress Intensity, S_m (psi)	16,100.	S_m

Fitting

Fitting Discription	3/4" SWFOB	
Nominal Wall Thickness (in)	.688	T_f
Minimum Wall Thickness (in)	.656	t_{mf}
Outside Diameter (in)	1.75	D_{of}
Maximum Laying Height of Fitting (in)	.794	L_N (max)
Corrosion Allowance (in)	0.0	a
Material	SA 182 F 304	
Design Stress Intensity, S_m(psi)	16,100.	S_m

Run Pipe

Nominal Size (in) and Schedule	14" SCH 140	
Nominal Wall Thickness (in)	1.25	T_r
Minimum Wall Thickness (in)	1.094	t_{mr}
Outside Diameter (in)	14.0	D_{or}
Corrosion Allowance (in)	0.0	a
Material	SA 312 TP 304	
Design Stress Intensity, S_m (psi)	16,100.	S_m

ITEM: Case Number Six 3/4" SWFOB on 14" SCH 140		CLIENT: Duke Power Company	
		PROJECT: Catawba	
		JOB NO.	
BY: JTP	DATE: 11-30-77 CKD: VKY	DATE: 11/30/77	ITEM NO. SHT. 1 OF 2

1 NB-3643.3(6) REQUIREMENT

$d_f < 0.2\sqrt{R_m T_r}$ NO AREA REINFORCEMENT REQUIRED

$d_f = d_{of} - 2T_f = 1.750 - 2(.688) = .374$

$R_m = (D_{or} - T_r)/2 = (14.00 - 1.25)/2 = 6.375$

$.2\sqrt{(6.375)(1.25)} = .565 \geq .374$

∴ NO AREA REINFORCEMENT REQUIRED FOR THIS COMBINATION

2. NB-3686.1(e) REQUIREMENT

$\frac{r'_m}{R_m} \leq 0.5$ CODE STRESS INDICES MAY BE USED

$r'_m = (D_{ob} - T_b)/2 = (1.05 - .218)/2 = .416$

$R_m = 6.375$

$\frac{r'_m}{R_m} = .065 < 0.50$

∴ CODE STRESS INDICES MAY BE USED

3. IN THE PROGRAM THE 90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE DEFAULTS TO THE SMALLER MAXIMUM ALLOWABLE PRESSURE OF THE RUN PIPE OR CONNECTING BRANCH PIPE.

4. IN THE PROGRAM THE MAXIMUM POSSIBLE PRESSURE DEFAULTS TO THE SMALLER MAXIMUM ALLOWABLE PRESSURE OF THE RUN PIPE OR CONNECTING BRANCH PIPE. THE REQUIRED R2 DEFAULTS TO THE GREATER OF $T_f/2$ AND $T_r/2$.

$T_b/2 = .688/2 = .344$

$T_r/2 = 1.25/2 = .625$

ITEM CASE NUMBER SIX - 3/4" SW/FOB ON 14" SCH 140	CLIENT DUKE POWER CO
	PROJECT CATAWBA
	JOB NO.
BY VKT DATE 11/30/77 CKD JTP DATE 11/30/77	ITEM NO. SHT. 2 OF 2

8.0 PROGRAM LISTING

```
      PROGRAM CL1BIC(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      COMMON A,ALPHA,Y,IFLAG,LMAX,STOR(1)
      DATA REV /10H 05/01/77 /
      CALL DATE(DAT)
  100 CONTINUE
      READ(5,5000) NFIT,NBRCH,NRUN,NFMATL,NPMATL
      NMATL=1
      IF(EOF(5).NE.0) GOTO 900
C     PRINT LOGO
      WRITE(6,6000) REV,DAT
      READ(5,5010) A,ALPHA,Y,IFLAG
C     LOCATE START OF EXPANDABLE STORAGE
      L0=LOCF(STOR(1))
C     CALC END OF FIT()
      L1=12*NFIT
C     CALC END OF BRCH()
      L2=7*NBRCH+L1
C     CALC END OF RUN()
      L3=7*NRUN+L2
C     CALC END OF FMATL()
      L4=4*NFMATL+L3
C     CALC END OF PMATL()
      L5=4*NPMATL+L4
C     RESET TO ACCOMMODATE ALL DATA EXCEPT MATERIAL NAMES
      LMAX=L0+L5+8
      CALL XRFL(LMAX)
C     INPUT ALL DATA
      CALL DINPUT(NFIT,NBRCH,NRUN,NFMATL,NPMATL,NMATL,
     *            STOR(1),STOR(L1+1),STOR(L2+1),STOR(L3+1),STOR(L4+1),
     *            STOR(L5+1))
C     EXECUTE CALCULATIONS AND PRINT TABLES
      CALL CL1CALC(NFIT,NBRCH,NRUN,NFMATL,NPMATL,NMATL,
     *            STOR(1),STOR(L1+1),STOR(L2+1),STOR(L3+1),STOR(L4+1),
     *            STOR(L5+1))
C     PRINT CLOSING LOGO AND EXIT
      WRITE(6,6010)
      GOTO 100
  900 CONTINUE
      CALL EXIT
C
C     FORMATS
 5000 FORMAT(16I5)
 5010 FORMAT(3E10.0,I5)
 6000 FORMAT(1H1,///////////
     *       40X,50H**************************************************/
     *       40X,50H*                                                */
     *       40X,50H*                  EDS NUCLEAR, INC              */
     *       40X,50H*                                                */
     *       40X,50H*                  PROGRAM *CL1BIC*              */
     *       40X,50H*                                                */
     *       40X,50H*      AREA REINFORCEMENT AND STRESS INDEX       */
     *       40X,50H*  CALCULATIONS FOR CLASS 1 BRANCH CONNECTIONS   */
     *       40X,50H*       PER ASME BPVC SECTION III NB-3600        */
     *       40X,50H*                                                */
     *       40X,29H*           PROGRAM VERSION ,A10,10X,          1H*/
     *       40X,32H*         CALCULATIONS PERFORMED ,A10,7X,      1H*/
     *       40X,50H*                                                */
```

```
     .        4X,5H ******************************************************)
    6 FORMAT(1H1,/////////)
     .        4X,5H ****************************************************** /
     .        4X,5H *                                                    * /
     .        4X,5H *              [illegible] NUCLEAR, INC.             * /
     .        4X,5H *                                                    * /
     .        4X,5H *              PROGRAM [illegible]                   * /
     .        4X,5H *                                                    * /
     .        4X,5H *      AREA REINFORCEMENT AND STRESS [illegible]     * /
     .        4X,5H * CALCULATIONS FOR CLASS 1 BRANCH CONNECTIONS        * /
     .        4X,5H *       PER ASME B&PV SECTION III [illegible]        * /
     .        4X,5H *                                                    * /
     .        4X,5H *              END OF EXECUTION                      * /
     .        4X,5H *                                                    * /
     .        4X,5H ******************************************************)
      END
```

```
      .     80X,50H**********************************************************)
      6010 FORMAT(1H1,//////////
60    .     80X,50H********************************************************** /
      .     80X,50H*                                                        * /
      .     80X,50H*                    EDS NUCLEAR, INC                    * /
      .     80X,50H*                                                        * /
      .     80X,50H*                    PROGRAM *CLIBIC*                    * /
65    .     80X,50H*                                                        * /
      .     80X,50H*       AREA REINFORCEMENT AND STRESS INDEX              * /
      .     80X,50H*  CALCULATIONS FOR CLASS 1 BRANCH CONNECTIONS           * /
      .     80X,50H*        PER ASME BPVC SECTION III NB-3600               * /
      .     80X,50H*                                                        * /
70    .     80X,50H*                    END OF EXECUTION                    * /
      .     80X,50H*                                                        * /
      .     80X,50H**********************************************************)
            END
```

```
      SUBROUTINE DINPUT(NFIT,NBRCH,NRUN,NFMATL,NPMATL,NMATL,
     *                  FIT, BRCH, RUN, FMATL, PMATL, MATL)
      COMMON A,ALPHA,Y,IFLAG,LMAX
      DIMENSION FIT(NFIT,12),BRCH(NBRCH,7),
     *          RUN(NRUN,7),FMATL(NFMATL,4),PMATL(NPMATL,4),MATL(8,NMATL)
C     ECHO CONTROLLING DATA
      WRITE(6,6200)
      WRITE(6,6000) NFIT,NBRCH,NRUN,NFMATL,NPMATL,A,ALPHA,Y
      IF(IFLAG.EQ.0) GOTO 10
      WRITE(6,6005)
   10 CONTINUE
C     READ AND ECHO FITTING DATA
      WRITE(6,6010)
      DO 20 I=1,NFIT
      READ(5,5020) (FIT(I,J),J=1,11)
      FLAG=1H
      IF(FIT(I,7).NE.5H      ) FLAG=1H*
      FIT(I,7)=FLAG
*     FIT(I,10)=.........P1
*     FIT(2,11)=.........P2
      FIT(I,12)=0.5*FIT(I,3)-FIT(I,5)+A
      WRITE(6,6020) I,(FIT(I,J),J=1,12)
   20 CONTINUE
C     READ AND ECHO BRANCH PIPE DATA
      WRITE(6,6030)
      DO 40 I=1,NBRCH
      READ(5,5040) (BRCH(I,J),J=1,5)
      IF(BRCH(I,5).LT.10.E-5) BRCH(I,5)=0.875*BRCH(I,4)
      BRCH(I,6)=0.5*(BRCH(I,3)-BRCH(I,4))
      WRITE(6,6040) I,(BRCH(I,J),J=1,5)
   40 CONTINUE
C     READ AND ECHO RUN PIPE DATA
      WRITE(6,6050)
      DO 60 I=1,NRUN
      READ(5,5060) (RUN(I,J),J=1,5)
      IF(RUN(I,5).LT.10.E-5) RUN(I,5)=0.875*RUN(I,4)
      RUN(I,6)=0.5*(RUN(I,3)-RUN(I,4))
      RUN(I,7)=SQRT(RUN(I,6)*RUN(I,4))
      WRITE(6,6060) I,(RUN(I,J),J=1,5)
   60 CONTINUE
C     PREPARE TO EXPAND STORAGE FOR MATERIALS
      LMAX=LMAX-8
      NMATL=0
C     READ AND ECHO FITTING MATERIAL DATA
C     INCREASE STORAGE FOR MATERIAL NAMES
      WRITE(6,6200)
      WRITE(6,6170)
      DO 100 I=1,NFMATL
      READ(5,5100) (FMATL(I,J),J=1,3)
      L=INT(FMATL(I,3))
      WRITE(6,6100) I,FMATL(I,1),FMATL(I,2),L
      L=NMATL+1
      FMATL(I,4)=FLOAT(L)
      NMATL=NMATL+INT(FMATL(I,3))
      LMAX=LMAX+8*INT(FMATL(I,3))
      CALL XREFL(LMAX)
      DO 80 K=L,NMATL
```

```
      READ(5,5060) (MATL(J,K),J=1,8)
      WRITE(6,6060) (MATL(J,K),J=1,8)
   80 CONTINUE
  100 CONTINUE
C     READ AND ECHO PIPE MATERIAL DATA
C     INCREASE STORAGE FOR MATERIAL NAMES
      WRITE(6,6110)
      DO 140 I=1,NPMATL
      READ(5,5140) (PMATL(I,J),J=1,3)
      L=INT(PMATL(I,3))
      WRITE(6,5140) I,PMATL(I,1),PMATL(I,2),L
      L=NMATL+1
      PMATL(I,4)=FLOAT(L)
      NMATL=NMATL+INT(PMATL(I,3))
      LMAX=LMAX+8*INT(PMATL(I,3))
      CALL XREL(LMAX)
      DO 120 K=L,NMATL
      READ(5,5120) (MATL(J,K),J=1,8)
      WRITE(6,6120) (MATL(J,K),J=1,8)
  120 CONTINUE
  140 CONTINUE
C
C     END OF DATA INPUT
      RETURN
C
C     FORMATS
 5060 FORMAT(5X,2A10,3E10.0)
 5080 FORMAT(5X,7A10,A5)
 5100 FORMAT(5X,2F10.0,F5.0)
 5120 FORMAT(5X,7A10,A5)
 5140 FORMAT(5X,2F10.0,F5.0)
 5020 FORMAT(5X,2A10,4E10.0,A5,2F5.0,/,25X,2E10.0)
 5040 FORMAT(5X,2A10,3E10.0)
 6000 FORMAT(40H0CONTROLLING PARAMETERS                                  //
     .    5X,40H NUMBER OF FITTINGS                          =    I6     /
     .    5X,40H NUMBER OF BRANCH PIPE CROSS-SECTIONS        =    I6     /
     .    5X,40H NUMBER OF RUN PIPE CROSS-SECTIONS           =    I6     /
     .    5X,40H NUMBER OF FITTING MATERIALS                 =    I6     /
     .    5X,40H NUMBER OF PIPE MATERIALS                    =    I6     /
     .    5X,40H CORROSION ALLOWANCE                         =  F6.3,5H (IN) /
     .    5X,40H BRANCH/RUN INTERSECTION ANGLE               =  F6.1,6H (DEG)//
     .    5X,40H Y PARAMETER                                 =  F6.1       )
 6005 FORMAT(51H0     STRESS INDICES WILL BE CALCULATED AND PRINTED     )
 6010 FORMAT(// 28H INPUT DATA FOR FITTINGS                              /
     .                                                                   )
 6020 FORMAT(I6,2X,A10,2X,A10,4F10.3,5X,A5,2F10.0,3F10.3)
 6030 FORMAT(// 42H INPUT DATA FOR BRANCH PIPE CROSS-SECTIONS            /
     .                                                                   )
 6040 FORMAT(I6,2X,A10,2X,A10,4F10.3)
 6050 FORMAT(///,39H INPUT DATA FOR RUN PIPE CROSS-SECTIONS              /
     .                                                                   )
 6060 FORMAT(I6,2X,A10,2X,A10,5F10.3)
 6070 FORMAT(///,33H INPUT DATA FOR FITTING MATERIALS                    )
 6080 FORMAT(13X,7A10,A5)
 6100 FORMAT(14H0     MATL NO. I3,13H   SM (PSI) = F8.0,5X,
     .       'DESIGN TEMP (DEG-F) = ',F5.0,/
     .       I12,'APPLICABLE MATERIALS')
```

```
      6110 FORMAT(///,30H INPUT DATA FOR PIPE MATERIALS                  )
      6120 FORMAT(13X,7A10,A5)
      6130 FORMAT(10HO      MATL NO. I3,13H   SM (PSI) = F8.0,5X,
     .        'DESIGN TEMP (DEG-F) = ',F5.0,/
     .        T12,'APPLICABLE MATERIALS')
      6200 FORMAT(1H1,///,41H *CLIRIC* AREA REINFORCEMENT CALCULATIONS
     .                  23H FOR BRANCH CONNECTIONS   / )
           END
```

```
      SUBROUTINE CLICALC(NFIT,NBRCH,NRUN,NFMATL,NPMATL,NMATL,
     .                   FIT, BRCH, RUN, FMATL, PMATL, MATL)
      COMMON A,ALPHA,Y,IFLAG,LMAY
      DIMENSION FIT(NFIT,12),BRCH(NBRCH,7),
     .       RUN(NRUN,7),FMATL(NFMATL,4),PMATL(NPMATL,4),MATL(A,NMATL)
C
C     LOOP OVER RUN PIPE MATERIALS
      DO 1000 IPM=1,NPMATL
C     PRINT TABLES
      WRITE(6,5555)
C
      SMR=PMATL(IPM,1)
      TEMPR=PMATL(IPM,2)
      MP1=INT(PMATL(IPM,4))
      MP2=MP1+INT(PMATL(IPM,3))-1
      WRITE(6,3333) (MATL(1,K),K=MP1,MP2)
C     LOOP OVER BRANCH (FITTING/PIPE) MATERIALS
      DO 1000 IFM=1,NFMATL
      SMF=FMATL(IFM,1)
      TEMPF=FMATL(IFM,2)
      MF1=INT(FMATL(IFM,4))
      MF2=MF1+INT(FMATL(IFM,3))-1
C     DESIGN TEMPERATURES OUT OF RANGE! SKIP THIS RUN/BRANCH MATERIAL COMBINATIO
      IF(ABS(TEMPR-TEMPF).GT.10.0) GOTO 1000
      WRITE(6,2222) (MATL(1,K),K=MF1,MF2)
      WRITE(6,1111)
      WRITE(6,1112)
C     LOOP OVER RUN PIPE SECTIONS
      DO  950   IR=1,NRUN
      IF(IR.NE.1) GO TO 777
      WRITE(6,6000) RUN(IR,1),RUN(IR,2),RUN(IR,4),RUN(IR,5)
      GO TO 888
  777 WRITE(6,5555)
      MP1=INT(PMATL(IPM,4))
      MP2=MP1 + INT(PMATL(IPM,3)) - 1
      WRITE(6,3333) (MATL(1,K),K=MP1,MP2)
      MF1=INT(FMATL(IFM,4))
      MF2=MF1 + INT(FMATL(IFM,3)) - 1
      WRITE(6,2222) (MATL(1,K),K=MF1,MF2)
      WRITE (6,1111)
      WRITE(6,1112)
      WRITE(6,6000) RUN(IR,1),RUN(IR,2),RUN(IR,4),RUN(IR,5)
  888 CONTINUE
      DRO = RUN(IR,3)
      TRM=RUN(IR,5) - A
      DRI = DRO - (TRM*2.0)
      RTM=RUN(IR,4)
      RRA = (DRO + RTM)/2.
      SMR = 2.0*SMR*TRM/(DRO - 2.0*Y*TRM)
      SCR = SQRT(RRA*RTM)
      WRITE(6,4444) SCR,SMR,Y
      RST=0.
  800 DO  900   IFIT=1,NFIT
      IFBS = INT(FIT(IFIT,8))
      IFBM = INT(FIT(IFIT,9))
      DRO = BRCH(IFBS,3)
      TRM = BRCH(IFBS,5) - A
```

```
      DRI = DRO - (TRM*2.0)
      RRA = (DRO - TRM)/2.0
      TEMPH = PMATL(IPH,2)
      SMR = PMATL(IPH,1)
      PMR = 2.0*SMR*TRM/(DRO - 2.0*Y*TRM)
      DFO = FIT(IFIT,3)
      TFM = FIT(IFIT,5) - A
      DFI = DFO - (TFM*2.0)
      TRA = RRCH(IFRS,4)
      TFA = FIT(IFIT,4)
      RRAA = (DRO -TRA)/2.
      RFAA = (DFO - TFA)/2.
      DFIA = DFO - (TFA*2.0)
      SLN = FIT(IFIT,6)
      RFA = (DFO - TFM)/2.0
      R2M = .5*AMAX1(RTM,TFA)
      IF ((RRA/RTM.LE.50.).AND.(RRAA/RRA.LE.0.5)) GO TO 108
C     ADD CARDS WHICH NOTE THE LIMITS OF NR=3686.1(E) WERE NOT MET
      IF(IFIT.EQ.NFIT)GO TO 735
      GO TO 900
  108 IF(.2*SQRT(RRA*RTM).LT.DFIA) GO TO 801
      PPA = AMIN1(PMR,PMR)
      R2R = R2M
      GO TO 804
  801 XLN = AMIN1(SLN,0.5*(SQRT(RFAA*TFA) + R2M))
      DLA = AMAX1(DFIA,(DFIA/2. + TFA + RTM))
      XLN = XLN*AMIN1(1.0,SMF/SMR)
      XLA = (DLA*2.0 - DFIA)/2.0
      PPP=(SMR*2.*(2.*XLN*TFA-DFI*TRM))/(2.*DFI*(TRM*Y-TRM+XLN)+4.*XLN*
     1    TFA*(1.-Y))
      IF(PPP.LT.PMR) GO TO 805
      PPA=AMIN1(PMR,PMR)
      R2R=R2M
      GO TO 804
  805  PPP = (4.0*SMR*(TFA*XLN+TRM*XLA))/(DFI*DRI+2.*(DFI*XLN + DRI*XLA)
     1      - 4.0*(Y-1.0)*(TFA*XLN + TRM*XLA))
      X23 = AMAX1((DFIA/2.0 + TFA + RTM),(DFIA/2.0 + 0.5*SQRT(RRA*RTM)))
      X23 = (X23*2.0 - DFIA)/2.0
      P23 = (6.0*SMR*(TFA*XLN + TRM*X23)) / (DFI*DRI + 3.0*(DFI*XLN +
     1      DRI*X23) - 6.0*(Y-1.0)*(TFA*XLN + TRM*X23))
      PPF=AMIN1(PPP,P23)
      PPL=AMIN1(PMR,PMR)
      IF(PPF.GT.2500.) GO TO 802
      PPA=PPF
      P=2500.
      IF(P23.LT.PPP) GO TO 803
      R2R=(DRI*P*(DFI+2.*XLA)-4.*XLA*TRM*(SMR+Y*P-P))/(2.*TFA*(SMR+Y*P-P
     1    )-P*DFI)-SQRT(RFAA*TFA)
      GO TO 804
  803  R2R = ((.6667*(DFI*P*DRI)-(2.*TRM*(SMR+Y*P-P)-P*DRI)*2.*X23)/(2.*
     1TFA*(SMR+Y*P-P)-P*DFI))-SQRT(RFAA*TFA)
      GO TO 804
  802. PPA=PPF
      R2R=R2M
      IF(PPF.GE.PPL) PPA=PPL
  804  CONTINUE
      IF((RUN(IR,3).LT.8.625).OR.(RUN(IR,4).LT..5)) GO TO 705
```

```
      WRITE(6,6100) FIT(IFIT,1),FIT(IFIT,2),FIT(IFIT,4),FIT(IFIT,5),PPA,
     .     TEMPR,DLA,XLN,R2M,R2R,SCR,PMR
      GO TO 900
  705 CONTINUE
      IF(FIT(IFIT,7).EQ.5H     )GO TO 905
      RST=RST +1.
      WRITE(6,715) FIT(IFIT,1),FIT(IFIT,2),FIT(IFIT,4),FIT(IFIT,5),PPA,
     .     TEMPR,DLA,XLN,R2M,R2R,SCR,PMR
      IF(IFIT.EQ.NFIT) GO TO 735
      GO TO 900
  905 CONTINUE
      RST=RST + 1.
      WRITE(6,6100) FIT(IFIT,1),FIT(IFIT,2),FIT(IFIT,4),FIT(IFIT,5),PPA,
     .     TEMPR,DLA,XLN,R2M,R2R,SCR,PMR
      IF(IFIT.EQ.NFIT)GO TO 735
      GO TO 900
  735 CONTINUE
      IF(RST.GT.0.)GO TO 760
      GO TO 900
  760 CONTINUE
      WRITE(6,780)
      GO TO 900
 1111 FORMAT(//,
     .       99H   BRANCH            FITTING  FITTING      90 DEGREE
     .  MAXIMUM      REINFORCEMENT      MINIMUM    ,5X,'  SPACING        AL
     .LOWABLE',/
     .       96H    SIZE   FITTING  AVERAGE  MINIMUM       BRANCH
     .  DESIGN         LIMITS           R2    ,5X,'    CRITERIA    DESIG
     .N PRESSURE',/
     .       95H          ,  TYPE     WALL     WALL     ----------------
     .TEMPERATURE    LA       LN     REQUIRED,5X,'    SQUARE ROOT   FOR
     .STRAIGHT')
 1112 FORMAT(99H                                        ALLOWABLE DESIGN
     .       AND      ,5X,'OF RM X TR    FITT
     .ING TYPE',/
     .       97H                                          PRESSURE
     .                          REQUIRED R2,/
     .       97H   INCHES          INCHES   INCHES         PSI,
     .    F        INCHES   INCHES  FOR 2500PSI,7X,'  INCHES           P
     .SI.      ',/
     .       99H   ------  -------  -------  -------  ----------------
     .-----------  ---------------  -----------  ,5X,'--------------------
     .------------')
 4444 FORMAT(15X,4H SH=,F8.0,5H PSI,,2X,29H MAXIMUM ALLOWABLE PRESSURE=
     .       ,F6.0,'PSI',5X,'Y= ',F5.3,/
     .       '-------------------------------------------------------------
     .-------------------------------------      --------------------
     .-------')
 6000 FORMAT(/,10X,11H PIPE SIZE=,2A10,',',14H AVERAGE WALL=,F10.3,',',1
     .4H MINIMUM WALL=,F10.3,)
 6100 FORMAT(4A,A10,2F9.3,8X,F6.0,8X,F5.0,6X,F5.3,2X,F5.3,5X,F5.3,F6.3,
     .       7X,F8.3,10X,F5.0)
 5555 FORMAT(1H1,//,10X,28H APPLICABLE FOR MATERIALS:  ,/
     .       11X,'-------------------------')
 2222 FORMAT(17X,19H FITTING MATERIALS:,7(2X,A10),2X,A5)
 3333 FORMAT(17X,16H PIPE MATERIALS:,7(2X,A10),2X,A5)
  715 FORMAT(4A,A10,'*',F8.3,F9.3,8X,F6.0,8X,F5.0,6X,F5.3,2X,F5.3,5X,F5.
```

```
                .       3,F6.3,7X,F6.3,10X,F5.0)
                780 FORMAT(///,'**COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICK
                  .NESS AND/OR NOMINAL PIPE SIZE BELOW VALUES',/
            175   .5X,'SHOWN IN MDG-ES-2')
                900 CONTINUE
                950 CONTINUE
                1000 CONTINUE
                    RETURN
            180     END
```

Notes Applicable to Branch Connection Tables

(1) No such fitting exists for this piping configuration.

(2) Special welding Boss (SWB) not permitted per MDG-ES-2.

(3) Combination not included in original proposed work effort.

APPLICABLE MATERIALS

Fitting: SA 182 F304

Piping: SA 376 TP304; SA 312 TP304; SA 376 TP316

TABLE 2.1

TEMPERATURE: 600°F

Minimum Allowable Stress (S_m) : 16,400

Corrosion Allowance : 0.0

RUN PIPE		FITTING PIPE (See Figures 1, 2, and 3)	BRANCH PIPE - Size, Schedule, and Allowable Pressure (psi)					
Size & Schedule	Allowable Pressure (psi)		1/2 in. Sch 160	3/4 in. Sch 160	1 in. Sch 160	1-1/4 in. Sch 160	1-1/2 in. Sch 160	2 in. Sch 160
			7570	6970	6290	4830	4730	4610
2 in. Sch 160	4610	6000#HC	(3)	4610	NR	NR	NR	NR
2½ in. Sch 160	4120	6000#HC	(3)	4120	4120	NR	NR	NR
3 in. Sch 160	3930	6000#HC	(3)	3930	3930	3670	NR	NR
4 in. Sch 160	3690	6000#HC	(3)	3690	3640	3330	3380	NR
		SWB	(2)	(2)	(2)	(2)	(2)	NR
		SWFOB	(1)	(2)	(1)	(1)	(1)	(1)
5 in. Sch 160	3500	6000#HC	(3)	3440	3390	3110	3120	3210
		SWB	(2)	(2)	(2)	(2)	(2)	(2)
		SWFOB	(1)	(2)	(1)	(1)	(1)	(1)
6 in. Sch 160	3360	6000#HC	(3)	3270	3220	2960	2970	3010
		SWB	(2)	(2)	(2)	(2)	(2)	(2)
		SWFOB	(1)	(2)	(1)	(1)	(1)	(1)
8 in. Sch 160	3250	6000#HC	(3)	3120	3060	2840	2830	2840
		SWB	3250	3250	3250	3010	3150	3170
		SWFOB	(1)	3250	(1)	(1)	(1)	(1)
10 in. Sch 140	2850	6000#HC	(3)	2730	2680	*2490	*2480	*2480
		SWB	2850	2840	2850	2630	2740	2740
		SWFOB	(1)	2850	(1)	(1)	(1)	(1)
12 in. Sch 140	2700	6000#HC	(3)	2570	2520	*2360	*2340	*2340
		SWB	2700	2660	2700	*2470	2560	2550
		SWFOB	(1)	2700	(1)	(1)	(1)	(1)
14 in. Sch 140	2730	6000#HC	(3)	2600	2550	*2390	*2370	*2360
		SWB	2730	2680	2720	*2490	2570	2550
		SWFOB	(1)	2730	(1)	(1)	(1)	(1)

NR = Combination not recommended since mean radius ratio would invalidate use of current code stress indices.

* = These pressures may be increased to 2500psi if a r_2 value given in Appendix B can be met.

APPLICABLE MATERIALS

TABLE 2.2

Fitting: SA 182 F304

Piping: SA 376 TP304; SA 312 TP304; SA 376 TP316

TEMPERATURE: 650°F

Minimum Allowable Stress (S_m) : 16,100

Corrosion Allowable : 0.0

RUN PIPE		FITTING PIPE (See Figures 1, 2, and 3)	BRANCH PIPE - Size, Schedule, and Allowable Pressure (psi)					
Size & Schedule	Allowable Pressure (psi)		1/2 in. Sch 160	3/4 in. Sch 160	1 in. Sch 160	1-1/4 in. Sch 160	1-1/2 in. Sch 160	2 in. Sch 160
			7430	6840	6180	4740	4650	4520
2 in. Sch 160	4520	6000#HC	(3)	4520	NR	NR	NR	NR
2½ in. Sch 160	4040	6000#HC	(3)	4040	4040	NR	NR	NR
3 in. Sch 160	3860	6000#HC	(3)	3860	3860	3610	NR	NR
4 in. Sch 160	3620	6000#HC	(3)	3620	3580	3270	3320	NR
		SWB	(2)	3620	3620	3620	3620	NR
		SWFOB	(1)	3620	3620	(2)	(1)	(1)
5 in. Sch 160	3430	6000#HC	(3)	3370	3330	3050	3060	3160
		SWB	(2)	3430	3430	3320	3430	3430
		SWFOB	(1)	3430	3430	(1)	(1)	(1)
6 in. Sch 160	3300	6000#HC	(3)	3210	3160	2910	2910	2950
		SWB	(2)	3300	3300	3120	3300	3300
		SWFOB	(1)	3300	3300	(1)	(1)	(1)
8 in. Sch 160	3190	6000#HC	(3)	3060	3000	2780	2780	2790
		SWB	3190	3190	3190	2960	3090	3110
		SWFOB	(1)	3190	3190	(1)	(1)	(1)
10 in. Sch 140	2800	6000#HC	(3)	2680	2630	*2450	*2440	*2440
		SWB	2800	2780	2800	2580	2690	2690
		SWFOB	(1)	2800	2800	(1)	(1)	(1)
12 in. Sch 140	2650	6000#HC	(3)	2530	*2480	*2310	*2300	*2290
		SWB	2650	2610	2650	*2430	2510	2510
		SWFOB	(1)	2650	2650	(1)	(1)	(1)
14 in. Sch 140	2680	6000#HC	(3)	2550	2500	*2340	*2330	*2310
		SWB	2680	2630	2670	*2440	2520	2510
		SWFOB	(1)	2680	2680	(1)	(1)	(1)

NR = Combination not recommended since mean radius ratio would invalidate use of current code stress indices.

* = These pressures may be increased to 2500psi if a r_2 value given in Appendix B can be met.

APPLICABLE MATERIALS

Fitting: SA 182 F304

Piping: SA 376 TP304; SA 312 TP304; SA 376 TP316

TABLE 2.3

TEMPERATURE: 700°F

Minimum Allowable Stress (S_m): 15,900

Corrosion Allowance : 0.0

RUN PIPE		FITTING PIPE (See Figures 1, 2, and 3)	BRANCH PIPE - Size, Schedule, and Allowable Pressure (psi)					
Size & Schedule	Allowable Pressure (psi)		1/2 in. Sch 160	3/4 in. Sch 160	1 in. Sch 160	1-1/4 in. Sch 160	1-1/2 in. Sch 160	2 in. Sch 160
			7340	6760	6100	4680	4590	4470
2 in. Sch 160	4470	6000#HC	(3)	4470	NR	NR	NR	NR
2½ in. Sch 160	3990	6000#HC	(3)	3990	3990	NR	NR	NR
3 in. Sch 160	3810	6000#HC	(3)	3810	3810	3560	NR	NR
4 in. Sch 160	3580	6000#HC	(3)	3570	3530	3320	3270	NR
		SWB	(2)	(2)	(2)	(2)	(2)	NR
		SWFOB	(1)	(2)	(1)	(1)	(1)	(1)
5 in. Sch 160	3390	6000#HC	(3)	3330	3280	3010	3020	3120
		SWB	(2)	(2)	(2)	(2)	(2)	(2)
		SWFOB	(1)	(2)	(1)	(1)	(1)	(1)
6 in. Sch 160	3260	6000#HC	(3)	3170	3120	2870	2870	2920
		SWB	(2)	(2)	(2)	(2)	(2)	(2)
		SWFOB	(1)	(2)	(1)	(1)	(1)	(1)
8 in. Sch 160	3150	6000#HC	(3)	3020	2970	2750	2740	2750
		SWB	3160	3160	3160	2920	3050	3070
		SWFOB	(1)	3160	(1)	(1)	(1)	(1)
10 in. Sch 140	2770	6000#HC	(3)	2650	2600	*2420	*2410	*2410
		SWB	2770	2750	2760	2550	2660	2660
		SWFOB	(1)	2760	(1)	(1)	(1)	(1)
12 in. Sch 140	2610	6000#HC	(3)	*2490	*2450	*2280	*2270	*2260
		SWB	2610	2580	2610	*2400	*2480	*2480
		SWFOB	(1)	2610	(1)	(1)	(1)	(1)
14 in. Sch 140	2650	6000#HC	(3)	2520	*2470	*2310	*2300	*2280
		SWB	2650	2600	2640	*2410	*2490	*2480
		SWFOB	(1)	2650	(1)	(1)	(1)	(1)

NR = Combination not recommended since mean radius ratio would invalidate use of current code stress indices.

* = These pressures may be increased to 2500psi if a r_2 value given in Appendix B can be met.

Table 4.1

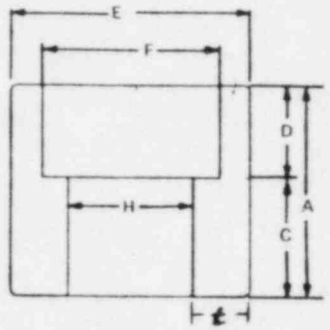
Minimum Laying Heights

Nominal Size	Half-Coupling 6000 lb. (in.)	Special Welding Boss (in.)	Special Welding Flow Orifice Boss (in.)
1/2	.815	.654	.794
3/4	.878	.716	.794
1	1.045	.841	.904
1-1/4	1.108	.903	-
1-1/2	1.170	.966	-
2	1.545	1.341	-

Table 4.2

Design Stress Intensity Values S_m

Material	Temperature		
	600°F	650°F	700°F
SA-376 TP304	16,400	16,100	15,900
SA-312 TP304	16,400	16,100	15,900
SA-376 TP316	16,400	16,100	15,900

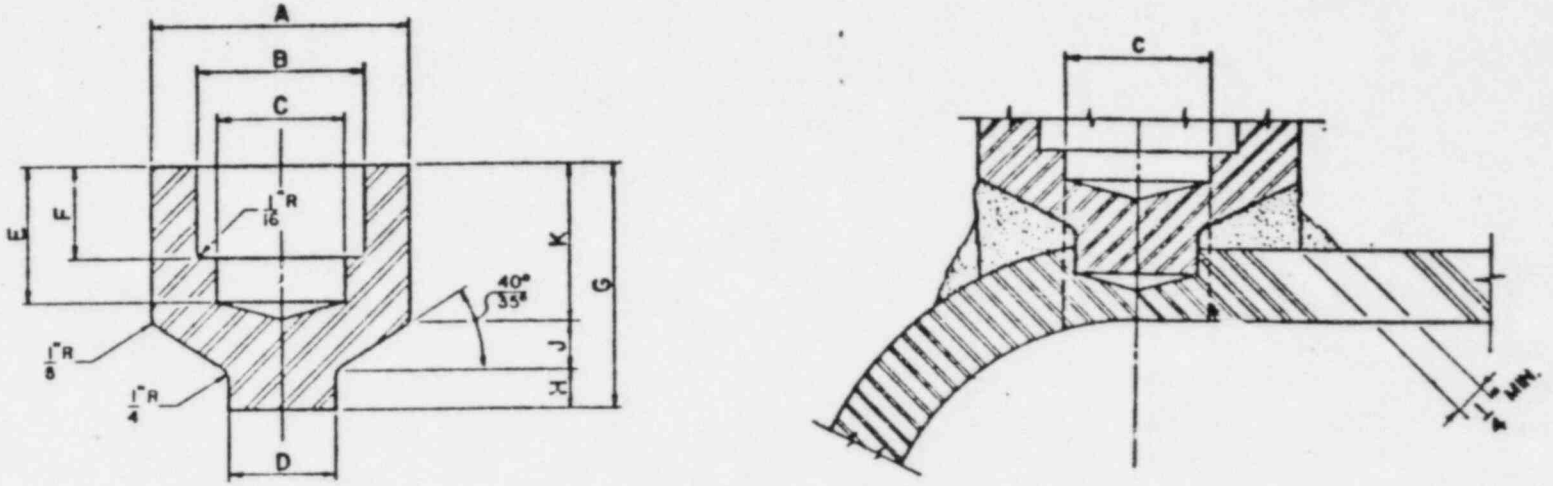


6000# Half-Coupling

Size (Inches)	3/4"	1"	1-1/4"	1-1/2"	2"		
A - Length, End to End	1.500	1.625	1.750	1.750	2.250	-	nominal
C - Bottom of Socket to Opp. End	.878	1.045	1.108	1.170	1.745	-	minimum
D - Depth of Socket	.500	.500	.500	.500	.625	-	minimum
E - Diameter	1.541	1.876	2.221	2.529	3.154	-	minimum
F - Bore for O.D. of Pipe	1.070	1.335	1.680	1.920	2.411	-	nominal
H - Diameter of Bore	.629	.830	1.175	1.353	1.704	-	maximum
t - thickness	.456	.523	.523	.588	.725	-	minimum

Reference: ANSI B16.11 - 1973

Figure 2.1 6000# HALF-COUPLING



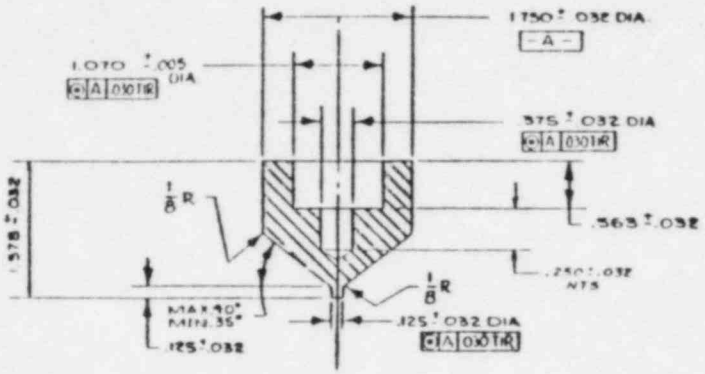
SPECIAL WELDING BOSS (SWB) (nominal dimensions)

N. P. S.	A ±0.032"	B ±0.005"	C ±0.032"	D ±0.032"	E ±0.032"	F ±0.032"	G ±0.032"	H ±0.032"	J ±0.065"	K ±0.032"
1/2"	1.500	0.860	0.438	0.313	0.750	0.500	1.375	0.188	0.438	0.750
3/4"	1.750	1.070	0.594	0.469	0.813	0.563	1.500	0.188	0.484	0.828
1"	2.250	1.335	0.781	0.656	0.875	0.625	1.750	0.250	0.609	0.891
1-1/4"	2.500	1.670	1.156	1.031	1.000	0.688	1.875	0.250	0.563	1.063
1-1/2"	3.000	1.920	1.328	1.203	1.000	0.750	2.000	0.250	0.703	1.047
2"	3.625	2.411	1.688	1.563	1.250	0.875	2.500	0.250	0.781	1.469

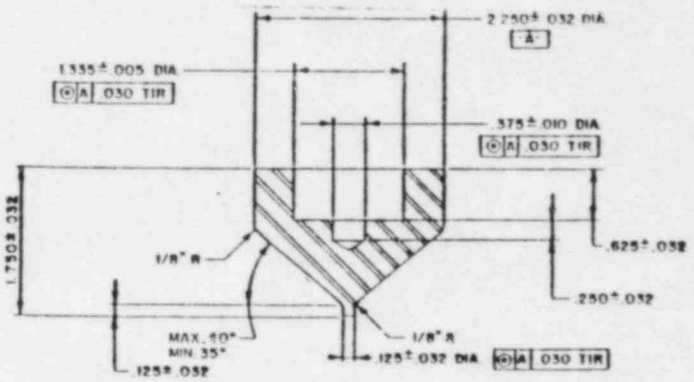
Note: Header wall thickness must be a minimum of 0.500 In. Header must be 8 in. NSP.

Reference: Duke Power Co. Engineering Standards MDG-ES-2 Rev. 0 and MDG-ES-3 Rev. 1.

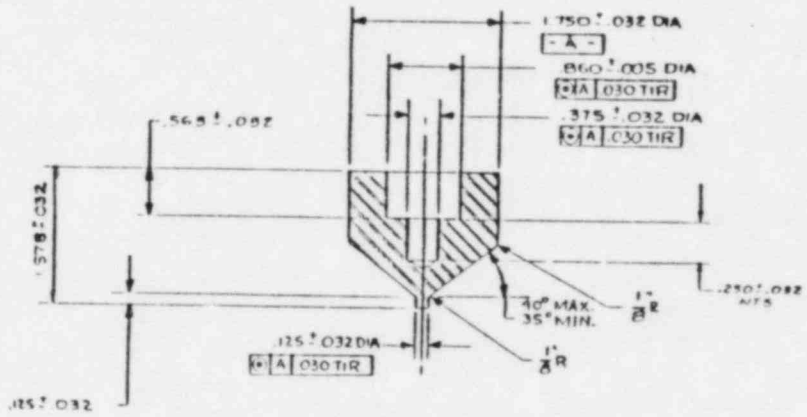
Figure 2.2 SPECIAL WELDING BOSS (SWB)



3/4" SWFOB



1" SWFOB



1/2" SWFOB

FIGURE 2.3 SPECIAL WELDING FLOW ORIFICE BOSS (SWFOB)

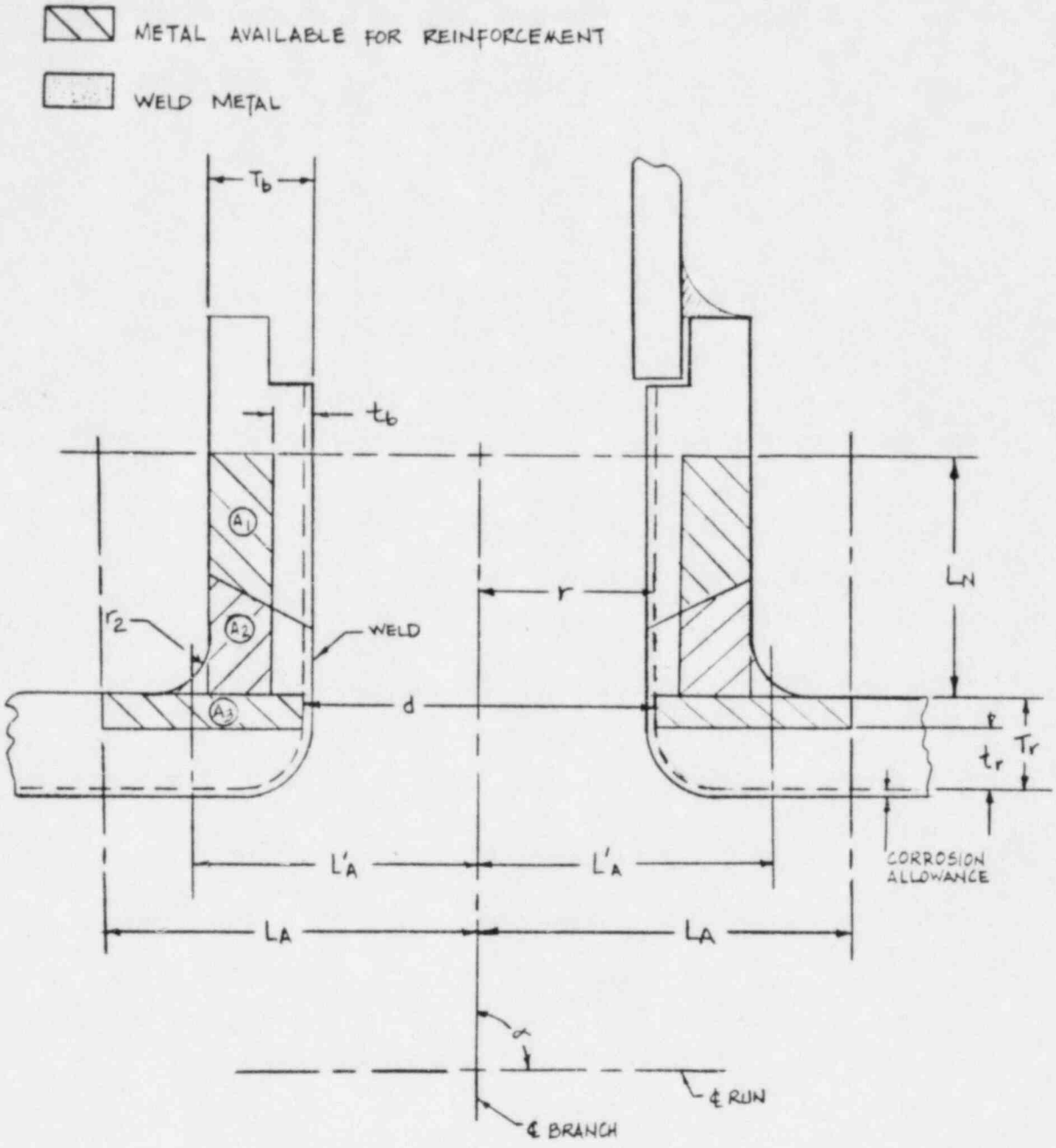


Figure 3.1 CROSS-SECTIONAL AREA AVAILABLE FOR REINFORCEMENT FOR SOCKET WELDING FITTING ATTACHED TO STRAIGHT PIPE

Appendix A

Applicability of Results to McGuire Nuclear Station

The basic pipe and fitting dimensional information is independent of the ASME Code and Duke Design Specification. The ASME Code of Record for Catawba Nuclear Station is 1974 edition with addenda through summer of 1974. For McGuire Nuclear Station, the ASME Code of Record is 1971 edition with addenda through winter of 1971. A review of NB-3643 and NB-3686 for these two separate Code of Records shows no differences which affects these results. A review of the design stress intensity values for the materials considered in this report shows the two separate Code of Records to be identical.

"In Summary," these results may be used for the McGuire Nuclear Station ASME Section III Class 1 area reinforcement verification for branch connection types considered in this report.

Appendix B

Program Output

EDS NUCLEAR, INC

PROGRAM *CL1BIC*

AREA REINFORCEMENT AND STRESS INDEX
CALCULATIONS FOR CLASS 1 BRANCH CONNECTIONS
PER ASME BPVC SECTION III NB-3600

PROGRAM VERSION 02/09/78
CALCULATIONS PERFORMED 03/20/78

CLIBIC AREA REINFORCEMENT CALCULATIONS FOR BRANCH CONNECTIONS

CONTROLLING PARAMETERS

NUMBER OF FITTINGS	= 14
NUMBER OF BRANCH PIPE CROSS-SECTIONS	= 6
NUMBER OF RUN PIPE CROSS-SECTIONS	= 10
NUMBER OF FITTING MATERIALS	= 3
NUMBER OF PIPE MATERIALS	= 4
CORROSION ALLOWANCE	= 0.000 (IN)
BRANCH/RUN INTERSECTION ANGLE	= 90.0 (DEG)
Y PARAMETER	= .4

STRESS INDICES WILL BE CALCULATED AND PRINTED

INPUT DATA FOR FITTINGS

1	1/2 IN	SWR	1.500	.531	.499	.654	*	1.	1.	0.000	0.000	.253
2	1/2 IN	SWEDR	1.750	.688	.656	.794	*	1.	1.	0.000	0.000	.219
3	3/4 IN	6000 SWHC	1.546	.466	.456	.938		2.	1.	0.000	0.000	.317
4	3/4 IN	SWR	1.750	.578	.546	.716	*	2.	1.	0.000	0.000	.329
5	3/4 IN	SWEDR	1.750	.688	.656	.794	*	2.	1.	0.000	0.000	.219
6	1 IN	6000 SWHC	1.881	.533	.523	1.125		3.	1.	0.000	0.000	.418
7	1 IN	SWR	2.250	.735	.703	.841	*	3.	1.	0.000	0.000	.422
8	1 IN	SWEDR	2.250	.938	.917	.904	*	3.	1.	0.000	0.000	.208
9	1-1/4 IN	6000 SWHC	2.226	.533	.528	1.188		4.	1.	0.000	0.000	.585
10	1-1/4 IN	SWR	2.500	.672	.640	.903	*	4.	1.	0.000	0.000	.610
11	1-1/2 IN	6000 SWHC	2.534	.598	.593	1.250		5.	1.	0.000	0.000	.674
12	1-1/2 IN	SWR	3.000	.836	.804	.966	*	5.	1.	0.000	0.000	.696
13	2 IN	6000 SWHC	3.159	.735	.725	1.625		6.	1.	0.000	0.000	.855
14	2 IN	SWR	3.625	.969	.937	1.341	*	6.	1.	0.000	0.000	.876

INPUT DATA FOR BRANCH PIPE CROSS-SECTIONS

1	1/2 IN	SCH 160	.840	.187	.164
2	3/4 IN	SCH 160	1.050	.218	.191
3	1 IN	SCH 160	1.315	.250	.219
4	1-1/4 IN	SCH 160	1.660	.250	.219
5	1-1/2 IN	SCH 160	1.900	.281	.246
6	2 IN	SCH 160	2.375	.343	.300

INPUT DATA FOR RUN PIPE CROSS-SECTIONS

1	2 IN	SCH 160	2.375	.343	.300
2	2-1/2 IN	SCH 160	2.875	.375	.328
3	3 IN	SCH 160	3.500	.438	.383
4	4 IN	SCH 160	4.500	.531	.465
5	5 IN	SCH 160	5.563	.625	.547
6	6 IN	SCH 160	6.625	.718	.628
7	8 IN	SCH 160	8.625	.906	.793
8	10 IN	SCH 140	10.750	1.000	.875
9	12 IN	SCH 140	12.750	1.125	.984
10	14 IN	SCH 140	14.000	1.250	1.094

CLIRIC AREA REINFORCEMENT CALCULATIONS FOR BRANCH CONNECTIONS

INPUT DATA FOR FITTING MATERIALS

MATL NO. 1 SM (PSI) = 16400. DESIGN TEMP (DEG-F) = 600.
1APPLICABLE MATERIALS
SA182 F304

MATL NO. 2 SM (PSI) = 16100. DESIGN TEMP (DEG-F) = 650.
1APPLICABLE MATERIALS
SA182 F304

MATL NO. 3 SM (PSI) = 15900. DESIGN TEMP (DEG-F) = 700.
1APPLICABLE MATERIALS
SA182 F304

INPUT DATA FOR PIPE MATERIALS

MATL NO. 1 SM (PSI) = 16400. DESIGN TEMP (DEG-F) = 600.
3APPLICABLE MATERIALS
SA376TP304
SA376TP316
SA312TP304

MATL NO. 2 SM (PSI) = 16100. DESIGN TEMP (DEG-F) = 650.
3APPLICABLE MATERIALS
SA312TP304
SA376TP304
SA376TP316

MATL NO. 3 SM (PSI) = 15900. DESIGN TEMP (DEG-F) = 700.
3APPLICABLE MATERIALS
SA376TP304
SA312TP304
SA376TP316

MATL NO. 4 SM (PSI) = 16300. DESIGN TEMP (DEG-F) = 700.
1APPLICABLE MATERIALS
SA376TP316

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA376TP316 SA312TP304
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 2 IN SCH 160, AVERAGE WALL= .343, MINIMUM WALL= .300											
				SM= 16400. PSI, MAXIMUM ALLOWABLE PRESSURE= 4611. PSI			Y= .400				
1/2	SWR*	.531	.499	4611.	600.	1.093	.386	.266	.266	.590	7569.
1/2	SWEDR*	.688	.656	4611.	600.	1.218	.474	.344	.344	.590	7569.
3/4	6000 SWNC	.466	.456	4611.	600.	1.116	.367	.233	.233	.590	6972.
3/4	SWR*	.578	.546	4611.	600.	1.218	.435	.289	.289	.590	6972.
3/4	SWEDR*	.688	.656	4611.	600.	1.218	.474	.344	.344	.590	6972.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON PDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA376TP316 SA312TP304
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED ID REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 2-1/2 IN SCH 160, AVERAGE WALL= .375, MINIMUM WALL= .328											
				SM= 16400. PSI, MAXIMUM ALLOWABLE PRESSURE= 4120. PSI			Y= .400				
1/2	SWR*	.531	.499	4120.	600.	1.125	.386	.266	.266	.685	7569.
1/2	SWEOR*	.688	.656	4120.	600.	1.250	.474	.344	.344	.685	7569.
3/4	6000 SWHC	.466	.456	4120.	600.	1.148	.367	.233	.233	.685	6972.
3/4	SWR*	.579	.546	4120.	600.	1.250	.435	.289	.289	.685	6972.
3/4	SWEOR*	.688	.656	4120.	600.	1.250	.474	.344	.344	.685	6972.
1	6000 SWHC	.533	.523	4120.	600.	1.316	.433	.267	.267	.685	6294.
1	SWR*	.735	.703	4120.	600.	1.500	.557	.368	.368	.685	6294.
1	SWEOR*	.938	.917	4120.	600.	1.500	.627	.469	.469	.685	6294.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA376TP316 SA312TP304
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TH	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 3 IN SCH 160, AVERAGE WALL= .438, MINIMUM WALL= .383											
	SM= 16400. PSI.			MAXIMUM ALLOWABLE PRESSURE= 3936. PSI			Y= .400				
1/2	SWA*	.531	.499	3936.	600.	1.188	.386	.266	.266	.819	7569.
1/2	SWEDA*	.688	.656	3936.	600.	1.313	.474	.344	.344	.819	7569.
3/4	6000 SWHC	.466	.456	3936.	600.	1.211	.367	.233	.233	.819	6972.
3/4	SWA*	.578	.546	3936.	600.	1.313	.435	.289	.289	.819	6972.
3/4	SWEDA*	.688	.656	3936.	600.	1.313	.474	.344	.344	.819	6972.
1	6000 SWHC	.533	.523	3936.	600.	1.379	.433	.267	.267	.819	6294.
1	SWA*	.735	.703	3936.	600.	1.563	.557	.368	.368	.819	6294.
1	SWEDA*	.938	.917	3936.	600.	1.563	.627	.469	.469	.819	6294.
1-1/4	6000 SWHC	.533	.528	3678.	600.	1.551	.469	.267	.267	.819	4832.
1-1/4	SWA*	.672	.640	3936.	600.	1.688	.560	.336	.336	.819	4832.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-SP-97

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA376TP316 SA312TP304
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 4 IN SCH 160, AVERAGE WALL= .531, MINIMUM WALL= .465 SM= 16400. PSI, MAXIMUM ALLOWABLE PRESSURE= 3692.PSI Y= .400											
1/2	SWR*	.531	.499	3692.	600.	1.281	.386	.266	.266	1.027	7569.
1/2	SWEDR*	.688	.656	3692.	600.	1.406	.474	.344	.344	1.027	7569.
3/4	6000 SWHC	.466	.456	3691.	600.	1.304	.384	.266	.266	1.027	6972.
3/4	SWR*	.578	.546	3692.	600.	1.406	.435	.289	.289	1.027	6972.
3/4	SWEDR*	.688	.656	3692.	600.	1.406	.474	.344	.344	1.027	6972.
1	6000 SWHC	.533	.523	3647.	600.	1.472	.433	.267	.267	1.027	6294.
1	SWR*	.735	.703	3692.	600.	1.656	.557	.368	.368	1.027	6294.
1	SWEDR*	.938	.917	3692.	600.	1.656	.627	.469	.469	1.027	6294.
1-1/4	6000 SWHC	.533	.528	3331.	600.	1.644	.469	.267	.267	1.027	4832.
1-1/4	SWR*	.672	.640	3692.	600.	1.781	.560	.336	.336	1.027	4832.
1-1/2	6000 SWHC	.598	.593	3381.	600.	1.798	.530	.299	.299	1.027	4735.
1-1/2	SWR*	.836	.804	3692.	600.	2.031	.685	.418	.418	1.027	4735.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA376TP316 SA312TP304
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 5 IN SCH 160, AVERAGE WALL= .625, MINIMUM WALL= .547											
SM= 16400. PSI, MAXIMUM ALLOWABLE PRESSURE= 3500.PSI							Y= .400				
1/2	SWB*	.531	.499	3500.	600.	1.375	.410	.313	.313	1.242	7569.
1/2	SWEDR*	.689	.656	3500.	600.	1.500	.474	.344	.344	1.242	7569.
3/4	6000 SWHC	.466	.456	3441.	600.	1.398	.407	.313	.313	1.242	6972.
3/4	SWB*	.578	.546	3500.	600.	1.500	.447	.313	.313	1.242	6972.
3/4	SWEDR*	.688	.656	3500.	600.	1.500	.474	.344	.344	1.242	6972.
1	6000 SWHC	.533	.523	3392.	600.	1.566	.456	.313	.313	1.242	6294.
1	SWB*	.735	.703	3500.	600.	1.750	.557	.368	.368	1.242	6294.
1	SWEDR*	.938	.917	3500.	600.	1.750	.627	.469	.469	1.242	6294.
1-1/4	6000 SWHC	.533	.528	3112.	600.	1.738	.492	.313	.313	1.242	4832.
1-1/4	SWB*	.672	.640	3388.	600.	1.875	.560	.336	.336	1.242	4832.
1-1/2	6000 SWHC	.598	.593	3125.	600.	1.892	.537	.313	.313	1.242	4735.
1-1/2	SWB*	.836	.804	3500.	600.	2.125	.685	.418	.418	1.242	4735.
2	6000 SWHC	.735	.725	3219.	600.	2.205	.656	.368	.368	1.242	4611.
2	SWB*	.969	.937	3500.	600.	2.438	.809	.485	.485	1.242	4611.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA376TP316 SA312TP304
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 6 IN SCH 160, AVERAGE WALL= .718, MINIMUM WALL= .628											
SM= 16400. PSI. MAXIMUM ALLOWABLE PRESSURE= 3366.PSI Y= .400											
1/2	SWR*	.531	.499	3366.	600.	1.468	.433	.359	.359	1.456	7569.
1/2	SWEDR*	.688	.656	3366.	600.	1.593	.482	.359	.359	1.456	7569.
3/4	6000 SWHC	.466	.456	3273.	600.	1.491	.430	.359	.359	1.456	6972.
3/4	SWR*	.578	.546	3366.	600.	1.593	.470	.359	.359	1.456	6972.
3/4	SWEDR*	.688	.656	3366.	600.	1.593	.482	.359	.359	1.456	6972.
1	6000 SWHC	.533	.523	3220.	600.	1.659	.479	.359	.359	1.456	6294.
1	SWR*	.735	.703	3366.	600.	1.843	.557	.368	.368	1.456	6294.
1	SWEDR*	.938	.917	3366.	600.	1.843	.627	.469	.469	1.456	6294.
1-1/4	6000 SWHC	.533	.528	2965.	600.	1.831	.515	.359	.359	1.456	4832.
1-1/4	SWR*	.672	.640	3186.	600.	1.968	.571	.359	.359	1.456	4832.
1-1/2	6000 SWHC	.598	.593	2969.	600.	1.985	.560	.359	.359	1.456	4735.
1-1/2	SWR*	.836	.804	3366.	600.	2.218	.685	.418	.418	1.456	4735.
2	6000 SWHC	.735	.725	3013.	600.	2.298	.656	.368	.368	1.456	4611.
2	SWR*	.969	.937	3366.	600.	2.531	.809	.485	.485	1.456	4611.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA376TP316 SA312TP304
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
	PIPE SIZE= 8 IN SCH 160, AVERAGE WALL= .906, MINIMUM WALL= .793										
	SM= 16400. PSI, MAXIMUM ALLOWABLE PRESSURE= 3254.PSI Y= .400										
1/2	SWR	.531	.499	3254.	600.	1.656	.480	.453	.453	1.870	7569.
1/2	SWEDR	.688	.656	3254.	600.	1.781	.529	.453	.453	1.870	7569.
3/4	6000 SWHC	.466	.456	3122.	600.	1.679	.477	.453	.453	1.870	6972.
3/4	SWR	.578	.546	3254.	600.	1.781	.517	.453	.453	1.870	6972.
3/4	SWEDR	.689	.656	3254.	600.	1.781	.529	.453	.453	1.870	6972.
1	6000 SWHC	.533	.523	3064.	600.	1.847	.526	.453	.453	1.870	6294.
1	SWR	.735	.703	3254.	600.	2.031	.600	.453	.453	1.870	6294.
1	SWEDR	.938	.917	3254.	600.	2.031	.627	.469	.469	1.870	6294.
1-1/4	6000 SWHC	.533	.528	2840.	600.	2.019	.562	.453	.453	1.870	4832.
1-1/4	SWR	.672	.640	3011.	600.	2.156	.618	.453	.453	1.870	4832.
1-1/2	6000 SWHC	.598	.593	2831.	600.	2.173	.607	.453	.453	1.870	4735.
1-1/2	SWR	.836	.804	3148.	600.	2.406	.702	.453	.453	1.870	4735.
2	6000 SWHC	.735	.725	2842.	600.	2.486	.698	.453	.453	1.870	4611.
2	SWR	.969	.937	3169.	600.	2.719	.809	.485	.485	1.870	4611.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA376TP316 SA312TP304
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 10 IN SCH 140, AVERAGE WALL= 1.000, MINIMUM WALL= .875											
	SM= 16400. PSI.			MAXIMUM ALLOWABLE PRESSURE= 2856.PSI			Y= .400				
1/2	SWR	.531	.499	2856.	600.	2.719	.809	.500	.500	2.208	7569.
1/2	SWEDR	.688	.656	2856.	600.	2.719	.809	.500	.500	2.208	7569.
3/4	6000 SWHC	.466	.456	2735.	600.	1.773	.501	.500	.500	2.208	6972.
3/4	SWR	.578	.546	2841.	600.	1.875	.541	.500	.500	2.208	6972.
3/4	SWEDR	.688	.656	2856.	600.	1.875	.541	.500	.500	2.208	6972.
1	6000 SWHC	.533	.523	2684.	600.	1.941	.550	.500	.500	2.208	6294.
1	SWR	.735	.703	2856.	600.	2.125	.623	.500	.500	2.208	6294.
1	SWEDR	.938	.917	2856.	600.	2.125	.623	.500	.500	2.208	6294.
1-1/4	6000 SWHC	.533	.528	2496.	600.	2.213	.586	.500	.514	2.208	4832.
1-1/4	SWR	.672	.640	2633.	600.	2.250	.642	.500	.500	2.208	4832.
1-1/2	6000 SWHC	.598	.593	2485.	600.	2.267	.630	.500	.547	2.208	4735.
1-1/2	SWR	.836	.804	2744.	600.	2.500	.726	.500	.500	2.208	4735.
2	6000 SWHC	.735	.725	2489.	600.	2.580	.722	.500	.534	2.208	4611.
2	SWR	.969	.937	2745.	600.	2.813	.817	.500	.500	2.208	4611.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA376TP316 SA312TP304
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM x TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 12 IN SCH 140, AVERAGE WALL= 1.125, MINIMUM WALL= .984 SM= 16400. PSI, MAXIMUM ALLOWABLE PRESSURE= 2699.PSI Y= .400											
1/2	SWR	.531	.499	2699.	600.	2.813	.817	.563	.563	2.557	7569.
1/2	SWEDR	.688	.656	2699.	600.	2.813	.817	.563	.563	2.557	7569.
3/4	6000 SWHC	.466	.456	2578.	600.	1.898	.532	.563	.563	2.557	6972.
3/4	SWR	.578	.546	2666.	600.	2.000	.572	.563	.563	2.557	6972.
3/4	SWEDR	.688	.656	2699.	600.	2.000	.572	.563	.563	2.557	6972.
1	6000 SWHC	.533	.523	2528.	600.	2.066	.581	.563	.563	2.557	6294.
1	SWR	.735	.703	2699.	600.	2.250	.654	.563	.563	2.557	6294.
1	SWEDR	.938	.917	2699.	600.	2.250	.654	.563	.563	2.557	6294.
1-1/4	6000 SWHC	.533	.528	2360.	600.	2.238	.617	.563	1.153	2.557	4832.
1-1/4	SWR	.672	.640	2475.	600.	2.375	.673	.563	.649	2.557	4832.
1-1/2	6000 SWHC	.598	.593	2346.	600.	2.392	.662	.563	1.186	2.557	4735.
1-1/2	SWR	.836	.804	2565.	600.	2.625	.757	.563	.563	2.557	4735.
2	6000 SWHC	.735	.725	2341.	600.	2.705	.753	.563	1.166	2.557	4611.
2	SWR	.969	.937	2559.	600.	2.938	.848	.563	.563	2.557	4611.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA376TP316 SA312TP304
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 14 IN SCH 140, AVERAGE WALL= 1.250, MINIMUM WALL= 1.094											
SM= 16400. PSI, MAXIMUM ALLOWABLE PRESSURE= 2733.PSI Y= .400											
1/2	SWR	.531	.499	2733.	600.	2.938	.848	.625	.625	2.823	7569.
1/2	SWEDR	.688	.656	2733.	600.	2.938	.848	.625	.625	2.823	7569.
3/4	6000 SWHC	.466	.456	2605.	600.	2.023	.563	.625	.625	2.823	6972.
3/4	SWR	.578	.546	2684.	600.	2.125	.603	.625	.625	2.823	6972.
3/4	SWEDR	.688	.656	2733.	600.	2.125	.603	.625	.625	2.823	6972.
1	6000 SWHC	.533	.523	2554.	600.	2.191	.612	.625	.625	2.823	6294.
1	SWR	.735	.703	2723.	600.	2.375	.686	.625	.625	2.823	6294.
1	SWEDR	.938	.917	2733.	600.	2.375	.686	.625	.625	2.823	6294.
1-1/4	6000 SWHC	.533	.528	2392.	600.	2.363	.648	.625	1.152	2.823	4832.
1-1/4	SWR	.672	.640	2495.	600.	2.500	.704	.625	.645	2.823	4832.
1-1/2	6000 SWHC	.598	.593	2374.	600.	2.517	.693	.625	1.211	2.823	4735.
1-1/2	SWR	.836	.804	2573.	600.	2.750	.788	.625	.625	2.823	4735.
2	6000 SWHC	.735	.725	2361.	600.	2.830	.788	.625	1.229	2.823	4611.
2	SWR	.969	.937	2559.	600.	3.063	.880	.625	.625	2.823	4611.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA312TP304 SA376TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 2 IN SCH 160, AVERAGE WALL= .343, MINIMUM WALL= .300											
SM= 16100. PSI, MAXIMUM ALLOWABLE PRESSURE= 4527.PSI							Y= .400				
1/2	SWR*	.531	.499	4527.	650.	1.093	.386	.266	.266	.590	7430.
1/2	SWEDR*	.688	.656	4527.	650.	1.218	.474	.344	.344	.590	7430.
3/4	6000 SWHC	.466	.456	4527.	650.	1.116	.367	.233	.233	.590	6844.
3/4	SWR*	.578	.546	4527.	650.	1.218	.435	.289	.289	.590	6844.
3/4	SWEDR*	.688	.656	4527.	650.	1.218	.474	.344	.344	.590	6844.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-SP-97

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA312TP304 SA376TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 2-1/2 IN SCH 160, AVERAGE WALL= .375, MINIMUM WALL= .328											
	SME= 16100. PSI, MAXIMUM ALLOWABLE PRESSURE= 4044.PSI Y= .400										
1/2	SWR*	.531	.499	4044.	650.	1.125	.386	.266	.266	.685	7430.
1/2	SWEDR*	.688	.656	4044.	650.	1.250	.474	.344	.344	.685	7430.
3/4	6000 SWHC	.466	.456	4044.	650.	1.148	.367	.233	.233	.685	6844.
3/4	SWR*	.578	.546	4044.	650.	1.250	.435	.289	.289	.685	6844.
3/4	SWEDR*	.688	.656	4044.	650.	1.250	.474	.344	.344	.685	6844.
1	6000 SWHC	.533	.523	4044.	650.	1.316	.433	.267	.267	.685	6179.
1	SWR*	.735	.703	4044.	650.	1.500	.557	.368	.368	.685	6179.
1	SWEDR*	.938	.917	4044.	650.	1.500	.627	.469	.469	.685	6179.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA312TP304 SA376TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 3 IN SCH 160, AVERAGE WALL= .438, MINIMUM WALL= .383											
		SM= 16100. PSI, MAXIMUM ALLOWABLE PRESSURE= 3864.PSI					Y= .400				
1/2		SWR*	.531	.499	3864.	650.	1.188	.386	.266	.266	.819	7430.
1/2		SWEDR*	.688	.656	3864.	650.	1.313	.474	.344	.344	.819	7430.
3/4	6000	SWHC	.466	.456	3864.	650.	1.211	.367	.233	.233	.819	6844.
3/4		SWR*	.578	.546	3864.	650.	1.313	.435	.289	.289	.819	6844.
3/4		SWEDR*	.688	.656	3864.	650.	1.313	.474	.344	.344	.819	6844.
1	6000	SWHC	.533	.523	3864.	650.	1.379	.433	.267	.267	.819	6179.
1		SWR*	.735	.703	3864.	650.	1.563	.557	.368	.368	.819	6179.
1		SWEDR*	.938	.917	3864.	650.	1.563	.627	.469	.469	.819	6179.
1-1/4	6000	SWHC	.533	.528	3610.	650.	1.551	.469	.267	.267	.819	4743.
1-1/4		SWR*	.672	.640	3864.	650.	1.688	.560	.336	.336	.819	4743.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA312TP304 SA376TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TM	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 4 IN SCH 160, AVERAGE WALL= .531, MINIMUM WALL= .465 SM= 16100. PSI, MAXIMUM ALLOWABLE PRESSURE= 3624. PSI Y= .400											
1/2	SWB*	.531	.499	3624.	650.	1.281	.386	.266	.266	1.027	7430.
1/2	SWEDB*	.688	.656	3624.	650.	1.406	.474	.344	.344	1.027	7430.
3/4	6000 SWHC	.466	.456	3623.	650.	1.304	.384	.266	.266	1.027	6844.
3/4	SWB*	.578	.546	3624.	650.	1.406	.435	.289	.289	1.027	6844.
3/4	SWEDB*	.688	.656	3624.	650.	1.406	.474	.344	.344	1.027	6844.
1	6000 SWHC	.533	.523	3580.	650.	1.472	.433	.267	.267	1.027	6179.
1	SWB*	.735	.703	3624.	650.	1.656	.557	.368	.368	1.027	6179.
1	SWEDB*	.938	.917	3624.	650.	1.656	.627	.469	.469	1.027	6179.
1-1/4	6000 SWHC	.533	.528	3270.	650.	1.604	.469	.267	.267	1.027	4743.
1-1/4	SWB*	.672	.640	3624.	650.	1.781	.560	.336	.336	1.027	4743.
1-1/2	6000 SWHC	.598	.593	3320.	650.	1.798	.530	.299	.299	1.027	4648.
1-1/2	SWB*	.836	.804	3624.	650.	2.031	.685	.418	.418	1.027	4648.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-SP-97

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA312TP304 SA376TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM x TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 5 IN SCH 160, AVERAGE WALL= .625, MINIMUM WALL= .547											
	SM= 16100. PSI, MAXIMUM ALLOWABLE PRESSURE= 3436.PSI						Y= .400				
1/2	SWR*	.531	.499	3436.	650.	1.375	.410	.313	.313	1.242	7430.
1/2	SWEDR*	.688	.656	3436.	650.	1.500	.474	.344	.344	1.242	7430.
3/4	6000 SWHC	.466	.456	3379.	650.	1.398	.407	.313	.313	1.242	6844.
3/4	SWR*	.578	.546	3436.	650.	1.500	.447	.313	.313	1.242	6844.
3/4	SWEDR*	.688	.656	3436.	650.	1.500	.474	.344	.344	1.242	6844.
1	6000 SWHC	.533	.523	3330.	650.	1.566	.456	.313	.313	1.242	6179.
1	SWR*	.735	.703	3436.	650.	1.750	.557	.368	.368	1.242	6179.
1	SWEDR*	.938	.917	3436.	650.	1.750	.627	.469	.469	1.242	6179.
1-1/4	6000 SWHC	.533	.528	3055.	650.	1.738	.492	.313	.313	1.242	4743.
1-1/4	SWR*	.672	.640	3326.	650.	1.875	.560	.336	.336	1.242	4743.
1-1/2	6000 SWHC	.598	.593	3068.	650.	1.892	.537	.313	.313	1.242	4648.
1-1/2	SWR*	.836	.804	3436.	650.	2.125	.685	.418	.418	1.242	4648.
2	6000 SWHC	.735	.725	3160.	650.	2.205	.656	.368	.368	1.242	4527.
2	SWR*	.969	.937	3436.	650.	2.438	.809	.485	.485	1.242	4527.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-SP-97

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA312TP304 SA376TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 6 IN SCH 160, AVERAGE WALL= .718, MINIMUM WALL= .628											
S= 16100. PSI, MAXIMUM ALLOWABLE PRESSURE= 3304.PSI Y= .400											
1/2	SWR*	.531	.499	3304.	650.	1.468	.433	.359	.359	1.456	7430.
1/2	SWEDR*	.688	.656	3304.	650.	1.593	.482	.359	.359	1.456	7430.
3/4	6000 SWHC	.466	.456	3213.	650.	1.491	.430	.359	.359	1.456	6844.
3/4	SWR*	.578	.546	3304.	650.	1.593	.470	.359	.359	1.456	6844.
3/4	SWEDR*	.688	.656	3304.	650.	1.593	.482	.359	.359	1.456	6844.
1	6000 SWHC	.533	.523	3161.	650.	1.659	.479	.359	.359	1.456	6179.
1	SWR*	.735	.703	3304.	650.	1.843	.557	.368	.368	1.456	6179.
1	SWEDR*	.938	.917	3304.	650.	1.843	.627	.469	.469	1.456	6179.
1-1/4	6000 SWHC	.533	.528	2911.	650.	1.831	.515	.359	.359	1.456	4743.
1-1/4	SWR*	.672	.640	3128.	650.	1.968	.571	.359	.359	1.456	4743.
1-1/2	6000 SWHC	.598	.593	2915.	650.	1.985	.560	.359	.359	1.456	4648.
1-1/2	SWR*	.836	.804	3304.	650.	2.218	.685	.418	.418	1.456	4648.
2	6000 SWHC	.735	.725	2958.	650.	2.298	.656	.368	.368	1.456	4527.
2	SWR*	.969	.937	3304.	650.	2.531	.809	.485	.485	1.456	4527.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA312TP304 SA376TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 8 IN SCH 160, AVERAGE WALL= .906, MINIMUM WALL= .793											
	SM= 16100. PSI, MAXIMUM ALLOWABLE PRESSURE= 3194.PSI						Y= .400				
1/2	SWR	.531	.499	3194.	650.	1.656	.480	.453	.453	1.870	7430.
1/2	SWEDR	.688	.656	3194.	650.	1.781	.529	.453	.453	1.870	7430.
3/4	6000 SWHC	.466	.456	3065.	650.	1.679	.477	.453	.453	1.870	6844.
3/4	SWR	.578	.546	3194.	650.	1.781	.517	.453	.453	1.870	6844.
3/4	SWEDR	.688	.656	3194.	650.	1.781	.529	.453	.453	1.870	6844.
1	6000 SWHC	.533	.523	3008.	650.	1.847	.526	.453	.453	1.870	6179.
1	SWR	.735	.703	3194.	650.	2.031	.600	.453	.453	1.870	6179.
1	SWEDR	.938	.917	3194.	650.	2.031	.627	.469	.469	1.870	6179.
1-1/4	6000 SWHC	.533	.528	2788.	650.	2.019	.562	.453	.453	1.870	4743.
1-1/4	SWR	.672	.640	2955.	650.	2.156	.618	.453	.453	1.870	4743.
1-1/2	6000 SWHC	.598	.593	2780.	650.	2.173	.607	.453	.453	1.870	4648.
1-1/2	SWR	.836	.804	3091.	650.	2.406	.702	.453	.453	1.870	4648.
2	6000 SWHC	.735	.725	2790.	650.	2.486	.698	.453	.453	1.870	4527.
2	SWR	.969	.937	3111.	650.	2.719	.809	.485	.485	1.870	4527.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA312TP304 SA376TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE INCHES	FITTING TYPE	FITTING AVERAGE WALL INCHES	FITTING MINIMUM WALL INCHES	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE PSI.	MAXIMUM DESIGN TEMPERATURE F	REINFORCEMENT LIMITS LA INCHES	REINFORCEMENT LIMITS LN INCHES	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI	SPACING CRITERIA SQUARE ROOT OF RM X TR INCHES	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE PSI.
PIPE SIZE= 10 IN SCH 140, AVERAGE WALL= 1.000, MINIMUM WALL= .875 SM= 16100. PSI, MAXIMUM ALLOWABLE PRESSURE= 2803.PSI Y= .400										
1/2	SWA	.531	.499	2803.	650.	2.719	.809	.500 .500	2.208	7430.
1/2	SWEOR	.688	.656	2803.	650.	2.719	.809	.500 .500	2.208	7430.
3/4	6000 SWHC	.466	.456	2685.	650.	1.773	.501	.500 .500	2.208	6844.
3/4	SWA	.578	.546	2789.	650.	1.875	.541	.500 .500	2.208	6844.
3/4	SWEOR	.688	.656	2803.	650.	1.875	.541	.500 .500	2.208	6844.
1	6000 SWHC	.533	.523	2635.	650.	1.941	.550	.500 .500	2.208	6179.
1	SWA	.735	.703	2803.	650.	2.125	.623	.500 .500	2.208	6179.
1	SWEOR	.938	.917	2803.	650.	2.125	.623	.500 .500	2.208	6179.
1-1/4	6000 SWHC	.533	.528	2450.	650.	2.113	.586	.500 .671	2.208	4743.
1-1/4	SWA	.672	.640	2585.	650.	2.250	.642	.500 .500	2.208	4743.
1-1/2	6000 SWHC	.598	.593	2440.	650.	2.267	.630	.500 .700	2.208	4648.
1-1/2	SWA	.836	.804	2694.	650.	2.500	.726	.500 .500	2.208	4648.
2	6000 SWHC	.735	.725	2444.	650.	2.580	.722	.500 .677	2.208	4527.
2	SWA	.969	.937	2695.	650.	2.813	.817	.500 .500	2.208	4527.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA312TP304 SA376TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 12 IN SCH 140, AVERAGE WALL= 1.125, MINIMUM WALL= .984											
SM= 16100. PSI, MAXIMUM ALLOWABLE PRESSURE= 2650.PSI Y= .400											
1/2	SWB	.531	.499	2650.	650.	2.813	.817	.563	.563	2.557	7430.
1/2	SWEDB	.688	.656	2650.	650.	2.813	.817	.563	.563	2.557	7430.
3/4	6000 SWHC	.466	.456	2530.	650.	1.898	.552	.563	.563	2.557	6844.
3/4	SWB	.578	.546	2617.	650.	2.000	.572	.563	.563	2.557	6844.
3/4	SWEDB	.688	.656	2650.	650.	2.000	.572	.563	.563	2.557	6844.
1	6000 SWHC	.533	.523	2482.	650.	2.066	.581	.563	.630	2.557	6179.
1	SWB	.735	.703	2650.	650.	2.250	.654	.563	.563	2.557	6179.
1	SWEDB	.938	.917	2650.	650.	2.250	.654	.563	.563	2.557	6179.
1-1/4	6000 SWHC	.533	.528	2317.	650.	2.238	.617	.563	1.354	2.557	4743.
1-1/4	SWB	.672	.640	2430.	650.	2.375	.673	.563	.812	2.557	4743.
1-1/2	6000 SWHC	.598	.593	2303.	650.	2.392	.662	.563	1.380	2.557	4648.
1-1/2	SWB	.836	.804	2518.	650.	2.625	.757	.563	.563	2.557	4648.
2	6000 SWHC	.735	.725	2298.	650.	2.705	.753	.563	1.348	2.557	4527.
2	SWB	.969	.937	2512.	650.	2.938	.848	.563	.563	2.557	4527.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA312TP304 SA376TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 10 IN SCH 140, AVERAGE WALL= 1.250, MINIMUM WALL= 1.094											
SM= 16100. PSI, MAXIMUM ALLOWABLE PRESSURE= 2683.PSI Y= .400											
1/2	SWR	.531	.499	2683.	650.	2.938	.848	.625	.625	2.823	7430.
1/2	SWEDR	.698	.656	2683.	650.	2.938	.848	.625	.625	2.823	7430.
3/4	6000 SWHC	.466	.456	2557.	650.	2.023	.563	.625	.625	2.823	6844.
3/4	SWR	.578	.546	2635.	650.	2.125	.603	.625	.625	2.823	6844.
3/4	SWEDR	.688	.656	2683.	650.	2.125	.603	.625	.625	2.823	6844.
1	6000 SWHC	.533	.523	2507.	650.	2.191	.612	.625	.625	2.823	6179.
1	SWR	.735	.703	2673.	650.	2.375	.686	.625	.625	2.823	6179.
1	SWEDR	.938	.917	2683.	650.	2.375	.686	.625	.625	2.823	6179.
1-1/4	6000 SWHC	.533	.528	2348.	650.	2.363	.648	.625	1.383	2.823	4743.
1-1/4	SWR	.672	.640	2449.	650.	2.500	.704	.625	.832	2.823	4743.
1-1/2	6000 SWHC	.598	.593	2331.	650.	2.517	.693	.625	1.433	2.823	4648.
1-1/2	SWR	.836	.804	2526.	650.	2.750	.788	.625	.625	2.823	4648.
2	6000 SWHC	.735	.725	2317.	650.	2.830	.784	.625	1.436	2.823	4527.
2	SWR	.969	.937	2512.	650.	3.063	.880	.625	.625	2.823	4527.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA312TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 2 IN SCH 160, AVERAGE WALL= .343, MINIMUM WALL= .300											
SM= 15900. PSI, MAXIMUM ALLOWABLE PRESSURE= 4470.PSI Y= .400											
1/2	SWB*	.531	.499	4470.	700.	1.093	.386	.266	.266	.590	7338.
1/2	SWEDB*	.688	.656	4470.	700.	1.218	.474	.344	.344	.590	7338.
3/4	6000 SWHC	.466	.456	4470.	700.	1.116	.367	.233	.233	.590	6759.
3/4	SWB*	.578	.546	4470.	700.	1.218	.435	.289	.289	.590	6759.
3/4	SWEDB*	.688	.656	4470.	700.	1.218	.474	.344	.344	.590	6759.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-SP-97

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA312TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI	SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI,	F	INCHES	INCHES		INCHES	PSI,
PIPE SIZE= 2-1/2 IN SCH 160, AVERAGE WALL= .375, MINIMUM WALL= .328										
SH= 15900, PSI, MAXIMUM ALLOWABLE PRESSURE= 3994,PSI Y= .400										
1/2	SWA*	.531	.499	3994,	700,	1.125	.386	.266	.266	.685	7338,
1/2	SWEDR*	.688	.656	3994,	700,	1.250	.474	.344	.344	.685	7338,
3/4	6000 SWHC	.466	.456	3994,	700,	1.148	.367	.233	.233	.685	6759,
3/4	SWA*	.578	.546	3994,	700,	1.250	.435	.289	.289	.685	6759,
3/4	SWEDR*	.688	.656	3994,	700,	1.250	.474	.344	.344	.685	6759,
1	6000 SWHC	.533	.523	3994,	700,	1.316	.433	.267	.267	.685	6102,
1	SWA*	.735	.703	3994,	700,	1.500	.557	.368	.368	.685	6102,
1	SWEDR*	.938	.917	3994,	700,	1.500	.627	.469	.469	.685	6102,

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA312TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 3 IN SCH 160, AVERAGE WALL= .438, MINIMUM WALL= .383 SM= 15000. PSI, MAXIMUM ALLOWABLE PRESSURE= 3816.PSI Y= .400											
1/2	SWB*	.531	.499	3816.	700.	1.188	.386	.266	.266	.819	7338.
1/2	SWEDB*	.688	.656	3816.	700.	1.313	.474	.344	.344	.819	7338.
3/4	6000 SWHC	.466	.456	3816.	700.	1.211	.367	.233	.233	.819	6759.
3/4	SWB*	.578	.546	3816.	700.	1.313	.435	.289	.289	.819	6759.
3/4	SWEDB*	.688	.656	3816.	700.	1.313	.474	.344	.344	.819	6759.
1	6000 SWHC	.533	.523	3816.	700.	1.379	.433	.267	.267	.819	6102.
1	SWB*	.735	.703	3816.	700.	1.563	.557	.368	.368	.819	6102.
1	SWEDB*	.938	.917	3816.	700.	1.563	.627	.469	.469	.819	6102.
1-1/4	6000 SWHC	.533	.528	3566.	700.	1.551	.469	.267	.267	.819	4684.
1-1/4	SWB*	.672	.640	3816.	700.	1.688	.560	.336	.336	.819	4684.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-SP-97

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA312TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 6300PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 4 IN SCH 160, AVERAGE WALL= .531, MINIMUM WALL= .465											
SM= 15900. PSI. MAXIMUM ALLOWABLE PRESSURE= 3579.PSI Y= .400											
1/2	SWA*	.531	.499	3579.	700.	1.281	.386	.266	.266	1.027	7338.
1/2	SWEOA*	.688	.656	3579.	700.	1.406	.474	.344	.344	1.027	7338.
3/4	6000 SWHC	.466	.456	3578.	700.	1.304	.384	.266	.266	1.027	6759.
3/4	SWA*	.578	.546	3579.	700.	1.406	.435	.289	.289	1.027	6759.
3/4	SWEOA*	.688	.656	3579.	700.	1.406	.474	.344	.344	1.027	6759.
1	6000 SWHC	.533	.523	3536.	700.	1.472	.433	.267	.267	1.027	6102.
1	SWA*	.735	.703	3579.	700.	1.656	.557	.368	.368	1.027	6102.
1	SWEOA*	.938	.917	3579.	700.	1.656	.627	.469	.469	1.027	6102.
1-1/4	6000 SWHC	.533	.528	3229.	700.	1.644	.469	.267	.267	1.027	4684.
1-1/4	SWA*	.672	.640	3579.	700.	1.781	.560	.336	.336	1.027	4684.
1-1/2	6000 SWHC	.598	.593	3278.	700.	1.798	.530	.299	.299	1.027	4590.
1-1/2	SWA*	.836	.804	3579.	700.	2.031	.685	.418	.418	1.027	4590.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA312TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE INCHES	FITTING TYPE	FITTING AVERAGE WALL INCHES	FITTING MINIMUM WALL INCHES	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE PSI.	MAXIMUM DESIGN TEMPERATURE F	REINFORCEMENT LIMITS LA INCHES	REINFORCEMENT LIMITS LN INCHES	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI	SPACING CRITERIA SQUARE ROOT OF RM X TR INCHES	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE PSI.
PIPE SIZE= 5 IN SCH 160, AVERAGE WALL= .625, MINIMUM WALL= .547 SM= 15900. PSI, MAXIMUM ALLOWABLE PRESSURE= 3393. PSI Y= .400										
1/2	SWB*	.531	.499	3393.	700.	1.375	.410	.313 .313	1.242	7338.
1/2	SWEOB*	.688	.656	3393.	700.	1.500	.474	.344 .344	1.242	7338.
3/4	6000 SWHC	.466	.456	3337.	700.	1.398	.407	.313 .313	1.242	6759.
3/4	SWB*	.578	.546	3393.	700.	1.500	.447	.313 .313	1.242	6759.
3/4	SWEOB*	.688	.656	3393.	700.	1.500	.474	.344 .344	1.242	6759.
1	6000 SWHC	.533	.523	3289.	700.	1.566	.456	.313 .313	1.242	6102.
1	SWB*	.735	.703	3393.	700.	1.750	.557	.368 .368	1.242	6102.
1	SWEOB*	.938	.917	3393.	700.	1.750	.627	.469 .469	1.242	6102.
1-1/4	6000 SWHC	.533	.528	3017.	700.	1.738	.492	.313 .313	1.242	4684.
1-1/4	SWB*	.672	.640	3285.	700.	1.875	.560	.336 .336	1.242	4684.
1-1/2	6000 SWHC	.598	.593	3029.	700.	1.892	.537	.313 .313	1.242	4590.
1-1/2	SWB*	.836	.804	3393.	700.	2.125	.685	.418 .418	1.242	4590.
2	6000 SWHC	.735	.725	3121.	700.	2.205	.656	.368 .368	1.242	4470.
2	SWB*	.969	.937	3393.	700.	2.438	.809	.485 .485	1.242	4470.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-SP-97

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA312TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 6 IN SCH 160, AVERAGE WALL= .718, MINIMUM WALL= .628											
	SM= 15900. PSI, MAXIMUM ALLOWABLE PRESSURE= 3263. PSI Y= .400										
1/2	SWA*	.531	.499	3263.	700.	1.468	.433	.359	.359	1.456	7338.
1/2	SWEDA*	.688	.656	3263.	700.	1.593	.482	.359	.359	1.456	7338.
3/4	6000 SWHC	.466	.456	3173.	700.	1.491	.430	.359	.359	1.456	6759.
3/4	SWA*	.578	.546	3263.	700.	1.593	.470	.359	.359	1.456	6759.
3/4	SWEDA*	.688	.656	3263.	700.	1.593	.482	.359	.359	1.456	6759.
1	6000 SWHC	.533	.523	3122.	700.	1.659	.479	.359	.359	1.456	6102.
1	SWA*	.735	.703	3263.	700.	1.843	.557	.368	.368	1.456	6102.
1	SWEDA*	.938	.917	3263.	700.	1.843	.627	.469	.469	1.456	6102.
1-1/4	6000 SWHC	.533	.528	2875.	700.	1.831	.515	.359	.359	1.456	4684.
1-1/4	SWA*	.672	.640	3089.	700.	1.968	.571	.359	.359	1.456	4684.
1-1/2	6000 SWHC	.598	.593	2879.	700.	1.985	.560	.359	.359	1.456	4590.
1-1/2	SWA*	.836	.804	3263.	700.	2.218	.685	.418	.418	1.456	4590.
2	6000 SWHC	.735	.725	2921.	700.	2.298	.656	.368	.368	1.456	4470.
2	SWA*	.969	.937	3263.	700.	2.531	.809	.485	.485	1.456	4470.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-SP-97

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA312TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE=		B IN	SCH 160, AVERAGE WALL=		.906, MINIMUM WALL=			.793			
SM=	15900. PSI.		MAXIMUM ALLOWABLE PRESSURE=		3155. PSI	Y=	.400				
1/2	SWR	.531	.499	3155.	700.	1.656	.480	.453	.453	1.870	7338.
1/2	SWEDR	.688	.656	3155.	700.	1.781	.529	.453	.453	1.870	7338.
3/4	6000 SWHC	.466	.456	3027.	700.	1.679	.477	.453	.453	1.870	6759.
3/4	SWR	.578	.546	3155.	700.	1.781	.517	.453	.453	1.870	6759.
3/4	SWEDR	.688	.656	3155.	700.	1.781	.529	.453	.453	1.870	6759.
1	6000 SWHC	.533	.523	2971.	700.	1.847	.526	.453	.453	1.870	6102.
1	SWR	.735	.703	3155.	700.	2.031	.600	.453	.453	1.870	6102.
1	SWEDR	.938	.917	3155.	700.	2.031	.627	.469	.469	1.870	6102.
1-1/4	6000 SWHC	.533	.528	2754.	700.	2.019	.562	.453	.453	1.870	4684.
1-1/4	SWR	.672	.640	2919.	700.	2.156	.618	.453	.453	1.870	4684.
1-1/2	6000 SWHC	.598	.593	2745.	700.	2.173	.607	.453	.453	1.870	4590.
1-1/2	SWR	.836	.804	3052.	700.	2.406	.702	.453	.453	1.870	4590.
2	6000 SWHC	.735	.725	2755.	700.	2.486	.698	.453	.453	1.870	4470.
2	SWR	.969	.937	3072.	700.	2.719	.809	.485	.485	1.870	4470.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA312TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 10 IN SCH 140, AVERAGE WALL= 1.000, MINIMUM WALL= .875											
				SH= 15000. PSI, MAXIMUM ALLOWABLE PRESSURE= 2769.PSI			Y= .400				
1/2	SWA	.531	.499	2769.	700.	2.719	.609	.500	.500	2.208	7338.
1/2	SWEDA	.688	.656	2769.	700.	2.719	.809	.500	.500	2.208	7338.
3/4	6000 SWHC	.466	.456	2651.	700.	1.773	.501	.500	.500	2.208	6759.
3/4	SWA	.578	.546	2754.	700.	1.875	.541	.500	.500	2.208	6759.
3/4	SWEDA	.688	.656	2769.	700.	1.875	.541	.500	.500	2.208	6759.
1	6000 SWHC	.533	.523	2602.	700.	1.941	.550	.500	.500	2.208	6102.
1	SWA	.735	.703	2769.	700.	2.125	.623	.500	.500	2.208	6102.
1	SWEDA	.938	.917	2769.	700.	2.125	.623	.500	.500	2.208	6102.
1-1/4	6000 SWHC	.533	.528	2420.	700.	2.113	.586	.500	.781	2.208	4684.
1-1/4	SWA	.672	.640	2553.	700.	2.250	.642	.500	.500	2.208	4684.
1-1/2	6000 SWHC	.598	.593	2410.	700.	2.267	.630	.500	.806	2.208	4590.
1-1/2	SWA	.836	.804	2660.	700.	2.500	.726	.500	.500	2.208	4590.
2	6000 SWHC	.735	.725	2413.	700.	2.580	.722	.500	.778	2.208	4470.
2	SWA	.969	.937	2661.	700.	2.813	.817	.500	.500	2.208	4470.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA312TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI	SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES		INCHES	PSI.
PIPE SIZE= 12 IN SCH 140, AVERAGE WALL= 1.125, MINIMUM WALL= .984										
SM= 15900. PSI, MAXIMUM ALLOWABLE PRESSURE= 2617.PSI								Y= .400		
1/2	SWR	.531	.499	2617.	700.	2.813	.817	.563 .563	2.557	7338.
1/2	SWEDR	.688	.656	2617.	700.	2.813	.817	.563 .563	2.557	7338.
3/4	6000 SWHC	.466	.456	2499.	700.	1.898	.532	.563 .567	2.557	6759.
3/4	SWR	.578	.546	2585.	700.	2.000	.572	.563 .563	2.557	6759.
3/4	SWEDR	.688	.656	2617.	700.	2.000	.572	.563 .563	2.557	6759.
1	6000 SWHC	.533	.523	2451.	700.	2.066	.581	.563 .748	2.557	6102.
1	SWR	.735	.703	2617.	700.	2.250	.654	.563 .563	2.557	6102.
1	SWEDR	.938	.917	2617.	700.	2.250	.654	.563 .563	2.557	6102.
1-1/4	6000 SWHC	.533	.528	2288.	700.	2.238	.617	.563 1.493	2.557	4684.
1-1/4	SWR	.672	.640	2400.	700.	2.375	.673	.563 .925	2.557	4684.
1-1/2	6000 SWHC	.598	.593	2275.	700.	2.392	.662	.563 1.515	2.557	4590.
1-1/2	SWR	.836	.804	2487.	700.	2.625	.757	.563 .605	2.557	4590.
2	6000 SWHC	.735	.725	2269.	700.	2.705	.753	.563 1.475	2.557	4470.
2	SWR	.969	.937	2481.	700.	2.938	.848	.563 .623	2.557	4470.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP304 SA312TP304 SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI	SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES		INCHES	PSI.
PIPE SIZE= 14 IN SCH 140, AVERAGE WALL= 1.250, MINIMUM WALL= 1.094 SM= 15900. PSI, MAXIMUM ALLOWABLE PRESSURE= 2650.PSI Y= .400										
1/2	SWR	.531	.499	2650.	700.	2.938	.848	.625 .625	2.823	7338.
1/2	SWEDR	.688	.656	2650.	700.	2.938	.848	.625 .625	2.823	7338.
3/4	6000 SWHC	.466	.456	2525.	700.	2.023	.563	.625 .625	2.823	6759.
3/4	SWR	.578	.546	2602.	700.	2.125	.603	.625 .625	2.823	6759.
3/4	SWEDR	.688	.656	2650.	700.	2.125	.603	.625 .625	2.823	6759.
1	6000 SWHC	.533	.523	2476.	700.	2.191	.612	.625 .731	2.823	6102.
1	SWR	.735	.703	2640.	700.	2.375	.686	.625 .625	2.823	6102.
1	SWEDR	.938	.917	2650.	700.	2.375	.686	.625 .625	2.823	6102.
1-1/4	6000 SWHC	.533	.528	2319.	700.	2.363	.648	.625 1.544	2.823	4684.
1-1/4	SWR	.672	.640	2419.	700.	2.500	.708	.625 .962	2.823	4684.
1-1/2	6000 SWHC	.598	.593	2302.	700.	2.517	.693	.625 1.588	2.823	4590.
1-1/2	SWR	.836	.804	2494.	700.	2.750	.788	.625 .646	2.823	4590.
2	6000 SWHC	.735	.725	2289.	700.	2.830	.784	.625 1.581	2.823	4470.
2	SWR	.969	.937	2481.	700.	3.063	.880	.625 .692	2.823	4470.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 2 IN SCH 160, AVERAGE WALL= .343, MINIMUM WALL= .300											
SM= 16300. PSI, MAXIMUM ALLOWABLE PRESSURE= 4583. PSI Y= .400											
1/2	SWR*	.531	.499	4583.	700.	1.093	.377	.266	.266	.590	7522.
1/2	SWEDR*	.688	.656	4583.	700.	1.218	.463	.344	.344	.590	7522.
3/4	6000 SWHC	.466	.456	4583.	700.	1.116	.358	.233	.233	.590	6929.
3/4	SWR*	.578	.546	4583.	700.	1.218	.425	.289	.289	.590	6929.
3/4	SWEDR*	.688	.656	4583.	700.	1.218	.463	.344	.344	.590	6929.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 2-1/2 IN SCH 160, AVERAGE WALL= .375, MINIMUM WALL= .328											
SM= 16300. PSI. MAXIMUM ALLOWABLE PRESSURE= 4094.PSI Y= .400											
1/2		SWA*	.531	.499	4094.	700.	1.125	.377	.266	.266	.685	7522.
1/2		SWEDA*	.688	.656	4094.	700.	1.250	.463	.344	.344	.685	7522.
3/4	6000	SWHC	.466	.456	4094.	700.	1.148	.358	.233	.233	.685	6929.
3/4		SWA*	.578	.546	4094.	700.	1.250	.425	.289	.289	.685	6929.
3/4		SWEDA*	.688	.656	4094.	700.	1.250	.463	.344	.344	.685	6929.
1	6000	SWHC	.533	.523	4094.	700.	1.316	.422	.267	.267	.685	6255.
1		SWA*	.735	.703	4094.	700.	1.500	.543	.368	.368	.685	6255.
1		SWEDA*	.938	.917	4094.	700.	1.500	.611	.469	.469	.685	6255.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 3 IN SCH 160, AVERAGE WALL= .438, MINIMUM WALL= .383											
	SM= 16300. PSI.			MAXIMUM ALLOWABLE PRESSURE= 3912. PSI			Y= .400				
1/2	SWR*	.531	.499	3912.	700.	1.188	.377	.266	.266	.819	7522.
1/2	SWEDR*	.688	.656	3912.	700.	1.313	.463	.344	.344	.819	7522.
3/4	6000 SWHC	.466	.456	3912.	700.	1.211	.358	.233	.233	.819	6929.
3/4	SWR*	.578	.546	3912.	700.	1.313	.425	.289	.289	.819	6929.
3/4	SWEDR*	.688	.656	3912.	700.	1.313	.463	.344	.344	.819	6929.
1	6000 SWHC	.533	.523	3912.	700.	1.379	.422	.267	.267	.819	6255.
1	SWR*	.735	.703	3912.	700.	1.563	.543	.368	.368	.819	6255.
1	SWEDR*	.938	.917	3912.	700.	1.563	.611	.469	.469	.819	6255.
1-1/4	6000 SWHC	.533	.528	3633.	700.	1.551	.458	.267	.267	.819	4802.
1-1/4	SWR*	.672	.640	3912.	700.	1.688	.546	.336	.336	.819	4802.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-SP-97

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 4 IN SCH 160, AVERAGE WALL= .531, MINIMUM WALL= .465											
	SM= 16300. PSI, MAXIMUM ALLOWABLE PRESSURE= 3669. PSI						Y= .400				
1/2	SWR*	.531	.899	3669.	700.	1.281	.377	.266	.266	1.027	7522.
1/2	SWEDR*	.688	.656	3669.	700.	1.406	.463	.344	.344	1.027	7522.
3/4	6000 SWHC	.466	.456	3650.	700.	1.304	.374	.266	.266	1.027	6929.
3/4	SWR*	.578	.546	3669.	700.	1.406	.425	.289	.289	1.027	6929.
3/4	SWEDR*	.688	.656	3669.	700.	1.406	.463	.344	.344	1.027	6929.
1	6000 SWHC	.533	.523	3605.	700.	1.472	.422	.267	.267	1.027	6255.
1	SWR*	.735	.703	3669.	700.	1.656	.543	.368	.368	1.027	6255.
1	SWEDR*	.938	.917	3669.	700.	1.656	.611	.469	.469	1.027	6255.
1-1/4	6000 SWHC	.533	.528	3293.	700.	1.644	.458	.267	.267	1.027	4802.
1-1/4	SWR*	.672	.640	3658.	700.	1.781	.546	.336	.336	1.027	4802.
1-1/2	6000 SWHC	.598	.593	3341.	700.	1.798	.517	.299	.299	1.027	4706.
1-1/2	SWR*	.836	.804	3669.	700.	2.031	.668	.418	.418	1.027	4706.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-SP-97

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 5 IN SCH 160, AVERAGE WALL= .625, MINIMUM WALL= .547											
SM= 16300. PSI. MAXIMUM ALLOWABLE PRESSURE= 3478.PSI Y= .400											
1/2	SWA*	.531	.499	3478.	700.	1.375	.400	.313	.313	1.242	7522.
1/2	SWFDA*	.688	.656	3478.	700.	1.500	.463	.344	.344	1.242	7522.
3/4	6000 SWHC	.466	.456	3406.	700.	1.398	.397	.313	.313	1.242	6929.
3/4	SWA*	.578	.546	3478.	700.	1.500	.436	.313	.313	1.242	6929.
3/4	SWFDA*	.688	.656	3478.	700.	1.500	.463	.344	.344	1.242	6929.
1	6000 SWHC	.533	.523	3355.	700.	1.566	.445	.313	.313	1.242	6255.
1	SWA*	.735	.703	3478.	700.	1.750	.543	.368	.368	1.242	6255.
1	SWFDA*	.938	.917	3478.	700.	1.750	.611	.469	.469	1.242	6255.
1-1/4	6000 SWHC	.533	.528	3078.	700.	1.738	.480	.313	.313	1.242	4802.
1-1/4	SWA*	.672	.640	3348.	700.	1.875	.546	.336	.336	1.242	4802.
1-1/2	6000 SWHC	.598	.593	3089.	700.	1.892	.523	.313	.313	1.242	4706.
1-1/2	SWA*	.836	.804	3478.	700.	2.125	.668	.418	.418	1.242	4706.
2	6000 SWHC	.735	.725	3179.	700.	2.205	.640	.368	.368	1.242	4583.
2	SWA*	.969	.937	3478.	700.	2.438	.790	.485	.485	1.242	4583.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MDG-ES-2

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 6 IN SCH 160, AVERAGE WALL= .718, MINIMUM WALL= .628											
SM= 16300. PSI, MAXIMUM ALLOWABLE PRESSURE= 3345.PSI Y= .400											
1/2	SWR*	.531	.499	3345.	700.	1.468	.422	.359	.359	1.456	7522.
1/2	SWFOR*	.688	.656	3345.	700.	1.593	.470	.359	.359	1.456	7522.
3/4	6000 SWHC	.466	.456	3240.	700.	1.491	.420	.359	.359	1.456	6929.
3/4	SWR*	.578	.546	3345.	700.	1.593	.459	.359	.359	1.456	6929.
3/4	SWFOR*	.688	.656	3345.	700.	1.593	.470	.359	.359	1.456	6929.
1	6000 SWHC	.533	.523	3186.	700.	1.659	.467	.359	.359	1.456	6255.
1	SWR*	.735	.703	3345.	700.	1.843	.543	.368	.368	1.456	6255.
1	SWFOR*	.938	.917	3345.	700.	1.843	.611	.469	.469	1.456	6255.
1-1/4	6000 SWHC	.533	.528	2934.	700.	1.831	.503	.359	.359	1.456	4802.
1-1/4	SWR*	.672	.640	3150.	700.	1.968	.557	.359	.359	1.456	4802.
1-1/2	6000 SWHC	.598	.593	2937.	700.	1.985	.546	.359	.359	1.456	4706.
1-1/2	SWR*	.836	.804	3345.	700.	2.218	.668	.418	.418	1.456	4706.
2	6000 SWHC	.735	.725	2978.	700.	2.298	.640	.368	.368	1.456	4583.
2	SWR*	.969	.937	3345.	700.	2.531	.790	.485	.485	1.456	4583.

*COMBINATION NOT RECOMMENDED SINCE RUN PIPE WALL THICKNESS AND/OR NOMINAL PIPE SIZE BELOW VALUES SHOWN ON MSS-SP-97

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TM	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 8 IN SCH 160, AVERAGE WALL= .906, MINIMUM WALL= .793											
		SM= 16300. PSI, MAXIMUM ALLOWABLE PRESSURE= 3234. PSI					YE= .400				
1/2	SWR	.531	.499	3234.	700.	1.654	.468	.453	.453	1.870	7522.
1/2	SWFOR	.688	.656	3234.	700.	1.781	.516	.453	.453	1.870	7522.
3/4	6000 SWHC	.466	.456	3093.	700.	1.679	.466	.453	.453	1.870	6929.
3/4	SWR	.578	.546	3222.	700.	1.781	.505	.453	.453	1.870	6929.
3/4	SWFOR	.688	.656	3234.	700.	1.781	.516	.453	.453	1.870	6929.
1	6000 SWHC	.533	.523	3034.	700.	1.847	.513	.453	.453	1.870	6255.
1	SWR	.735	.703	3234.	700.	2.031	.585	.453	.453	1.870	6255.
1	SWFOR	.938	.917	3234.	700.	2.031	.611	.469	.469	1.870	6255.
1-1/4	6000 SWHC	.533	.528	2813.	700.	2.019	.549	.453	.453	1.870	4802.
1-1/4	SWR	.672	.640	2979.	700.	2.156	.603	.453	.453	1.870	4802.
1-1/2	6000 SWHC	.598	.593	2803.	700.	2.173	.592	.453	.453	1.870	4706.
1-1/2	SWR	.835	.804	3113.	700.	2.406	.685	.453	.453	1.870	4706.
2	6000 SWHC	.735	.725	2811.	700.	2.486	.681	.453	.453	1.870	4583.
2	SWR	.969	.937	3130.	700.	2.719	.790	.485	.485	1.870	4583.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 10 IN SCH 140, AVERAGE WALL= 1.000, MINIMUM WALL= .875											
SM= 16300. PSI, MAXIMUM ALLOWABLE PRESSURE= 2838.PSI Y= .400											
1/2	SWB	.531	.499	2838.	700.	2.719	.790	.500	.500	2.208	7522.
1/2	SWFOB	.688	.656	2838.	700.	2.719	.790	.500	.500	2.208	7522.
3/4	6000 SWHC	.466	.456	2710.	700.	1.773	.489	.500	.500	2.208	6929.
3/4	SWB	.578	.546	2813.	700.	1.875	.528	.500	.500	2.208	6929.
3/4	SWFOB	.688	.656	2838.	700.	1.875	.528	.500	.500	2.208	6929.
1	6000 SWHC	.533	.523	2658.	700.	1.941	.536	.500	.500	2.208	6255.
1	SWB	.735	.703	2838.	700.	2.125	.608	.500	.500	2.208	6255.
1	SWFOB	.938	.917	2838.	700.	2.125	.608	.500	.500	2.208	6255.
1-1/4	6000 SWHC	.533	.528	2472.	700.	2.113	.571	.500	.566	2.208	4802.
1-1/4	SWB	.672	.640	2606.	700.	2.250	.626	.500	.500	2.208	4802.
1-1/2	6000 SWHC	.598	.593	2461.	700.	2.267	.615	.500	.597	2.208	4706.
1-1/2	SWB	.836	.804	2713.	700.	2.500	.708	.500	.500	2.208	4706.
2	6000 SWHC	.735	.725	2462.	700.	2.580	.704	.500	.581	2.208	4583.
2	SWB	.969	.937	2712.	700.	2.813	.797	.500	.500	2.208	4583.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 12 IN SCH 140, AVERAGE WALL= 1.125, MINIMUM WALL= .984											
SM= 16300. PSI, MAXIMUM ALLOWABLE PRESSURE= 2683.PSI Y= .400											
1/2	SWR	.531	.499	2683.	700.	2.813	.797	.563	.563	2.557	7522.
1/2	SWEDR	.688	.656	2683.	700.	2.813	.797	.563	.563	2.557	7522.
3/4	6000 SWHC	.466	.456	2555.	700.	1.898	.519	.563	.563	2.557	6929.
3/4	SWR	.578	.546	2641.	700.	2.000	.558	.563	.563	2.557	6929.
3/4	SWEDR	.688	.656	2683.	700.	2.000	.558	.563	.563	2.557	6929.
1	6000 SWHC	.533	.523	2505.	700.	2.066	.567	.563	.563	2.557	6255.
1	SWR	.735	.703	2683.	700.	2.250	.638	.563	.563	2.557	6255.
1	SWEDR	.938	.917	2683.	700.	2.250	.638	.563	.563	2.557	6255.
1-1/4	6000 SWHC	.533	.528	2338.	700.	2.238	.602	.563	1.218	2.557	4802.
1-1/4	SWR	.672	.640	2450.	700.	2.375	.657	.563	.703	2.557	4802.
1-1/2	6000 SWHC	.598	.593	2324.	700.	2.392	.645	.563	1.249	2.557	4706.
1-1/2	SWR	.836	.804	2537.	700.	2.625	.738	.563	.563	2.557	4706.
2	6000 SWHC	.735	.725	2316.	700.	2.705	.735	.563	1.226	2.557	4583.
2	SWR	.969	.937	2530.	700.	2.938	.828	.563	.563	2.557	4583.

APPLICABLE FOR MATERIALS:

PIPE MATERIALS: SA376TP316
FITTING MATERIALS: SA182 F304

BRANCH SIZE	FITTING TYPE	FITTING AVERAGE WALL	FITTING MINIMUM WALL	90 DEGREE BRANCH ALLOWABLE DESIGN PRESSURE	MAXIMUM DESIGN TEMPERATURE	REINFORCEMENT LIMITS LA	LN	MINIMUM R2 REQUIRED AND REQUIRED R2 FOR 2500PSI		SPACING CRITERIA SQUARE ROOT OF RM X TR	ALLOWABLE DESIGN PRESSURE FOR STRAIGHT FITTING TYPE
INCHES		INCHES	INCHES	PSI.	F	INCHES	INCHES			INCHES	PSI.
PIPE SIZE= 14 IN SCH 140, AVERAGE WALL= 1.250, MINIMUM WALL= 1.094											
SM= 16300. PSI. MAXIMUM ALLOWABLE PRESSURE= 2717.PSI Y= .400											
1/2	SWR	.531	.499	2717.	700.	2.938	.828	.625	.625	2.823	7522.
1/2	SWEOR	.688	.656	2717.	700.	2.938	.828	.625	.625	2.823	7522.
3/4	6000 SWHC	.466	.456	2583.	700.	2.023	.549	.625	.625	2.823	6929.
3/4	SWB	.578	.546	2660.	700.	2.125	.589	.625	.625	2.823	6929.
3/4	SWEOR	.688	.656	2717.	700.	2.125	.589	.625	.625	2.823	6929.
1	6000 SWHC	.533	.523	2531.	700.	2.191	.597	.625	.625	2.823	6255.
1	SWR	.735	.703	2696.	700.	2.375	.669	.625	.625	2.823	6255.
1	SWEOR	.938	.917	2717.	700.	2.375	.669	.625	.625	2.823	6255.
1-1/4	6000 SWHC	.533	.528	2370.	700.	2.363	.632	.625	1.228	2.823	4802.
1-1/4	SWR	.672	.640	2471.	700.	2.500	.687	.625	.706	2.823	4802.
1-1/2	6000 SWHC	.598	.593	2352.	700.	2.517	.676	.625	1.284	2.823	4706.
1-1/2	SWR	.836	.804	2546.	700.	2.750	.769	.625	.625	2.823	4706.
2	6000 SWHC	.735	.725	2337.	700.	2.830	.765	.625	1.297	2.823	4583.
2	SWR	.969	.937	2531.	700.	3.063	.858	.625	.625	2.823	4583.

EDS NUCLEAR, INC

PROGRAM *CL1BIC*

AREA REINFORCEMENT AND STRESS INDEX
CALCULATIONS FOR CLASS 1 BRANCH CONNECTIONS
PER ASME BPVC SECTION III NB-3600

END OF EXECUTION

MCC1206·02-54-0005 ENCLOSURE 1

CERTIFICATION OF ENGINEERING CALCULATION MC-1206.02-54-000

ATTACHMENT 1.2

Station and Unit Number GENERAL - ALL PLANTS

Title of Calculation BEAM W TYP SECTION BASED ON PRESSURE REQUIREMENTS

Calculation Number DNK-3-28-77 Originally consisting of Pages 1 through 22.

These Engineering calculations cover items relating to nuclear safety. In accordance with established procedures, the quality has been assured and I certify that the above calculation has been performed, checked or approved as noted below:

Performed by D.N. KISLEY Date

Checked by Tommy C. Duncan Date

Approved by C.W. Schaffer Date 2-5-79

Revision/Addenda Log:

No.	Pages Revised	Pages Deleted	Pages Added	Performed By / Date	Checked By / Date	Approved By / Date
1	—	—	PR101 COVER SHEET	RLC 1-31-79	ENH 1-31-79	WHH 2-5-79

DIVISION COPY

LINE # 1760

CODED BY LCD

MCC1206.02-54-0005

BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

GENERAL - ALL PLANTS

Prepared By Robert H Cope Jr FOR DNKISLEY
D. N. Kisley

Checked By Tommy C. Deese
T. C. Deese

Approved By

CALCULATION DNK-3-28-77

Pages 1 through 22

RECORD OF REVISIONS

Rev. No.	Issue Date	Ppd. by	Ckd. by	App. by	Pages Revised and Description
0	3/28/77	DNK	TCD		Original Issue

MCC1206·02-54-0005

DISTRIBUTION OF THIS DOCUMENT

Name & Organization	Date	Rev	Date	Rev	Date
DN KISLEY	3/28/77				

MCC1206.02-54-0005

Division GENERAL Unit File No.

Subject BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

By DNK Date 3-25-77

Sheet No. 1 of 22 Problem No. DNK 3-28-77 Checked By TCD Date 3-25-77

PROBLEM STATEMENT:

TO ESTABLISH A PROCEDURE FOR BRANCH TYPE SELECTION BASED ON CODE REQUIREMENTS FOR AREA REINFORCEMENT DUE TO PRESSURE.

RELATION TO NUCLEAR SAFETY:

THIS PROCEDURE APPLIES TO PIPING OF DUKE CLASS B, C, E & F WHICH IS NUCLEAR SAFETY RELATED.

DESIGN METHOD:

THE METHOD IS DEFINED IN THE CODE REQUIREMENTS FOR AREA REINFORCEMENT. THE BASIC IDEA IS THAT METAL CUT OUT OF THE RUN PIPE WHEN INSTALLING A BRANCH MUST BE REPLACED BY EXCESS METAL IN THE BRANCH FITTING.

CODES AND STANDARDS:

ASME B&PVC SEC III 1974, THROUGH SUMMER 1976 ADDENDA, SUBSEC. NC & ND.
ANSI B31.1 1973, THROUGH WINTER 1976 ADDENDA. ANSI B16.11 1973

ASSUMPTIONS:

1. ASSUME PRESSURE IN THE BRANCH AND RUN ARE EQUAL
2. ASSUME THE RUN PIPE SEES THE MAXIMUM DESIGN PRESSURE FOR THE CORRESPONDING SCHEDULE., I.E. NO EXCESS METAL FOR REINFORCEMENT WILL BE TAKEN FROM THE RUN PIPE.
3. ASSUME BRANCH AND RUN ARE THE SAME MATERIALS
4. ASSUME THE BRANCH IS PERPENDICULAR TO THE RUN.
5. MANUFACTURE TOLERANCES ARE ACCOUNTED FOR IN THE MINIMUM DIMENSIONS ALLOWED FOR FITTINGS.
6. CORROSION ALLOWANCES ARE NOT CONSIDERED IN THIS CALCULATION.

Dev./Station GENERAL Unit Title No.

BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

By DNK 3-25-77

Sh. No. 2 of 22 Problem No. DNK 3-28-77 Checked By TCD Date 3-25-77

OTHER SOURCES OF INFORMATION:

MECHANICAL DESIGN SECTION MANUAL FOR MDS-25-2 REV. ORIG. DUKE POWER CO.

PRESENTATION OF CALCULATION:

NOTE: ALL EQS. COME FROM ASME SEC III 1974 (SUBSEC. NC 3643 & ND 3643)
ALL DIMENSIONS ARE EITHER FROM ANSI B 16.11 (FOR HALF COUPLINGS)
OR MECH. DESIGN SEC. MANUAL (FOR THE SPECIAL WELDING BOSS)

REQUIRED AREA = AVAILABLE AREA $A_R = A_A$

FIND THE MAXIMUM ALLOWABLE HEADER THICKNESS FOR EACH NOMINAL SIZE RUN PIPE WHEN GIVEN THE BRANCH FITTING SIZE AND PRESSURE CLASS.

$A_R = 1.07\, t_{mh}\, d_b$ (EQ 1) $\qquad A_A = 2L(T_h - t_{mh})$ (EQ. 2)

IF PRESSURES ARE EQUAL 3) $t_{mb} = \dfrac{P_1 d_b}{2(SE + P_1 y - P_1)}$ (EQ. 3) & $t_{mh} = \dfrac{P_1 d_h}{2(SE + P_1 y - P_1)}$ (EQ. 4)

$t_{mb} = \dfrac{P_1 d_b}{2\alpha_1}$ & $t_{mh} = \dfrac{P_1 d_h}{2\alpha_1}$ where $\alpha_1 = (SE + P_1 y - P_1)$

$P_1 = \dfrac{2\alpha_1 t_{mb}}{d_b} = \dfrac{2\alpha_1 t_{mh}}{d_h} \longrightarrow t_{mb} = \dfrac{d_b}{d_h} t_{mh}$

IF $A_A = A_R$ $\qquad 1.07\, t_{mh}\, d_b = 2L\, T_h - 2L \dfrac{d_b}{d_h} t_{mh}$

$2LT_h = 1.07\, t_{mh}\, d_b + 2L \dfrac{d_b}{d_h} t_{mh} \qquad t_{mh}\left(1.07 d_b + 2L \dfrac{d_b}{d_h}\right) = 2LT_h$

Dept./Station GENERAL Unit Calc No.

Subject BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

By DNK Date 3-25-77

Sheet No. 3 of 22 Problem No. DNK 3-28-77 Checked By TCD Date 3-25-77

IF ASSUMPTION 2 IS MET: $T_{H_{ALLOW}} = t_{min} = \dfrac{2LT_b}{1.07d_b + \dfrac{2Ld_b}{d_h}}$ (EQ.5)

WHERE L = HEIGHT OF REINFORCEMENT ZONE
T_b = THICKNESS OF BRANCH
d_b = INSIDE DIAMETER OF BRANCH
d_h = INSIDE DIAMETER OF RUN

BECAUSE THE INSIDE DIAMETER VARIES FOR EACH PIPE SCHEDULE OF THE SAME NOMINAL SIZE IT IS NECESSARY TO ESTIMATE $T_{H_{ALLOW}}$ USING THE O.D., TO AVOID EXCESSIVE CALCULATIONS. ONCE $T_{H_{ALLOW}}$ IS DETERMINED THE MAXIMUM ESTIMATED HEADER SCHEDULE CAN BE DETERMINED. FROM THIS $T_{H_{ALLOW}}$ MUST BE REFIGURED BASED ON THE I.D. OF THE ESTIMATED HEADER SCHEDULE TO DETERMINE THE EXACT $T_{H_{ALLOW}}$. OF COURSE USING THE O.D. WILL GIVE A $T_{H_{ALLOW}}$ HIGHER THAN THE EXACT VALUE. IF THE EXACT VALUE DROPS MUCH, IT MAY CAUSE THE EXACT HEADER SCHEDULE TO DROP TO THE NEXT LOWER SCHEDULE. THIS PROCEDURE IS ILLUSTRATED ON THE CHARTS AND CASES WHERE THE EXACT HEADER SCHEDULE DROPS ARE DENOTED BY A CHECK. (✓) THE CALCULATIONS WERE MADE FOR 3000 # & 6000 # HALF COUPLINGS AND FOR TUBE POWER - SPECIAL WELDING BOSS.

REMOVAL OF METAL FROM THE BRANCH FITTING, WHICH IS GROUND SO THE BRANCH FITS THE CONTOUR OF THE RUN, WAS ALSO CONSIDERED. THE AREA REMOVED DUE TO GRINDING WAS FIGURED BY MAKING SCALE DRAWINGS OF BRANCH FITTINGS AND RUN PIPES. THE REDUCTION IN HEIGHT OF REINFORCEMENT ZONE WAS MEASURED AND THE REDUCED (L) WAS USED IN THE CALCULATION.

MCC1206·02-5 0003

GENERAL

BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

by DNK 3-21-77

4 22 DNK 3-28-77 Checked by TCD 3-24-77

DIM FOR 3/4" 3000# HALF CPLG

HEADER SIZE	B	C	$D = d_b$	$D_{H_{OD}}$	$T_B = \frac{B+2C-D}{2}$	$T_{H_{ALLOW\ (EST)}}$	MAXIMUM HEADER SCH. (EST)	CHECK ESTIMATE $D_{H_{ID}}$	CHECK ESTIMATE $T_{H_{ALLOW\ (MIN)}}$	CHECK ESTIMATE MAX LIKELY SCH
2½	1.065	.193	.854	2.875	.299	.327	80	2.323	.304	80
3	1.065	.193	.854	3.5	.299	.349	80	2.9	.330	40
3½	1.065	.193	.854	4.0	.299	.362	80	3.364	.346	80
4			.854	4.5	.299	.373	80	3.826	.359	80
5			.854	5.563	.299	.391	80	4.813	.379	80
6			.854	6.625	.299	.404	40	6.065	.399	40
8			.854	8.625	.299	.421	40	7.981	.417	40
10			.854	10.75	.299	.433	40	10.02	.430	40
12			.854	12.75	.299	.441	40 (STD)	11.938	.437	40 (STD)
14			.854	14.0	.299	.445	40 (STD)	13.126	.442	40 (STD)
16			.854	16.0	.299	.450	30 (STD)	15.25	.448	30 (STD)
18			.854	18.0	.299	.454	30 (STD)	17.126	.453	30 (STD)
20			.854	20.0	.299	.457	20 (STD)	19.25	.456	20 (STD)
22			.854	22.0	.299	.460	20 (STD)	21.25	.459	20 STD
24			.854	24.0	.299	.462	20 STD	23.25	.462	20 STD

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GENERAL

BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

By DNK 3-21-77

Sh. 5 of 22 Problem No. DNK 3-28-77 Checked By TCD Date 3-24-77

DIM. FOR 1" 3000# HALF CPLG.

HEADER SIZE	B	C	$D = d_b$	$D_{H_{OD}}$	$T_B = \frac{B+2C-D}{2}$	$T_{H_{ALLOW\ (CALC)}}$	MAXIMUM HEADER SCH. (CALC)	CHECK ESTIMATE $D_{H_{ID}}$	CHECK ESTIMATE $T_{H_{ALLOW\ (CALC)}}$	CHECK ESTIMATE MAX END SCH
2½	1.33	.224	1.079	2.875	.350	.324	80	2.323	.299	80
3			1.079	3.5	.350	.360	80	2.9	.338	80
3½			1.079	4.0	.350	.375	80	3.364	.357	80
4			1.079	4.5	.350	.388	80	3.826	.371	80
5			1.079	5.563	.350	.409	80	4.913	.396	80
6			1.079	6.625	.350	.424	40	6.065	.418	40
8			1.079	8.625	.350	.444	40	7.981	.440	40
10			1.079	10.75	.350	.459	40	10.02	.456	40
12			1.079	12.75	.350	.468	40 & STD	11.938	.466	40 & STD
14			1.079	14.0	.350	.473	40 & STD	13.126	.471	40 & STD
16			1.079	16.0	.350	.479	30 (STD)	15.25	.479	30 (STD)
18			1.079	18.0	.350	.484	30 & STD	17.126	.484	30 & STD
20			1.079	20.0	.350	.488	20 (STD)	19.25	.482	20 (STD)
22			1.079	22.0	.350	.492	20 (STD)	21.25	.492	20 (STD)
24			1.079	24.0	.350	.495	20 (STD)	23.25	.495	20 (STD)

MCC1206-02-54-0003

GENERAL

BRANCH TYTE SELECTION BASED ON PRESSURE REQUIREMENTS

By: DNK Date: 3-21-77

Sheet 6 of 22 Published No. DNK 3-22-77 Checked By TCD Date 3-24-77

DIM FOR 1½ 3000# HALF CPLG.

HEADER SIZE	B	C	$D = d_b$	$D_{H_{OD}}$	$T_B = \frac{B+2C-D}{2}$	$T_{H_{ALLOW\ (EST)}}$	MAXIMUM HEADER SCH. (EST)	CHECK ESTIMATE $D_{H_{ID}}$	CHECK ESTIMATE $T_{H_{ALLOW\ (EST)}}$	MAX END SCH
2½	1.915	.25	1.64	2.875	.388	.191	10	2.635	.186	10
3			1.64	3.5	.388	.241	40	3.068	.232	40
3½			1.64	4.0	.388	.269	40	3.548	.260	40
4			1.64	4.5	.388	.290	40	4.026	.281	40
5			1.64	5.563	.388	.323	40	5.047	.315	40
6			1.64	6.625	.388	.337	40	6.065	.330	40
8			1.64	8.625	.388	.353	40	7.981	.349	40
10			1.64	10.75	.388	.366	40	10.136	.364	30
12			1.64	12.75	.388	.374	30 (NOTE)	12.09	.373	30
14			1.64	14.0	.388	.379	30 (STD)	13.25	.377	30 (STD)
16			1.64	16.0	.388	.384	30 (STD)	15.25	.383	30 (STD)
18			1.64	18.0	.388	.388	20 & STD	17.25	.388	20 & STD
20			1.64	20.	.388	.392	20 (STD)	19.25	.392	20 (STD)
22			1.64	22.0	.388	.395	20 (STD)	21.25	.395	20 (STD)
24			1.64	24.0	.388	.397	20 (STD)	23.25	.397	20 (STD)

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GENERAL

BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

By DNK 3-21-77

7, 22 Problem No. DNK 3-28-77 Checked By TCD Date 3-24-77

DIM FOR 2" 3000# HALF CPLG.

HEADER SIZE	B	C	$D = d_b$	$D_{H_{OD}}$	$T_B = \frac{B+2C-D}{2}$	$T_{H_{ALLOW}}$ (CEST)	MAXIMUM HEADER SCH. (CEST)	CHECK ESTIMATE $D_{H_{ID}}$	CHECK ESTIMATE $T_{H_{ALLOW}}$ (MCC)	CHECK ESTIMATE MAX ISO SCH
2½	2.406	.273	2.097	2.875	.428	Not suitable for use				
3				3.5	.428	.218	40	3.26	.213	10 ✓
3½				4.0	.428	.262	40	3.548	.252	40
4				4.5	.428	.282	40	4.026	.272	40
5				5.563	.428	.299	40	5.047	.292	40
6				6.625	.428	.313	40	6.065	.307	40
8				8.625	.428	.330	40	7.981	.326	40
10				10.75	.428	.343	30	10.136	.341	30
12				12.75	.428	.352	30	12.09	.350	30
14				14.0	.428	.356	20	13.376	.355	20
16				16.0	.428	.362	20	15.376	.361	20
18				18.0	.428	.367	20	17.376	.366	20
20				20.0	.428	.370	10	19.5	.370	10
22				22.0	.428	.373	10	21.5	373	10
24				24.0	.428	.376	10	23.5	.375	10

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GENERAL

BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

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DNK 3-23-77

DIM FOR 3/4" 6000# HALF CPLG.

HEADER SIZE	B	C	$D = d_b$	$D_{H_{OD}}$	$T_B = \frac{B+2C-D}{2}$	$T_{H_{ALLOW\ (CET)}}$	MAXIMUM HEADER SCH. (CET)	CHECK ESTIMATE $D_{H_{ID}}$	CHECK ESTIMATE $T_{H_{ALLOW\ (MIN)}}$	CHECK ESTIMATE MAX ALLOW SCH
2½	1.065	.274	.642	2.875	.486	.627	160	2.125	.618	160
3				3.5	.486	.750	160	2.626	.686	160
3½				4.0	.486	.801	160	2.728	.713	160
4				4.5	.486	.842	160	3.438	.782	160
5				5.563	.486	.910	160	4.313	.856	160
6				6.625	.486	.961	160	5.189	.912	160
8				8.625	.486	1.026	160	6.813	.985	160
10				10.75	.486	1.079	140	8.75	1.048	140
12				12.75	.486	1.114	120	10.75	1.090	120
14				14.0	.486	1.162	120	11.814	1.136	120
16				16.0	.486	1.199	100	13.938	1.181	100
18				18.0	.486	1.212	100	15.688	1.196	100
20				20.0	.486	1.223	80	17.938	1.212	80
22				22.0	.486	1.232	80	19.75	1.222	80
24				24	.486	1.240	80	21.564	1.230	80

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GENERAL

BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

By DNK 3-23-77

Sheet 9 of 22 Checked By TCD Date 3-25-77

DIM FOR 1" 6000 # HALF CPLG.

HEADER SIZE	U	C	$D = d_b$	$D_{H_{OD}}$	$T_B = \frac{B+2C-D}{2}$	$T_{H_{ALLOW\ (REQ'D)}}$	MAXIMUM HEADER SCH. (REQ'D)	CHECK ESTIMATE $D_{H_{ID}}$	CHECK ESTIMATE $T_{H_{ALLOW\ (MAX)}}$	CHECK ESTIMATE MAX HDR SCH
2½	1.33	.312	.845	2.875	.555	.630	160	2.125	.564	160
3				3.5	.555	.729	160	2.626	.660	160
3½				4.0	.555	.772	160	2.728	.679	160
4				4.5	.555	.817	160	3.438	.753	160
5				5.563	.555	.884	160	4.313	.827	160
6				6.625	.555	.943	160	5.189	.889	160
8				8.625	.555	1.026	160	6.813	.972	160
10				10.75	.555	1.090	140	8.75	1.053	140
12				12.75	.555	1.136	140	10.75	1.108	120
14				14.0	.555	1.196	120	11.814	1.168	120
16				16.0	.555	1.216	100	13.938	1.195	100
18				18.0	.555	1.232	100	15.688	1.213	100
20				20.0	555	1.245	80	17.938	1.231	80
22				22.0	.555	1.256	80	19.75	1.243	80
24				24.0	.555	1.265	80	21.564	1.253	80

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GENERAL

BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

By DNK 3-23-77

No. 10 : 22 Revised By DNK 3-28-77 Checked By TCD Date 3-25-77

DIM FOR 1½ 6000 # HALF CPLG.

HEADER SIZE	U	C	$D = d_b$	$D_{H_{OD}}$	$T_b = \frac{B1ZC - D}{2}$	$T_{H_{ALLOW\ (EST)}}$	MAXIMUM HEADER SCH. (EST)	CHECK ESTIMATE $D_{H_{ID}}$	CHECK ESTIMATE $T_{H_{ALLOW\ REQ'D}}$	CHECK ESTIMATE MAX THD SCH
2½	1.915	.351	1.368	2.875	.625	.271	40	2.469	.262	40
3				3.5	.625	.412	80	2.9	.391	80
3½				4.0	.625	.474	80	3.364	.452	80
4				4.5	.625	.536	160	3.626	.505	120
5				5.563	.625	.605	120	4.563	.575	120
6				6.625	.625	.650	120	5.501	.623	120
8				8.625	.625	.725	120	7.439	.701	100
10				10.75	.625	.788	100	9.314	.769	100
12				12.75	.625	.828	80	11.376	.814	80
14				14.0	.625	.915	80	12.5	.90	80
16				16.0	.625	.932	80	14.314	.918	80
18				18.0	.625	.945	80	16.5	.935	60
20				20.0	.625	.956	60	18.376	.947	60
22				22.0	.625	.965	60	20.25	.957	60
24				24.0	.625	.973	60	22.626	.967	40

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Station GENERAL Unit File No.

Subject BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

By DNK Date 3-23-77

Sheet No. 11 of 22 Problem No. DNK 3-28-77 Checked By TCD Date 3-25-77

DIM FOR 2" 6000# HALF CPLG

HEADER SIZE	U	C	D = d_b	$D_{H_{OD}}$	$T_B = \frac{B+2C-D}{2}$	$T_{H_{ALLOW\ (CEST)}}$	MAXIMUM HEADER SCH. (CEST)	CHECK ESTIMATE $D_{H_{ID}}$	CHECK ESTIMATE $T_{H_{ALLOW\ (ANSI)}}$	MAX ANSI SCH
2½	2.406	.430	1.717	2.875	.775	Not suitable for use				
3				3.5	.775	.289	40	3.068	.282	40
3½				4.0	.775	.455	80	3.364	.434	80
4				4.5	.775	.553	160	3.626	.519	120 ✓
5				5.563	.775	.664	160	4.563	.628	120 ✓
6				6.625	.775	.756	160	5.501	.719	120 ✓
8				8.625	.775	.856	140	7.001	.814	140
10				10.75	.775	.933	120	9.064	.902	120
12				12.75	.775	.986	100	11.064	.961	100
14				14.0	.775	1.124	100	12.126	1.094	100
16				16.0	.775	1.149	100	13.938	1.123	100
18				18.0	.775	1.170	100	16.126	1.151	80 ✓
20				20.0	.775	1.187	80	17.938	1.169	80
22				22.0	.775	1.202	80	19.75	1.185	80
24				24.0	.775	1.214	60	22.064	1.202	60

MCC1206.02-54-aw5

Div./Station GENERAL Unit File No.

Subject BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS
WELDING BOSS CALCULATIONS By DNK Date 11-2-76

Sheet No. 12 of 22 Problem No. DNK 3-28-77 Checked By TCO Date 11-3-76

Sample calc. for 3/4"

$$t_L = \frac{2LT_b + (A-B)F}{1.07d_b + \frac{2Ld_b}{d_H}} = \frac{2(.812)(.546) + (1.716-1.075)(.563)}{1.07(.626) + \frac{2(.812)(.626)}{12.75}}$$

$$\frac{1.249}{.670 + \frac{1.017}{D_H}} = 1.666 =$$

Sample calc. for 1"

$$t_L = \frac{2LT_b + (A-B)F}{1.07d_b + \frac{2Ld_b}{D_H}} \quad \frac{2(.937)(.703) + (2.218-1.340)(.625)}{1.07(.813) + \frac{2(.937)(.813)}{12.75}}$$

$$\frac{1.86}{.710 + \frac{1.524}{D_H}} = 1.866$$

Sample calc for 1½"

$$t_L = \frac{2LT_b + (A-B)F}{1.07d_b + \frac{2Ld_b}{D_H}} = \frac{2(1.062)(.801) + (2.968-1.925)(.75)}{1.07(1.36) + \frac{2(1.062)(1.36)}{12.75}}$$

$$\frac{2.490}{1.455 + \frac{2.689}{D_H}} = 1.481$$

Sample calc for 2"

$$t_L = \frac{2LT_b + (A-B)F}{1.07d_b + \frac{2Ld_b}{D_H}} = \frac{2(1.437)(.937) + (3.593-2.416)(.875)}{1.07(1.72) + \frac{2(1.437)(1.72)}{D_H}}$$

$$\frac{3.723}{1.84 + \frac{4.943}{D_H}}$$

Form 1874 (5-76)

MCC1206.02-54-C305

Dev./Station GENERAL Unit File No.

Subject BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

WELDING BOSS CALCULATIONS By DNK Date 10-29-76

Sheet No. 13 of 22 Problem No. DNK 3-28-77 Checked By TCO Date 10-29-76

$$T_H = \frac{2T_b L}{1.07d + \frac{2Ld}{D_H}}$$

(1) $$T_H = \frac{5T_b^2}{1.07d_b + \frac{5T_b d}{D_H}}$$ ← Divide by 1.07 to get (2)

For half coupling

(2) $$T_H = \frac{4.67T_b^2}{d_b + 4.67T_b \frac{d_b}{D_H}}$$

For special welding boss
Where $L < 2.5T_b$

$$T_H = \frac{2T_b L + (A-B)F}{1.07d_b + \frac{2Ld_b}{D_H}}$$

For special welding boss

$$T_b = \frac{A-C}{2}$$

$$L = [K - F + J + H - M]$$

SPECIAL WELDING BOSS

SIZE	A (min)	B (max)	C = d_b (min)	F	H	J	K	M	T_b	L
3/4	1.718	1.075	.626	.563	.188	.484	.828	.125	.546	.812
1	2.218	1.340	.813	.625	.25	.609	.891	.188	.703	.937
1½	2.968	1.925	1.360	.75	.25	.703	1.047	.188	.891	1.062
2	3.593	2.416	1.720	.875	.25	.781	1.469	.188	.937	1.437

Form IBM (5-76)

MCC1206·02-54-0005

Dev./Station GENERAL Unit File No.

Subject BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS

WELDING BOSS CALCULATIONS By DNK Date 10-27-76

Sheet No. 14 of 22 Problem No. DNK 3-28-77 Checked By TCO Date 10-29-76

3/4" SPECIAL WELDING BOSS

HEADER SIZE	$D_{H_{OD}}$	L	T_b	d_b	$T_{H_{ALLOW}}$ (EST)	MAX. RUN SCH (EST)	CHECK $D_{H_{ID}}$	ESTIMATE $T_{H_{ALLOW}}$ (CALC)	EXACT MIN RUN SCH
12	12.75	.812	.546	.626	1.666	160	10.126	1.621	160
14	14.0	.812	.546	.626	1.682	160	11.188	1.642	160
16	16.0	.812	.546	.626	1.703	160	12.814	1.667	160
18	18.0	.812	.546	.626	1.719	140	14.876	1.692	140
20	20.0	.812	.546	.626	1.733	120	17.0	1.711	120
22	22.0	.812	.546	.626	1.744	120	18.75	1.725	120
24	24.0	.812	.546	.626	1.753	100	20.938	1.738	100

SAMPLE CALC. (14 HEADER SIZE)

$$T_H = \frac{2T_b L + (A-B)F}{1.07 d_b + \frac{2Ld_b}{D_H}} = \frac{2(.546)(.812) + (1.712-1.075)563}{1.07(.626) + \frac{2(.812)(.621)}{14}}$$

$T_H = 1.682$

MCC1206·02-54-0005

Form 134 (5-76)

Div./Station GENERAL Unit File No.

Subject BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS
WELDING BOSS CALCULATIONS By DNK Date 10-29-76

Sheet No. 15 of 22 Problem No. DNK 3-28-77 Checked By TCD Date 10-29-76

1ª SECIAL WELDING BOSS

HEADER SIZE	D_H	L	T_b	d_b	$T_{H_{ALLOW(EST)}}$	MAX RUN SCH (EST)	CHECK ESTIMATE $D_{H\ ID}$	$T_{P_{ALLOW}}$ (CALC)	EXACT MAX RUN SCH
12	12.75	.937	.703	.813	1.896	160	10.126	1.929	160
14	14.0	.937	.703	.813	1.906	160	11.188	1.855	160
16	16.0	.937	.703	.813	1.933	160	12.814	1.887	160
18	18.0	.937	703	813	1.955	160	14.438	1.913	160
20	20.0	937	.703	.813	1.972	160	16.5	1.939	140
22	22.0	.937	.703	.813	1.987	140	18.25	1.957	140
24	24.0	.937	.703	.813	1.999	120	20.376	1.975	120

Form 1151 (5-76)

MCC1206·02-54-0005

Dev./Station GENERAL Unit File No.

Subject BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS
WELDING BOSS CALCULATIONS By DNK Date 11-2-76

Sheet No. 16 of 22 Problem No. DNK. 3-22-77 Checked By TCD Date 11-3-76

1½" SPECIAL WELDING BOSS

HEADER SIZE	D_H	L	T_b	d_b	$T_{H\ ALLOW}$ (EST)	MAX RUN SCH (EST)	CHECK ESTIMATE $D_{H\ ID}$	CHECK ESTIMATE $T_{H\ ALLOW}$ (EXACT)	CHECK ESTIMATE EXACT MAX RUN SCH
8	8.625	1.062	.804	1.36	1.391	160	6.813	1.325	160
10	10.75	1.062	.804	1.36	1.455	160	8.5	1.367	160
12	12.75	1.062	.804	1.36	1.481	160	10.126	1.431	160
14	14.0	1.062	.804	1.36	1.499	160	11.188	1.453	160
16	16.0	1.062	.801	1.36	1.522	140	13.126	1.487	140
18	18.0	1.062	.804	1.36	1.541	120	15.25	1.514	120
20	20.0	1.062	.804	1.36	1.557	120	17.0	1.532	120
22	22.0	1.062	.804	1.36	1.570	100	19.25	1.551	100
24	24.0	1.062	.804	1.36	1.581	100	20.938	1.563	100

Form 124 15 761

MCC1206·02-54-0005

Dev./Station GENERAL Unit File No.

Subject BRANCH TYPE SELECTION BASED ON PRESSURE REQUIREMENTS
WELDING BOSS CALCULATIONS By DNK Date 11-2-76

Sheet No. 17 of 22 Problem No. DNK 3-28-77 Checked By TCD Date 11-3-76

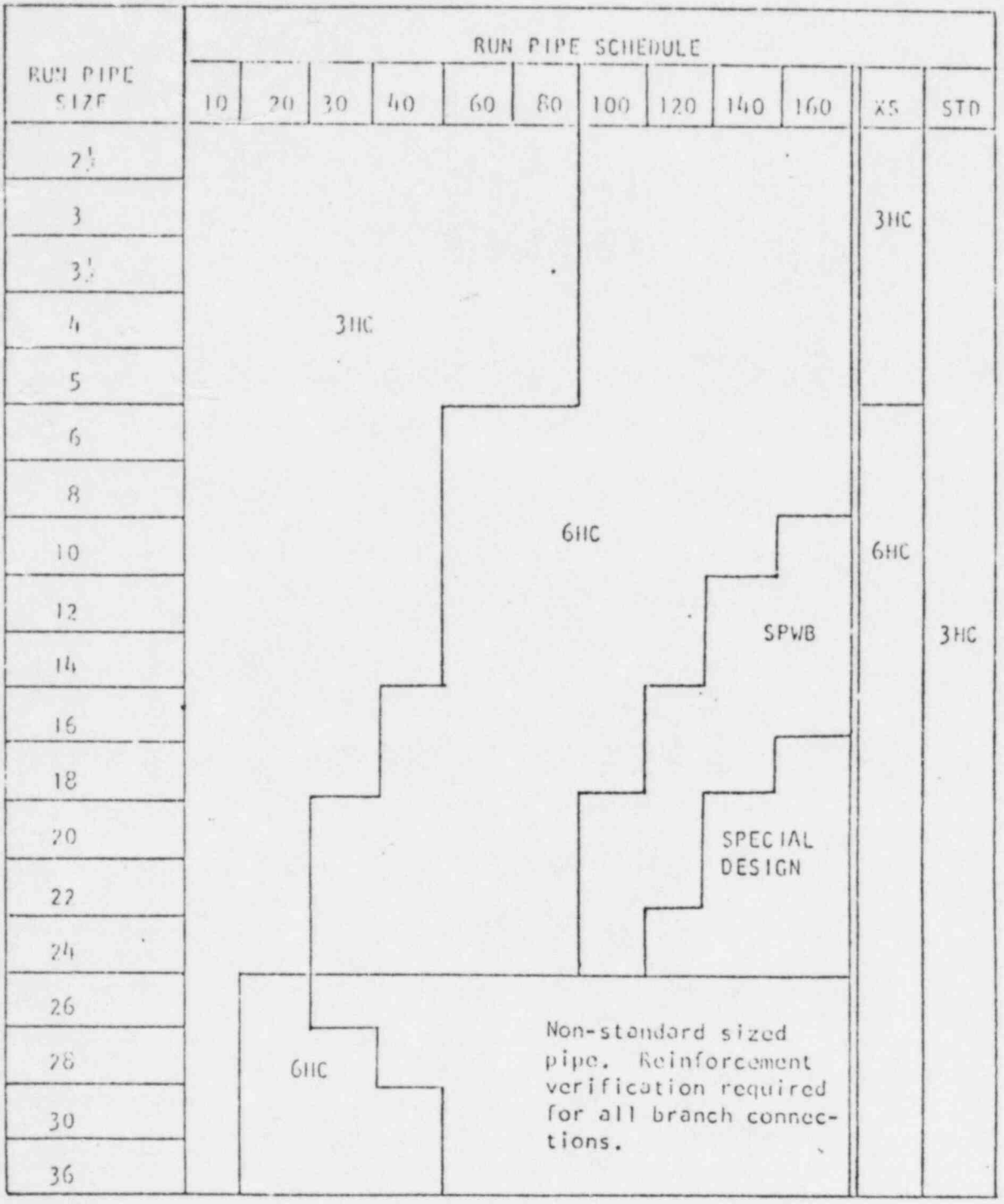
2" STECIAL WELDING BOSS

HEADER SIZE	D_H	L	T_b	d_b	$T_{H\ ALLOW}$ (EST)	MAX RUN SCH (EST)	CHECK ESTIMATE D_H ID	CHECK ESTIMATE $T_{H\ ALLOW}$ EXACT	CHECK ESTIMATE EXACT MAX RUN SCH	
10	10.75	1.437	.937	1.72	1.619	160	8.5	1.537	160	
12	12.75	1.437	.937	1.72	1.671	160	10.126	1.599	160	
14	14.0	1.437	.937	1.72	1.698	160	11.188	1.632	160	
16	16.0	1.437	.937	1.72	1.732	160	12.814	1.673	160	
18	18.0	1.437	.937	1.72	1.761	140	14.876	1.714	140	
20	20.0	1.437	.937	1.72	1.784	140	17.0	1.747	120	✓
22	22.0	1.437	.937	1.72	1.803	120	18.75	1.770	120	
24	24.0	1.437	.937	1.72	1.820	120	20.938	1.793	100	✓

PROB NO: DNK 3-28-77 CHCU TCD DATE 3-28-77

TABLE 3.1

1/2" AND 3/4" BRANCH PIPE SIZE



NOTE: SEE TABLE 2 FOR BRANCH TYPE DESCRIPTION

MCC1206·02-54-0005

PROB NO: DNK 3-28-77

CHKD: TCD DATE: 3-28-77

TABLE 3.2

1" BRANCH PIPE SIZE

RUN PIPE SIZE	RUN PIPE SCHEDULE											
	10	20	30	40	60	80	100	120	140	160	XS	STD
2½	3HC										3HC	3HC
3												
3½												
4												
5												
6											6HC	
8												
10							6HC					
12												
14												
16												
18									SPWB			
20												
22												
24									SPECIAL DESIGN			
26	6HC											
28												
30												
36												

Non-standard sized pipe. Reinforcement verification required for all branch connections.

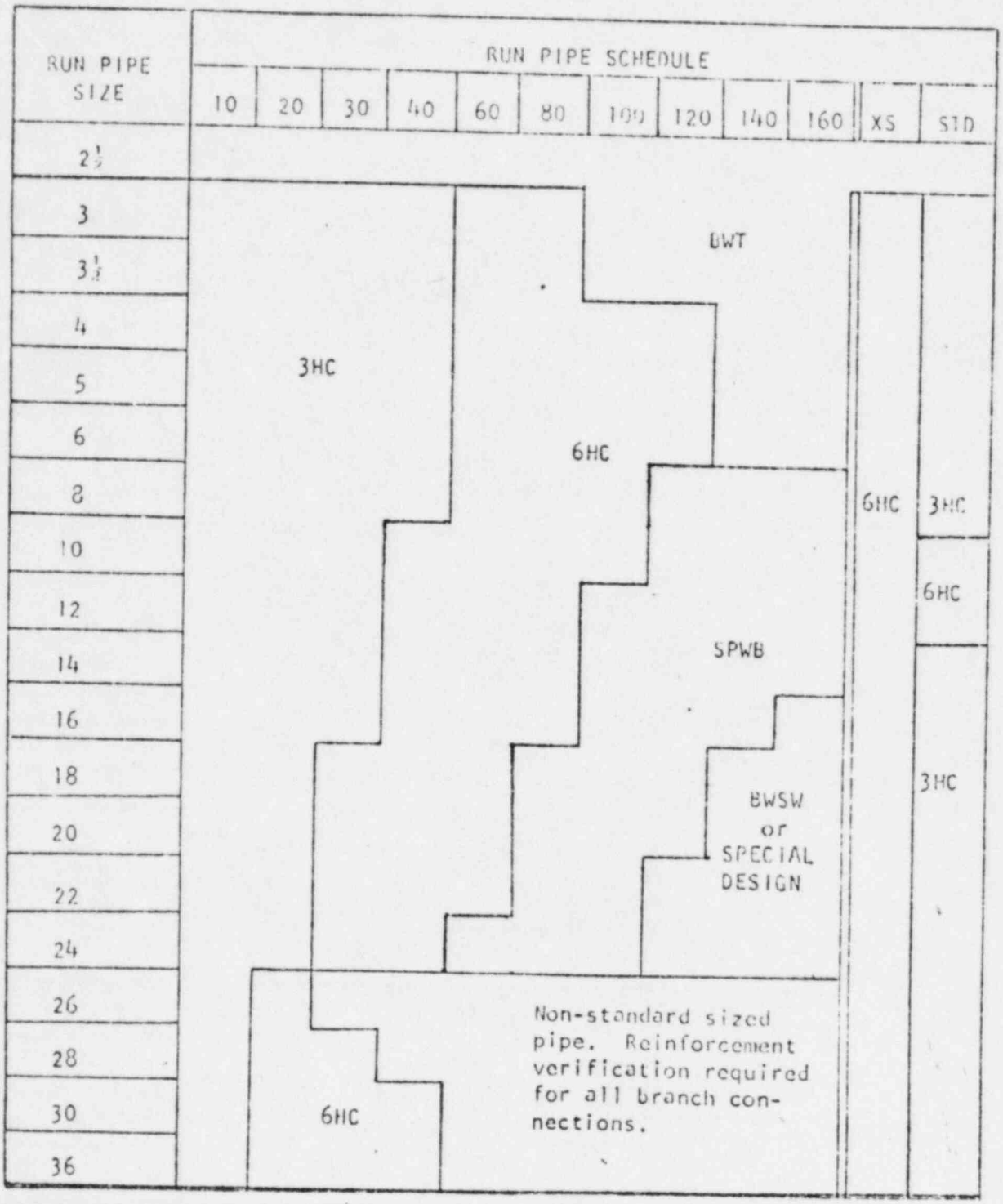
NOTE: SEE TABLE 2 FOR BRANCH TYPE DESCRIPTION

MCC1206·02-54-0005

PROB NO: DNK 3-28-77 CHKD:TCD DATE: 3-28-77

TABLE 3.3

1½" BRANCH PIPE SIZE



NOTE: SEE TABLE 2 FOR BRANCH TYPE DESCRIPTION

MCC1206·02-54-0005

PROB NO. DNK 3-28-77

CHKD TCD DATE 3-28-77

TABLE 3.4

2" BRANCH PIPE SIZE

RUN PIPE SIZE	RUN PIPE SCHEDULE											
	10	20	30	40	60	80	100	120	140	160	XS	STD
2½	BWT											
3												
3½	3HC				6HC		SPWB				6HC	3HC
4												
5												
6												
8												
10												6HC
12												
14												
16												
18												
20												
22									8WSW or SPECIAL DESIGN			
24												
26	6HC				Non-standard sized pipe. Reinforcement verification required for all branch connections.							
28												
30												
36												

Dev/Station GENERAL Unit File No.

Subject BRANCH TEE SELECTION BASED ON PRESSURE REQUIREMENTS

By DNK Date 3-28-77

Sheet No. 22 of 22 Problem No. DNK 3-28-77 Checked By TCD Date 3-28-77

CONCLUSIONS: THE CHARTS PROVIDE AREAS WHERE THE SELECTION OF A CERTAIN PRESSURE CLASS FITTING IS SUITABLE. IN MOST CASES THE ESTIMATED HEADER SCHEDULE WAS THE SAME AS THE EXACT VALUE. THIS FACT JUSTIFIED THE USE OF THE PROCEDURE OF "ESTIMATING, THEN CHECKING" AS THE MOST EFFICIENT WAY OF SOLVING EQUATION FIVE(5). FOR MOST CASES A FITTING CAN BE SELECTED TO MEET THE REQUIREMENT, HOWEVER SOMETIMES A SPECIAL DESIGN IS REQUIRED. THIS WILL NOT PRESENT A PROBLEM BECAUSE THIS ONLY OCCURS ON VERY LARGE THICKWALL PIPE WHICH IS NOT USED MUCH IN NUCLEAR PLANTS. THE CHARTS ARE GENERAL AND ARE VALID FOR CARBON OR STAINLESS STEELS SO LONG AS BRANCH AND RUN ARE THE SAME. GRINDING RESTRICTED THE USE OF LARGER BRANCHES ON SMALL RUN PIPE SIZES. A BUTT-WELDING TEE OR OTHER SUITABLE ALTERNATIVE IS RECOMMENDED HERE. IN KEEPING WITH THE REQUIREMENTS OF THE DUKE MECHANICAL DESIGN SECTION MANUAL, WELDING BOSSES ARE NOT USED ON PIPE < 8" NPS. OR < .5" THICK.

DISTRIBUTION OF INFORMATION FROM THIS CALCULATION:

NAME AND ORGANIZATION	DATE	REV	DATE	REV
DUKE POWER PROCEDURE MN-SAG-DP-77-3	4/15/77	ORIG		

ATTACHMENT 2

CERTIFICATION OF ENGINEERING CALCULATION

Station and Unit Number Catawba Nuclear Station Units 1 and 2

Title of Calculation Verification of required half-coupling ratings for branch connections on Piping drawings

Calculation Number CNC 1206.00-02-1001 Originally consisting of Pages 1 through 43.

These Engineering calculations cover QA CONDITION 1 items. In accordance with established procedures, the quality has been assured and I certify that the above calculation has been performed, checked or approved as noted below:

Performed by Jeffrey S Burbe Date 1-29-81

Checked by Joseph T McKinney, Jr. Date 1-29-81

Approved by R M Sandifer Date 1-29-81

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FEB 0 9 1981
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Revision/Addenda Log:

No.	Pages Revised	Pages Deleted	Pages Added	Performed By / Date	Checked By / Date	Approved By / Date

Form 101.1
Revision 5

PROBLEM

Qualification of discrepancies between the half coupling shown on the piping drawings and the Preferred Branch Selection Chart in the Catawba Piping Specification CNS-1206.00-02-1002 Appendix E Table 8.2-7. Half coupling ratings shown on the piping drawings were based on full coupling ratings shown on the PS sheets of Table 8.2-1 Appendix D of the Catawba Piping Specification instead of the Preferred Branch Selection Chart.

Applicable Codes and Standards

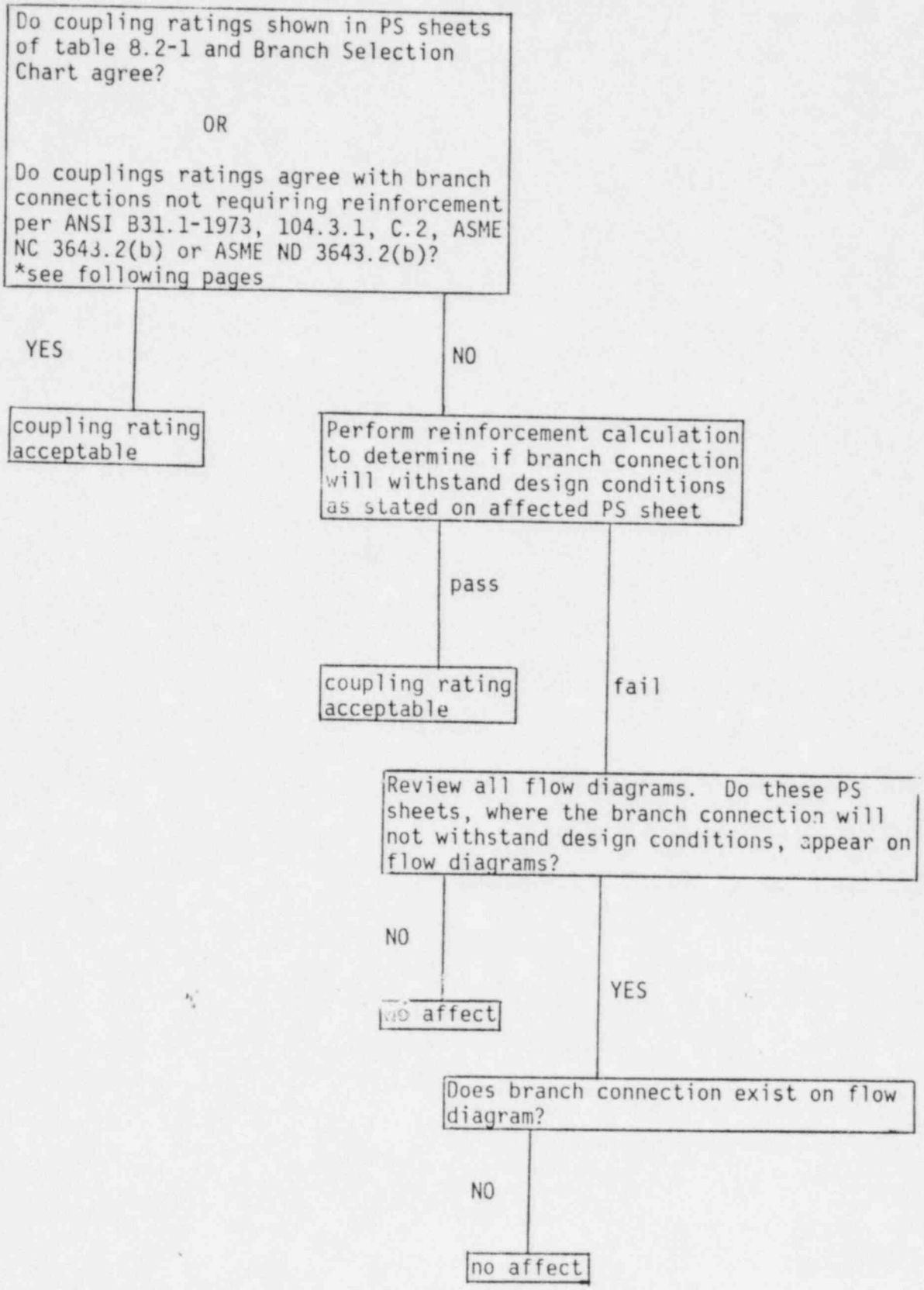
ANSI B16.11 1973
ANSI B31.1 1977
ASME Boiler and Pressure Vessel Code Section III
Division 1 - 1974 summer addenda
Subsection NA
Subsection NC
Subsection ND

Catawba Piping Specification CNS-1206.00-02-1002
(was CNS-1206.00-2.2), revision 16

Welding End Preparations CN-1676-1.1, Detail x, revision 5
See attachments

Piping Engineering, Fourth Edition, 1979

FLOW CHART FOR HALF COUPLING ANALYSIS



EXEMPTIONS FOR HALF COUPLING ANALYSIS

Branch connections where the run pipe is 2" or less, tees are used.

Branch connections where there is less than a 50% reduction, tees are used.

Duke does not use 3½" pipe; therefore, this size run pipe was not considered as a possible branch connection.

Since a 2" half coupling is the largest used by Duke, a 6" run pipe is the largest for which a calculation may have to be performed. Per ANSI B31.1 104.3.1, C.2, ASME ND 3643.2 and ASME 3643.2, any run 8" or greater is exempt because a 2" branch would be less than or equal to 1/4 the run size. For 6" and less, pipe sizes schedules 40, 80, and 160 are the only schedules specified on the PS sheets, except for PS sheet 153 for embedded pipe only on the WL System which has schedule 10 pipe. Therefore, in the Preferred Branch Selection Chart, run pipe schedules of 40, 80, and 160 were the ones checked against the PS sheets.

On the following pages is a copy of ASME NC 3643.2, ASME ND 3643.2 and ANSI B31.1, 104.3.1, C.2 qualifying branch connections not requiring reinforcement.

design of branch connections to sustain internal and external pressure in cases where the axes of the branch and the run intersect, and the angle between the axes of the branch and of the run is between 45 and 90 degrees inclusive, and no allowance is required for corrosion and/or erosion.

Branch connections in which the smaller angle between the axes of the branch and the run is less than 45 degrees impose special design and fabrication problems. The rules given for angles of 45 and 90 degrees inclusive may be used as a guide, but sufficient additional strength must be provided to assure safe service. Such branch connections shall be designed to meet the requirement of Para 104.7.

B. Branch connections in piping may be made by the use of the following:

B.1 Flanged, butt welding, socket welding or screwed fittings made in accordance with the applicable standards listed in Table 126.1

B.2 Welding outlet fittings, such as cast or forged nozzles, couplings of maximum size of 3 inches and adaptors or similar items having butt welding, socket welding, threaded or flanged ends for attachment of the branch pipe. Such welding outlet fittings are attached to the main pipe by welding/in accordance with Fig. 127.8.E.

B.3 Extruded outlets at right angles to the run pipe, in accordance with Para 104.3.1.G, where the attachment of the branch pipe is by butt welding.

B.4 Attaching the branch pipe directly to the run pipe by welding or threading as stipulated below and in Para 127.4.8.

B.4.1 Right angle branch connections may be made by attaching the branch pipe to the run pipe by socket welding provided:

B.4.1.1 The nominal size of branch does not exceed 2 in. or ¼ the nominal size of the run, which ever is smaller.

B.4.1.2 The depth of the socket in the run is at least equal to that shown in ANSI B16.11 with a minimum shoulder of $^{1}/_{16}$ in. between the bottom of the socket and the inside diameter of the run pipe. Weld metal may be deposited on the run pipe to provide the required socket depth and to provide any reinforcement required.

B.4.1.3 Approximately $^{1}/_{16}$ in. clearance shall be provided between the bottom of the socket and the end of the inserted pipe.

B.4.1.4 The size of the fillet weld shall not be less than 1.25 times the branch minimum wall thickness.

B.4.2 Right angle branch connections may be made by attaching the branch pipe directly to the run by threading within the provisions of Para 106.1 and provided:

B.4.2.1 The nominal size of the branch does not exceed 2 in. or ¼ of the nominal size of the run whichever is smaller.

B.4.2.2 Minimum thread engagement shall be 6 full threads for ½ in. and ¾ in. branches; 7 for 1 in., 1¼ in., and 1½ in. branches; and 8 for 2 in. branches. Weld metal may be deposited on the run pipe to provide sufficient thickness for required thread engagement.

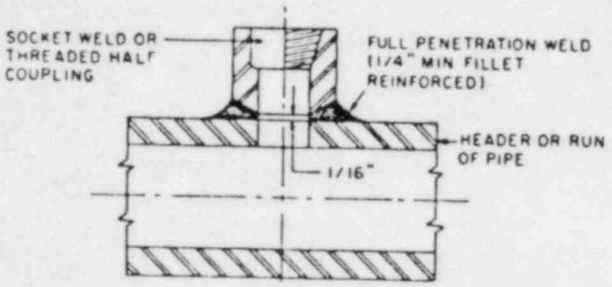
C. *Branch Connections Not Requiring Reinforcement.* A pipe having a branch connection is weakened by the opening that must be made in it, and unless the wall thickness of the pipe is sufficiently in excess of that required to sustain the pressure, it is necessary to provide additional reinforcement. The amount of reinforcement required shall be determined in accordance with Para 104.3.1.D and E. There are certain branch connections for which no supporting calculations are required.

C.1 A branch connection may be made by the use of a fitting, (tee, lateral, or cross), manufactured in accordance with a standard listed in Table 126.1, and used within the limits of pressure-temperature ratings specified in such standard. A butt welding fitting made in accordance with ANSI B16.9 shall be of nominal thickness not less than the nominal thickness required for the adjoining pipe.

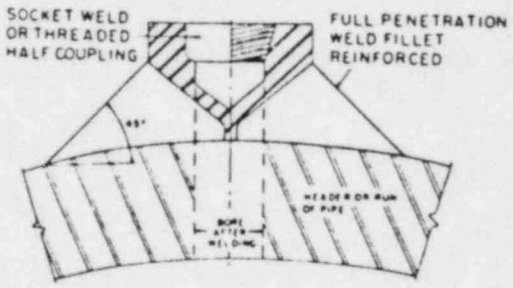
C.2 A branch connection may be made by welding a coupling or half coupling directly to the run pipe in accordance with Fig. 127.4.8.E provided the nominal diameter of the branch does not exceed 2 in. pipe size or ¼ the nominal diameter of the run, whichever is less; the wall thickness of the coupling is not less than that of the branch pipe; and in no case is the thickness of the coupling less than extra heavy or 3000 lb rating.

Small branch connections 2 in. pipe size and smaller as shown in Fig. 127.4.8.F may be used provided t_w is not less than the thickness of schedule 160 pipe.

C.3 A branch connection may be made by the use of an extruded outlet, provided the nominal diameter of the branch does not exceed 2 in pipe size or ¼ of the nominal diameter of the run, whichever is less; and the minimum wall thickness at the abutting end of the outlet is not less than required for the branch pipe wall.



Branch conn. for use where design press. & design temp. do not exceed the press.–temp. service ratings in ANSI B16.11 Forged Steel Fittings, Socket Welding and Threaded.



Branch connection for use at pressures and temperatures exceeding Range of Standard Fittings in accordance with ANSI B16.11 (and design does not exceed 5000 psi and 1050 F) Forged Steel Fittings, Socket Welding and Threaded.

FIG. 127.4.8E TYPICAL FULL PENETRATION WELD CONNECTIONS FOR 3 in. BRANCHES & SMALLER USING FITTINGS

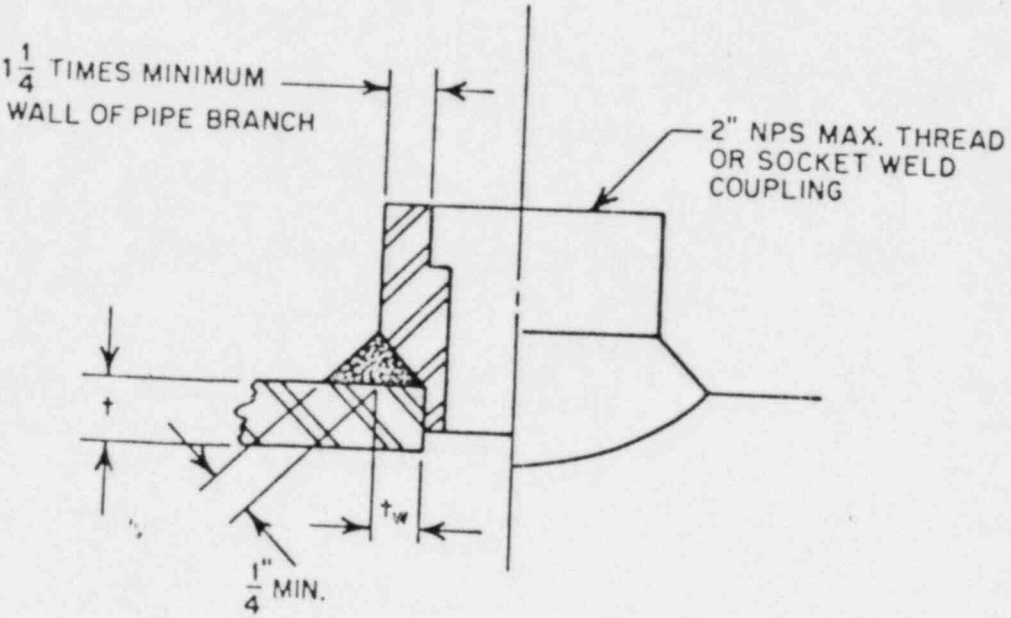


FIG. 127.4.8F PARTIAL PENETRATION COUPLING CONNECTION WITHOUT ADDITIONAL REINFORCEMENT

provided the requirements of (1) and (2) below are met:

(1) The nominal size of the branch does not exceed 2 in. or ¼ of the nominal size of the run, whichever is less.

(2) Minimum thread engagement shall be 6 full threads for ½ in. and ¾ in. branches; 7 for 1 in., 1¼ in. and 1½ in. branches; and 8 for 2 in. branches; weld metal may be deposited on the run pipe to provide sufficient thickness for required thread engagement.

ND-3643.2 Branch Connections Not Requiring Reinforcement. Reinforcement need not be provided if the branch connection is made in accordance with the requirements of (a) through (c) below.

W76 *(a)* By the use of a fitting manufactured in accordance with one of the standards listed in Table ND-3132-1 and used within the limits of pressure-temperature ratings specified in such standard. A butt welding fitting made in accordance with ANSI B16.9 shall be of nominal thickness not less than the nominal thickness required for the adjoining pipe.

✳ *(b)* By welding a coupling or half coupling directly to the run pipe provided: the nominal diameter of the branch does not exceed 2 in. pipe size or ¼ the nominal diameter of the run, whichever is less; the wall thickness of the coupling is not less than that of the branch pipe; the coupling is joined to the run pipe by one of the methods shown in Fig. ND-3643.2(b)-1; in no case is the thickness of the coupling less than extra heavy or 3000 lb rating.

(c) By using an extruded outlet, provided the nominal diameter of the branch does not exceed 2 in. pipe size or ¼ of the nominal diameter of the pipe, whichever is less, and the minimum wall thickness at the abutting end of the outlet is not less than required for the branch pipe wall.

ND-3643.3 Branch Connections Requiring Reinforcement

(a) A branch connection may be made by welding an integrally reinforced fitting directly to the run pipe if the reinforcement provided by the fitting and the deposited weld metal meets the requirements of (b) and (c) below.

(b) A branch connection may be made by extruding an integrally reinforced outlet on the run pipe. The reinforcement requirements shall be in accordance with ND-3643.4.

(c) Additional reinforcement is required when it is not provided inherently in the branch connection. ND-3643.3 gives rules covering the design of branch connections to sustain internal pressure in cases where the angle between the axes of the branch and of the run ranges from 45 and 90 deg. NC-3643.5 gives rules governing the design of connections to sustain external pressure.

(1) Nomenclature. Figs. ND-3643.3(c)(1)-1 and ND-3643.3(c)(1)-2 illustrate the notations used in the pressure-temperature design conditions of branch connections which are as follows:

α = angle between axes of branch and run, deg.

b = subscript referring to branch

D_o = outside diameter of pipe, inches

d_1 = inside diameter of branch for right angle connections. For connections at angles between 45 and 90 deg.,

$d_1 = (D_{ob} - 2T_b) \div \sin \alpha$

d_2 = half width of reinforcing zone, inches

= the greater of d_1 or $\left(T_b + T_h + \frac{d_1}{2}\right)$ but in no case more than D_{ob}

h = subscript referring to run or header

L = height of reinforcement zone outside of run or reinforcement, inches

$= 2.5T_b$

t_e = thickness of attached reinforcing pad or height of the largest 60 deg. right triangle supported by the run and branch outside diameter projected surfaces and lying completely within the area of integral reinforcement, inches. (Fig. ND-3643.3(c)(1)-2)

T = nominal, actual (by measurement), or minimum wall thickness of pipe, inches, permissible under purchase specification

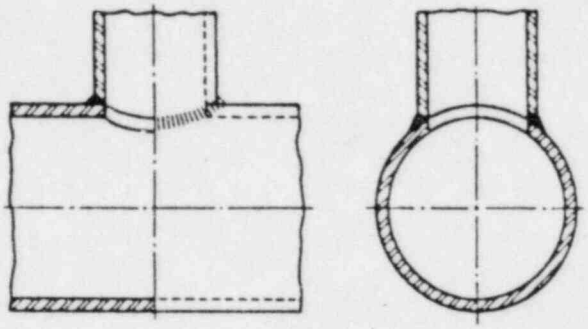
t_m = required minimum wall thickness, inches, of pipe for pressure-temperature design conditions as determined by use of formula (3) or (5), ND-3641.1.

(2) Requirements. A pipe having a branch connection is weakened by the opening that must be made in it and unless the wall thickness of the pipe is sufficiently in excess of that required to sustain the pressure, it is necessary to provide additional reinforcement. The amount of reinforcement required shall be determined in accordance with ND-3643.3(c)(3), (4), (5), (6), and (7); ND-3643.4, or ND-3643.5.

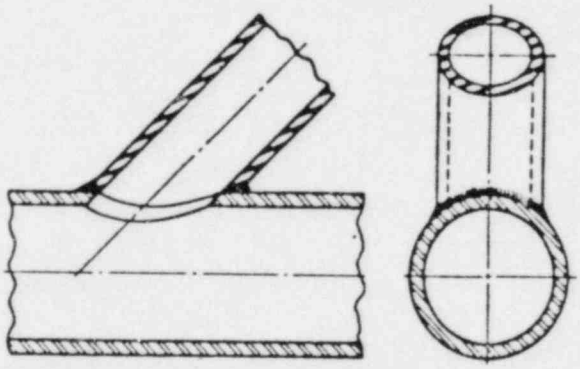
(3) Reinforcement Area. The required reinforcement area in sq. in. for branch connections shall be the quantity $1.07\,(t_{mh})\,(d_1)\,(2 - \sin \alpha)$.

(a) For right angle connections, the required reinforcement becomes $1.07\,(t_{mh})\,(d_1)$.

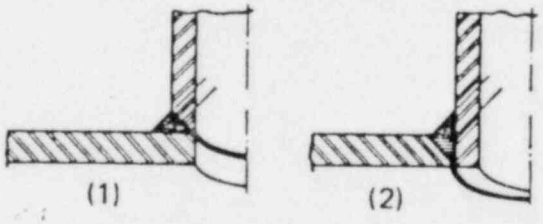
(b) The required reinforcement must be within



(a) TYPICAL WELDED BRANCH CONNECTION WITHOUT ADDITIONAL REINFORCEMENT.



(b) TYPICAL WELDED ANGULAR BRANCH CONNECTION WITHOUT ADDITIONAL REINFORCEMENT.



(c) SOME ACCEPTABLE TYPES OF WELDED BRANCH ATTACHMENT

FIG. ND-3643.2(b)-1 TYPICAL WELDED BRANCH CONNECTIONS

provide sufficient thickness for required thread engagement.

NC-3643.2 Branch Connections Not Requiring Reinforcement. Reinforcement need not be provided if the branch connection is made in accordance with the requirements of (a) through (c) below.

W76 *(a)* By the use of a fitting manufactured in accordance with one of the standards listed in Table NC-3132-1 and used within the limits of pressure-temperature ratings specified in such standard. A butt welding fitting made in accordance with ANSI B16.9 shall be of nominal thickness not less than the nominal thickness required for the adjoining pipe.

(b) By welding a coupling or half coupling directly to the run pipe provided the nominal diameter of the branch does not exceed 2 in. pipe size or ¼ the nominal diameter of the run, whichever is less; the wall thickness of the coupling is not less than that of the branch pipe; the coupling is joined to the run pipe by one of the methods shown in Fig. NC-3643.2(b)-1; in no case is the thickness of the coupling less than extra heavy or 3000 lb rating.

(c) By using an extruded outlet, provided the nominal diameter of the branch does not exceed 2 in. pipe size or ¼ of the nominal diameter of the pipe, whichever is less, and the minimum wall thickness at the abutting end of the outlet is not less than required for the branch pipe wall.

NC-3643.3 Branch Connections Requiring Reinforcement

(a) A branch connection may be made by welding an integrally reinforced fitting directly to the run pipe if the reinforcement provided by the fitting and the deposited weld metal meets the requirements of (b) and (c) below.

(b) A branch connection may be made by extruding an integrally reinforced outlet on the run pipe. The reinforcement requirements shall be in accordance with NC-3643.4.

(c) Additional reinforcement is required when it is not provided inherently in the branch connection. NC-3643.3 gives rules covering the design of branch connections to sustain internal pressure in cases where the angle between the axes of the branch and of the run ranges from 45 and 90 deg. NC-3643.5 gives rules governing the design of connections to sustain external pressure.

(1) Nomenclature. Figs. NC-3643.3(c)(1)-1 and NC-3643.3(c)(1)-2 illustrate the notations used in the pressure-temperature design conditions of branch connections which are as follows:

α = angle between axes of branch and run, deg.
b = subscript referring to branch
D_o = outside diameter of pipe, in.
d_1 = inside diameter of branch for right angle connections. For connections at angles between 45 and 90 deg.,
$d_1 = (D_{ob} - 2T_b)/\sin\alpha$
d_2 = half width of reinforcing zone, in.
= the greater of d_1 or $(T_b + T_h + d_1/2)$, but in no case more than D_{ob}
h = subscript referring to run or header
L = height of reinforcement zone outside of run or reinforcement, in.
$= 2.5T_b$
t_r = thickness of attached reinforcing pad or height of the largest 60 deg. right triangle supported by the run and branch outside diameter projected surfaces and lying completely within the area of integral reinforcement, in. (Fig. NC-3643.3(c)(1)-2).
T = nominal, actual by measurement, or minimum wall thickness of pipe, in. permissible under purchase specification
t_m = required minimum wall thickness, inches, of pipe for pressure and temperature design conditions as determined by use of formula (3) or (5), NC-3641.1.

(2) Requirements. A pipe having a branch connection is weakened by the opening that must be made in it and unless the wall thickness of the pipe is sufficiently in excess of that required to sustain the pressure, it is necessary to provide additional reinforcement. The amount of reinforcement required shall be determined in accordance with NC-3643.3(c)(3), (4), (5), (6), and (7); NC-3643.4, or NC-3643.5.

(3) Reinforcement Area. The required reinforcement area in sq. in. for branch connections shall be the quantity $1.07\,(t_{mh})\,(d_1)\,(2—\sin\alpha)$.

(a) For right angle connections, the required reinforcement becomes $1.07\,(t_{mh})\,(d_1)$.

(b The required reinforcement must be within the limits of the reinforcement zone as defined in NC-3643.3(c)(5).

(4) Area Contributing to Reinforcement. Metal S75
needed to meet reinforcement required by NC-3643.3(c) must be within the limits of reinforcement zone determined in NC-3643.3(c)(5) and may include the following:

A_1 = area provided by excess pipe wall in the run
$= d_2[(T_h$ – mill tolerance on $T_h) - t_{mh}]$
A_2 = area provided by excess pipe wall in the branch for a distance L above the run

SUMMARY OF BRANCH CONNECTIONS AND APPLICABLE EXEMPTIONS

BRANCH PIPE	RUN PIPE	COMMENTS
1/2"	≥2"	see note 1
3/4"	2 1/2"	no discrepancies
	≥3"	see note 1
1"	2 1/2"	no discrepancies
	3"	no discrepancies
	≥4"	see note 1
1 1/2"	2 1/2"	see note 2
	3"	calculation required*
	4"	calculation required*
	≥6"	see note 1
2"	2 1/2"	see note 2
	3"	see note 2
	4"	calculation required*
	6"	calculation required*
	≥8"	see note 1

NOTES:

1. Exempt per ASME NC 3643.2(b), ASME ND 3642.2(b), ANSI B31.1-1973, 104.3.1, C.2, because the diameter of the branch is less than or equal to 1/4 the diameter of the run.

2. Connection is less than a 50% reduction; therefore, a tee would be used.

*PS sheets below 900.2 were in agreement with the Preferred Branch Selection Chart and, therefore, were not affected.

DISCREPANCIES BETWEEN PS SHEETS AND PREFERRED BRANCH SELECTION CHART

PIPE SPEC	PROBLEM
900.2 .3 .4 .5 .6	On 1½"x3", 1½"x4", and 2"x4", and 2"x6" branch connections, the PS sheet specifies a 3000# coupling; and the Preferred Branch Selection Chart specifies a 6000# half coupling.
901.2 .4	PS Sheets below 900.2 were in agreement with the Preferred Branch Selection Chart and, therefore, were not affected.
1500.2 .4 .5 .6	
1501.1 .2 .4 .5 .6 .8	
2501.6 .8	

PIPE SPEC	PROBLEM
1500.8	On 1½"x3" and 1½"x4" branch connections, the PS sheet specifies a 3000# coupling; and the Preferred Branch Selection Chart specifies a 6000# half coupling. On 2"x4" and 2"x6" branch connections, the PS sheet specifies a 6000# coupling; and the Preferred Branch Selection Chart specifies a butt-welded tee.
2500.2 .3 .4	On 1½"x3", 1½"x4", and 2"x6" branch connections, the PS sheet specifies a 6000# coupling; and the Preferred Branch Selection Chart specifies a butt-welded tee.
2501.1 .2 .3 .4	PS sheets below 900.2 were in agreement with the Preferred Branch Selection Chart and, therefore, were not affected.

The reinforcement calculations show a limit of reinforcement "L". This limit is the height of the reinforcement zone outside of the run. In the case of half couplings, the height "L" could not extend into the socket end of the half coupling because the wall thickness is smaller at that end than what is used in the calculation. This height is shown as dimension F on Table 2, Steel Socket-Welding Fittings ANSI B16.11-1973. Below is a table showing "L" for 1 1/2" and 2" half couplings:

UPPER LIMIT OF REINFORCEMENT "L"

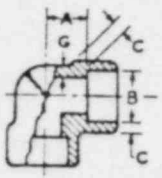
size	F-tolerance of F = L
1 1/2"	1.25 - .08 = 1.17 = L
2"	1.62 - .08 = 1.54 = L

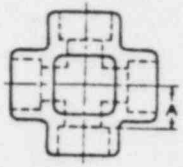
HALF COUPLING DIMENSIONS

	MINIMUM WALL THICKNESS	WALL THICKNESS AT CONNECTION	OUTSIDE DIAMETER
3000#	C	$\frac{B\ min + 2C\ min - D\ max}{2}$	B(ave) + 2 C(ave)
1 1/2"	.218	$\frac{1.915 + 2(.218) - 1.640}{2} = .356$	1.920 + 2(.250) = 2.420
2"	.238	$\frac{2.406 + 2(.238) - 2.097}{2} = .393$	2.411 + 2(.273) = 2.957
6000#			
1 1/2"	.307	$\frac{1.915 + 2(.307) - 1.368}{2} = .581$	1.920 + 2(.351) = 2.622
2"	.374	$\frac{2.406 + 2(.374) - 1.717}{2} = .719$	2.411 + 2(.430) = 3.271

NOTES:

1. Dimensions taken from ANSI B16.11 - 1973, Table 2 Steel Socket-Welding Fittings.


90° ELBOW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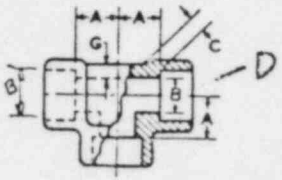
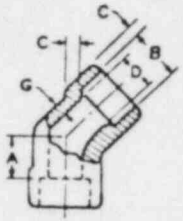
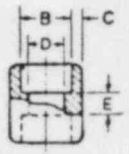

TEE


45° ELBOW


COUPLING

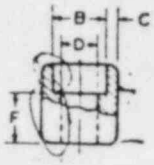

HALF-COUPLING

Table 2 Steel Socket – Welding Fittings

Nom. Pipe Size	Socket Bore Dia.[2]	Bore Diameter of Fitting D[2]			Socket Wall Thickness[1] C						Body Wall G			Depth of Socket	Center to Bottom of Socket – A						Laying Lengths		Tolerances ±		
		Pressure Class Designation			3000 lb		6000 lb		9000 lb		Pressure Class Designation				90° Elbows, Tees, and Crosses			45° Elbows							
															Pressure Class Designation						Couplings	Half Couplings			
		3000 lb	6000 lb	9000 lb	Ave.	Min.	Ave.	Min.	Ave.	Min.	3000 lb Min.	6000 lb Min.	9000 lb Min.	Min.	3000 lb	6000 lb	9000 lb	3000 lb	6000 lb	9000 lb	E	F	A	E	F
1/8	0.430	0.299	0.189		0.125	0.125	0.156	0.135			0.095	0.124		0.38	0.44	0.44		0.31	0.31		0.25	0.62	0.03	0.06	0.03
	0.420	0.239	0.126																						
1/4	0.565	0.394	0.280		0.149	0.130	0.181	0.158			0.119	0.145		0.38	0.44	0.53		0.31	0.31		0.25	0.62	0.03	0.06	0.03
	0.555	0.334	0.220																						
3/8	0.700	0.523	0.389		0.158	0.138	0.198	0.172			0.126	0.158		0.38	0.53	0.62		0.31	0.44		0.25	0.69	0.06	0.12	0.06
	0.690	0.463	0.329																						
1/2	0.865	0.652	0.494	0.282	0.184	0.161	0.235	0.204	0.368	0.322	0.147	0.188	0.294	0.38	0.62	0.75	1.00	0.44	0.50	0.62	0.38	0.88	0.06	0.12	0.06
	0.855	0.592	0.434	0.222																					
3/4	1.075	0.854	0.642	0.464	0.193	0.168	0.274	0.238	0.385	0.337	0.154	0.219	0.308	0.50	0.75	0.88	1.12	0.50	0.56	0.75	0.38	0.94	0.06	0.12	0.06
	1.065	0.794	0.582	0.404																					
1	1.340	1.079	0.845	0.629	0.224	0.196	0.312	0.273	0.448	0.392	0.179	0.250	0.358	0.50	0.88	1.06	1.25	0.56	0.69	0.81	0.50	1.12	0.08	0.16	0.08
	1.330	1.019	0.785	0.569																					
1-1/4	1.685	1.410	1.190	0.926	0.239	0.208	0.312	0.273	0.478	0.418	0.191	0.250	0.382	0.50	1.06	1.25	1.38	0.69	0.81	0.88	0.50	1.19	0.08	0.16	0.08
	1.675	1.350	1.130	0.866																					
1-1/2	1.925	1.640	1.368	1.130	0.250	0.218	0.351	0.307	0.500	0.438	0.200	0.281	0.400	0.50	1.25	1.50	1.50	0.81	1.00	1.00	0.50	1.25	0.08	0.16	0.08
	1.915	1.580	1.308	1.070																					
2	2.416	2.097	1.717	1.533	0.273	0.238	0.430	0.374	0.545	0.477	0.218	0.344	0.436	0.62	1.50	1.62	2.12	1.00	1.12	1.12	0.75	1.62	0.08	0.16	0.08
	2.406	2.037	1.657	1.473																					
2-1/2	2.921	2.529			0.345	0.302					0.276			0.62	1.62			1.12			0.75	1.69	0.10	0.20	0.10
	2.906	2.409																							
3	3.550	3.128			0.375	0.327					0.300			0.62	2.25			1.25			0.75	1.75	0.10	0.20	0.10
	3.535	3.008																							
4	4.560	4.086			0.421	0.368					0.337			0.75	2.62			1.62			0.75	1.88	0.10	0.20	0.10
	4.545	3.966																							

1. Average of Socket Wall Thickness around periphery shall be no less than listed values. The minimum values are permitted in localized areas.
2. Upper and lower values for each size are the respective maximum and minimum dimensions.

ANSI B31.1-1973, 104.2.1, C.2, ASME NC 3643.2, and ASME ND 3643.2 state that the wall thickness of the half coupling must be greater than the wall thickness of the branch pipe. Below is a table comparing the wall thicknesses of the half couplings and corresponding branch pipes.

COUPLING/PIPE TYPE		COUPLING MINIMUM WALL		PIPE NOMINAL WALL
3000#/sch 80	1 1/2"	.218	>	.200
	2"	.238	>	.218
6000#/sch 160	1 1/2"	.307	>	.281
	2"	.374	>	.343

PIPE DIMENSIONS

	NOMINAL WALL SCHEDULE 80	NOMINAL WALL SCHEDULE 160	OUTSIDE DIAMETER
1 1/2"	.200	.281	
2"	.218	.343	
3"	.300	.438	3.5
4"	.337	.531	4.5
6"	.432	.718	6.625

NOTE: Pipe dimension taken from "Piping Engineering", Fourth Edition, 1979

CONCLUSION

Pipe Specifications listed below did not pass the pressure calculation using a 2" 3000# half coupling on a 6" sch 80 header

P S SHEET	FLOW DIAGRAMS
2501.6	Not on flow diagrams
2501.8	Not on flow diagrams
1501.2	CN-1562-1.2, 1.3, 1.4
1501.4	CN-1562-1.2, 1.4, CN-1593-1.3, CN-1602-1.0

Flow diagrams containing the above pipe specifications were checked to see if a 2"x6" branch connection existed. None were found.

See attachments for flow diagrams listed above.

BRANCH SELECTION CHART

For 1/2", 3/4", 1" Branch Pipe

RUN PIPE SIZE	RUN PIPE SCHEDULE		
	40	80	160
2½ and larger See Note 1	3 HC		6 HC

For 1 1/2" Branch Pipe

RUN PIPE SIZE	RUN PIPE SCHEDULE		
	40	80	160
2 1/2	BWT		
3	3 HC see note 2		
4			
6 and larger	3 HC		6 HC

For 2" Branch Pipe

RUN PIPE SIZE	RUN PIPE SCHEDULE		
	40	80	160
2 1/2 3	BWT		
4	3 HC see note 3	see note 4	6 HC
6			
8 and larger			

NOTES:

1. 3 1/2" and 5" pipe not included.

2. 1 1/2 x 3, 1 1/2 x 4; ratings on these connections acceptable for maximum design conditions of 1800 psig @ 700°F.

3. 2 x 4; ratings on this connection acceptable for maximum design conditions of 1800 psig @ 700°F
   2 x 6; rating on this connection acceptable for maximum design conditions of 1800 psig @ 700°F for stainless steels and 1500 psig @ 650°F for carbon steel.

4. For carbon steel piping use 3 HC, for stainless steel piping use 6 HC.

In the Catawba Piping Specification CNS-1206.00-02-1002 PS sheets 901.6 and 901.8 specify the use of either seamless or EFW pipe, of material SA312 TP304. Per conversation with L. M. Coggins, the EFW pipe is purchased with 100% radiographed welds. Because of this, the allowable stress values for seamless pipe were used in the half coupling calculations.

APPLICABLE P.S. SHEETS FOR BRANCH SELECTION CHART

PS-150.2
PS-150.3
PS-150.4
PS-150.5
PS-150.6
PS-150.7
PS-150.8
PS-150.9
PS-151.2
PS-151.3
PS-151.4
PS-300.2
PS-300.3
PS-300.4
PS-300.5
PS-300.6
PS-301.2
PS-301.3
PS-301.4
PS-400.2
PS-400.3
PS-400.4
PS-401.2
PS-401.3
PS-401.4
PS-600.2
PS-600.3
PS-600.4
PS-600.5
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PS-601.3
PS-601.4
PS-601.6
PS-601.8
PS-900.2
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PS-900.6
PS-901.2
PS-901.4
PS-901.6
PS-901.8
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PS-1500.6
PS-1500.8
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PS-2501.4
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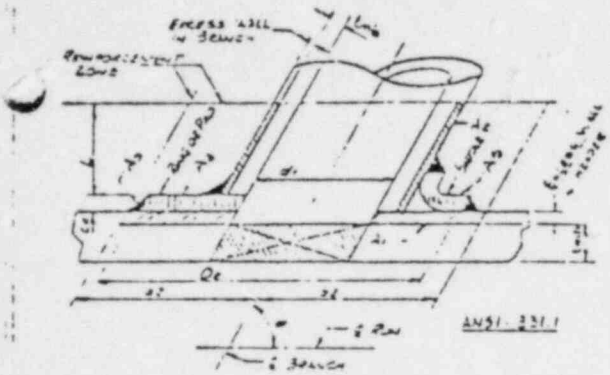


Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 1800 psi @ 700 °F

		HEADER		BRANCH
Nominal Size		3"		1½"
Outside Diameter	D_h	3.5	D_b	2.420
Nominal Wall	$\bar{T}_h$	.3	$\bar{T}_b$	.405
Actual or Min. Wall	T_h	.263	T_b	.356
Material Spec.		A106B		A105
Allowable Stress	S_h	14300	S_b	16600
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	—	A_b	—
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{1800 \times 3.5}{2\times 14300\times 1 + 2\times .4\times 1800} + \ldots = .210$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{1800 \times 2.420}{2\times 16600\times 1 + 2\times .4\times 1800} + \ldots = .126$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.420 - 2\times .356}{1} = 1.708$$

d_2 = a_1 or = $T_b + T_h + 0.5d_1$ = $.356 + .263 + 0.5\times 1.708$ = 1.473

Select larger of the values, but not to exceed D_h. d_2 = 1.708

$L = 2.5(\bar{T}_b) = 2.5 \times .405 = 1.013$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07\,(t_{mh})\,(d_1)\,(2 - \sin\alpha) = 1.07 \times .210 \times 1.708 \times (2 - 1) = .383$

$A_1 = (2d_2 - d_1)\,(T_h - t_{mh}) = 2\times 1.708 - 1.708)\,(.263 - .210) = .090$

$A_2 = 2L\,(T_b - t_{mb}) = 2\times 1.013 \times (.356 - .126) = .466$

$A_3 = t_f^2 = (\ldots)^2 = \ldots$

$A_1 + A_2 + A_3 = .090 + .466 + \ldots = .556$ sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

$A_3' = (t_f')^2 = (\ldots)^2 = \ldots$

$A_4 = (D_e - d_1)\,t_e = (\ldots - \ldots) \times \ldots = \ldots$

or

$A_5 = (D_e - D_b)\,t_e = (\ldots - \ldots) \times \ldots = \ldots$

$(A_1 + A_2 + A_3) + A_3' + A_4$ (or A_5) =

$= \ldots + \ldots + \ldots = \ldots$

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

LOCATION _____ SYSTEM _____

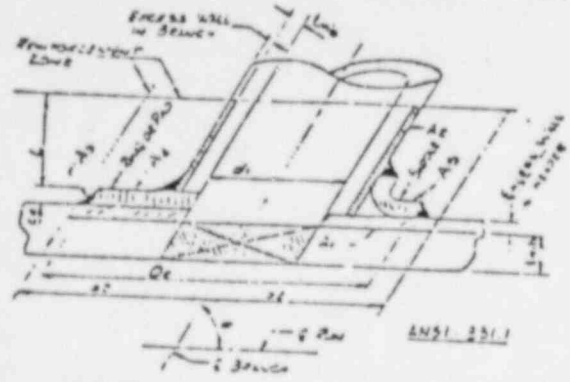
CALC. BY _____ CH. BY G.S. Bubic

DATE 5-23-80 DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75

1500.2 - 1500.4 - 1500.5 1500.6 - 1500.8 TB2 - 1975



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 1800. psi @ 700. °F

		HEADER		BRANCH
Nominal Size		4		1½
Outside Diameter	D_h	4.5	D_b	2.420
Nominal Wall	$\bar{T}_h$	.337	$\bar{T}_b$	.405
Actual or Min. Wall	T_h	.295	T_b	.356
Material Spec.		A106 B		A105
Allowable Stress	S_h	14300	S_b	16600
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	—	A_b	—
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{1800 \times 4.5}{2 \times 14300 \times 1 + 2 \times .4 \times 1800} + \dots = .270$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{1800 \times 2.420}{2 \times 16600 \times 1 + 2 \times .4 \times 1800} + \dots = .126$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.420 - 2 \times .356}{1} = 1.708$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .356 + .295 + 0.5 × 1.708 = 1.505

Select larger of the values, but not to exceed D_h. d_2 = 1.708

$L = 2.5(\bar{T}_b) = 2.5 \times .405 = 1.013$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .270 \times 1.708 \times (2 - 1) = .493$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times (1.708 - 1.708)(.295 - .270) = .043$

$A_2 = 2L(T_b - t_{mb}) = 2 \times 1.013 \times (.356 - .126) = .466$

$A_3 = t_f^2 = (\dots)^2 = \dots$

$A_1 + A_2 + A_3 = .043 + .466 + \dots = .509$ sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

$A'_3 = (t'_f)^2 = (\dots)^2 = \dots$

$A_4 = (D_e - d_1)\,t_e = (\dots - \dots) \times \dots = \dots$

$A_5 = (D_e - D_b)\,t_e = (\dots - \dots) \times \dots = \dots$

$(A_1 + A_2 + A_3) + A'_3 + A_4$ (or A_5) =

= ..... + ... + ... = ...

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

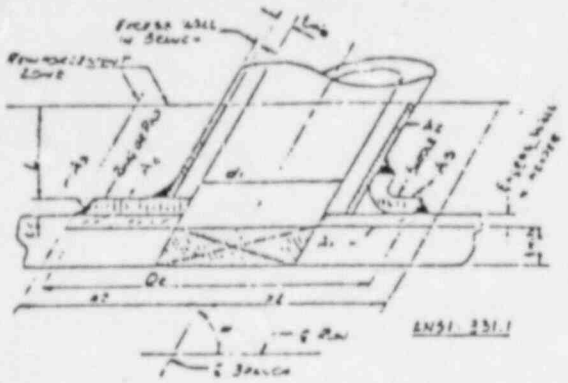
LOCATION _____ SYSTEM _____

CALC. BY ZKB DATE 5-23-80

CH. BY G.S. Buhl DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 1800.. psi @ ...700..°F

		HEADER		BRANCH
Nominal Size		4		2
Outside Diameter	D_h	4.5	D_b	2.957
Nominal Wall	$\bar{T}_h$	.337	$\bar{T}_b$	.445
Actual or Min. Wall	T_h	.275	T_b	.393
Material Spec.		A 106 B		A 105
Allowable Stress	S_h	14300	S_b	16600
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	–	A_b	–
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{1800 \times 4.5}{2\times14300 \times 1 + 2\times.4 \times 1800} + \ldots\ldots = .270$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{1800 \times .2957}{2\times16600\times 1 + 2\times.4 \times 1800} + \ldots\ldots = .154$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.957 - 2\times.393}{1} = 2.171$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .393 + .275 + 0.5×2.171 = 1.794

Select larger of the values, but not to exceed D_h. d_2 = 2.171

L = 2.5 ($\bar{T}_b$) = 2.5 × .445 = 1.113

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

A_{req} = 1.07 (t_{mh}) (d_1) (2 - sin α) = 1.07 × .270 × 2.171 × (2 - 1) = .626

A_1 = ($2d_2 - d_1$) ($T_h - t_{mh}$) = 2× (2.171 - 2.171) (.275 - .270) = .055

A_2 = 2L($T_b - t_{mb}$) = 2 × 1.113 × (.393 - .154) = .532

A_3 = t_f^2 = (.25)² = .0625 per CN-1676-1.1 detail x rev. 5

$A_1+A_2+A_3$ = .055 + .532 + .0625 = .650 sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

A_3' = $(t_f')^2$ = (.....)² = ...

A_4 = ($D_e - d_1$) t_e = (..... − .....) × ..... = ...

or

A_5 = ($D_e - D_b$) t_e = (..... − .....) × ..... = ...

($A_1+A_2+A_3$) + A_3' + A_4 (or A_5) =

= ..... + ... + ... = ...

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

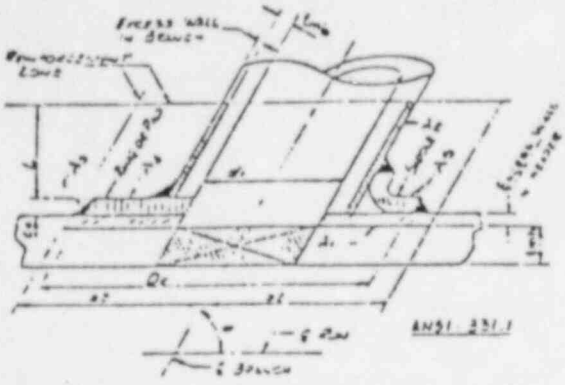
LOCATION _____ SYSTEM _____

CALC. BY [illegible] CH. BY J.S. Bulla

DATE 5-23-80 DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 1500 psi @ 650 °F

		HEADER		BRANCH
Nominal Size		6"		2"
Outside Diameter	D_h	6.625	D_b	2.957
Nominal Wall	$\bar{T}_h$	.432	$\bar{T}_b$	.445
Actual or Min. Wall	T_h	.378	T_b	.389
Material Spec.		A106 B		A105
Allowable Stress	S_h	15000	S_b	17500
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	–	A_b	–
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{1500 \times .6625}{2 \times 15000 \times 1 + 2 \times .4 \times 1500} + 0 = .319$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{1500 \times .2957}{2 \times 17500 \times 1 + 2 \times .4 \times 1500} + 0 = .123$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.957 - 2 \times .389}{1} = 2.178$$

$d_2 = d_1$ or $= T_b + T_h + 0.5d_1 = .389 + .378 + 0.5 \times 2.178 = 1.856$

Select larger of the values, but not to exceed D_h. $d_2 = 2.178$

$L = 2.5(\bar{T}_b) = 2.5 \times .445 = 1.113$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .319 \times 2.178 \times (2 - 1) = .742$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times 2.178 - 2.178 (.378 - .319) = .130$

$A_2 = 2L(T_b - t_{mb}) = 2 \times 1.113 \times (.389 - .123) = .594$

$A_3 = t_f^2 = (.25)^2 = .0625$ per CN-1676-1.1 Detail x rev. 5

$A_1 + A_2 + A_3 = .130 + .594 + .0625 = .787$ sq. in. available. Additional Req'd: Yes ☐ No ☒

ADDITIONAL REINFORCEMENT:

$A_3' = (t_f')^2 = (\quad)^2 = \quad$

$A_4 = (D_e - d_1)\,t_e = (\quad \rightarrow \quad) \times \quad =$

or

$A_5 = (D_e - D_b)\,t_e = (\quad \rightarrow \quad) \times \quad =$

$(A_1 + A_2 + A_3) + A_3' + A_4$ (or A_5) =

$= \quad + \quad + \quad =$

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

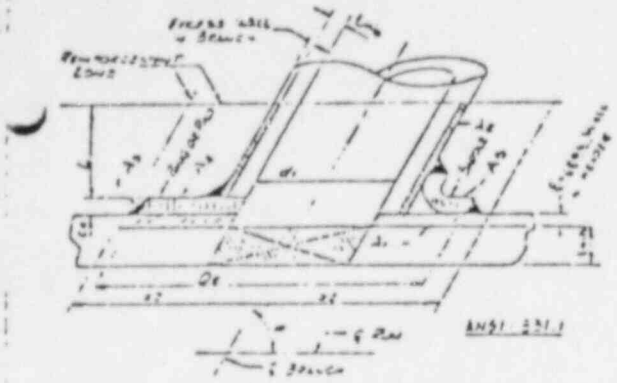
LOCATION _____ SYSTEM _____

CALC. BY [illegible] CH. BY G.S. Buba

DATE 5-23-80 DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 1800 psi @ 700 °F

		HEADER		BRANCH
Nominal Size		3"		1½
Outside Diameter	D_h	3.5	D_b	2.420
Nominal Wall	$\bar{T}_h$	.3	$\bar{T}_b$	.405
Actual or Min. Wall	T_h	.263	T_b	.354
Material Spec.		SA376 TP 304		SA182 F304
Allowable Stress	S_h	15900	S_b	15100
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	-	A_b	-
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{1800 \times 3.5}{2 \times 15900 \times 1 + 2 \times .4 \times 1800} + \ldots\ldots = .190$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{1800 \times 2.420}{2 \times 15900 \times 1 + 2 \times .4 \times 1800} + \ldots\ldots = .131$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.420 - 2 \times .354}{1} = 1.711$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .354 + .263 + 0.5 × 1.711 = 1.473

Select larger of the values, but not to exceed D_h. d_2 = 1.711

$L = 2.5(\bar{T}_b) = 2.5 \times .405 = 1.013$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .190 \times 1.711 \times (2 - 1) = .347$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times 1.711 - 1.711)(.263 - .190) = .125$

$A_2 = 2L(T_b - t_{mb}) = 2 \times 1.013 \times (.354 - .131) = .452$

$A_3 = t_f^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_1 + A_2 + A_3 = .125 + .452 + \ldots\ldots = .577$ sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

$A_3' = (t_f')^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_4 = (D_e - d_1)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

or

$A_5 = (D_e - D_b)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

$(A_1 + A_2 + A_3) + A_3' + A_4$ (or A_5) =

$= \ldots\ldots + \ldots\ldots + \ldots\ldots = \ldots\ldots$

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

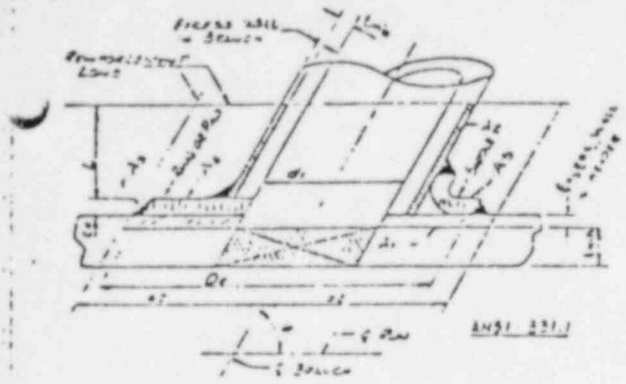
LOCATION _____ SYSTEM _____

CALC. BY DBS DATE 5-23-80

CH. BY G.S. Buhr DATE 9-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 1800 psi @ 700 °F

		HEADER		BRANCH
Nominal Size		4"		1½"
Outside Diameter	D_h	4.5	D_b	2.420
Nominal Wall	$\bar{T}_h$	.337	$\bar{T}_b$	.405
Actual or Min. Wall	T_h	.295	T_b	.354
Material Spec.		SA 376 TP 304		SA 182 F 304
Allowable Stress	S_h	15900	S_b	15900
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	–	A_b	–
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{1800 \times 4.5}{2 \times 15900 \times 1 + 2 \times .4 \times 1800} + \ldots\ldots = .244$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{1800 \times 2420}{2 \times 15900 \times 1 + 2 \times .4 \times 1800} + \ldots\ldots = .131$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.420 - 2 \times .354}{1} = 1.711$$

$d_2 = d_1$ or $= T_b + T_h + 0.5d_1 = .354 + .295 + 0.5 \times 1.711 = 1.505$

Select larger of the values, but not to exceed D_h. $d_2 = 1.711$

$L = 2.5(\bar{T}_b) = 2.5 \times .405 = 1.013$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .244 \times 1.711 \times (2 - 1) = .446$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times 1.711 - 1.711)(.295 - .244) = .088$

$A_2 = 2L(T_b - t_{mb}) = 2 \times 1.013 \times (.354 - .131) = .452$

$A_3 = t_f^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_1 + A_2 + A_3 = .088 + .452 + \ldots\ldots = .540$ sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

$A'_3 = (t'_f)^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_4 = (D_e - d_1)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

or

$A_5 = (D_e - D_b)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

$(A_1 + A_2 + A_3) + A'_3 + A_4$ (or A_5) =

$= \ldots\ldots + \ldots\ldots + \ldots\ldots = \ldots\ldots$

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

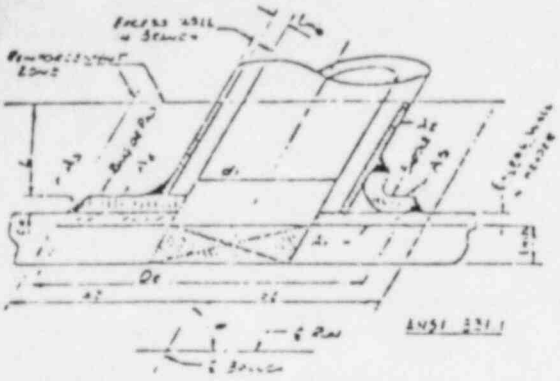
LOCATION _____ SYSTEM _____

CALC. BY DBL | CH. BY J.S. Becker

DATE 5-23-80 | DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 1800. psi @ 700. °F

		HEADER		BRANCH
Nominal Size		4"		2"
Outside Diameter	D_h	4.5	D_b	2.957
Nominal Wall	$\bar{T}_h$	.337	$\bar{T}_b$	.445
Actual or Min. Wall	T_h	.295	T_b	.389
Material Spec.		SA 376 TP 304		SA 182 F304
Allowable Stress	S_h	15900	S_b	15900
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	—	A_b	—
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{1800. \times 4.5}{2 \times 15100 \times .1 + 2 \times .4 \times 1800.} + \ldots\ldots = .244$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{1800. \times 2.957}{2 \times 15900 \times .1 + 2 \times .4 \times 1800.} + \ldots\ldots = .160$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.957 - 2 \times .389}{1} = 2.178$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .389 + .295 + 0.5 × 2.178 = 1.773

Select larger of the values, but not to exceed D_h. d_2 = 2.178

$L = 2.5(\bar{T}_b) = 2.5 \times .445 = 1.113$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or A_b ≠0, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .244 \times 2.178 \times (2 - 1) = .568$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times (2.178 - 2.178)(.295 - .244) = .112$

$A_2 = 2L(T_b - t_{mb}) = 2 \times 1.113 \times (.389 - .160) = .510$

$A_3 = t_f^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_1 + A_2 + A_3 = .112 + .510 + \ldots\ldots = .622$ sq. in. available. Additional Req'd: Yes ☐ No ☒

ADDITIONAL REINFORCEMENT:

$A'_3 = (t'_f)^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_4 = (D_e - d_1)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

or

$A_5 = (D_e - D_b)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

$(A_1 + A_2 + A_3) + A'_3 + A_4$ (or A_5) =

= ..... + ... + ... = ...

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

LOCATION _____ SYSTEM _____

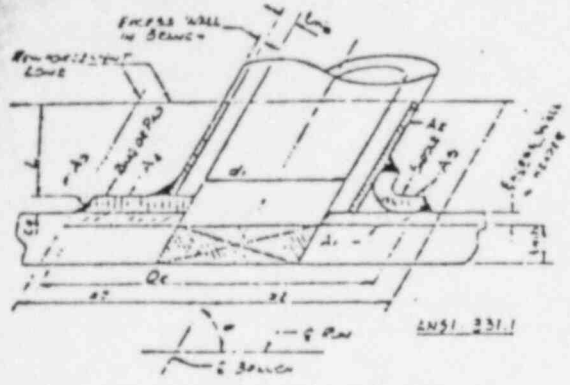
CALC. BY [illegible] CH BY J.S. Bute

DATE 5-23-80 DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75

1501.8 , 2501.6 , 2501.8



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 1800 psi @ 700 °F

		HEADER		BRANCH
Nominal Size		6"		2
Outside Diameter	D_h	6625	D_b	3.271
Nominal Wall	$\bar{T}_h$	.432	$\bar{T}_b$	.792
Actual or Min. Wall	T_h	.378	T_b	.719
Material Spec.		SA 376 TP 304		SA 182 F304
Allowable Stress	S_h	15900	S_b	15900
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	—	A_b	—
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{1800 \times 6.625}{2 \times 15900 \times 1 + 2 \times .4 \times 1800} + \ldots\ldots = .359$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{1800 \times 3.271}{2 \times 15900 \times 1 + 2 \times .4 \times 1800} + \ldots\ldots = .177$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{3.271 - 2 \times .719}{1} = 1.833$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .719 + .378 + 0.5 × 1.833 = 2.014

Select larger of the values, but not to exceed D_h. d_2 = 2.014

$L = 2.5(\bar{T}_b) = 2.5 \times .792 = 1.980$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07\,(t_{mh})\,(d_1)\,(2 - \sin\alpha) = 1.07 \times .359 \times 1.833 \times (2 - 1) = .703$

$A_1 = (2d_2 - d_1)\,(T_h - t_{mh}) = 2 \times (2.014 - 1.833)\,(.378 - .359) = .042$

$A_2 = 2L(T_b - t_{mb}) = 2 \times 1.980 \times (.719 - .177) = 2.146$

$A_3 = t_f^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_1 + A_2 + A_3 = .042 + 2.146 + \ldots\ldots = 2.188$ sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

$A'_3 = (t'_f)^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_4 = (D_e - d_1)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

or

$A_5 = (D_e - D_b)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

$(A_1 + A_2 + A_3) + A'_3 + A_4$ (or A_5) =

$= \ldots\ldots + \ldots\ldots + \ldots\ldots = \ldots\ldots$

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

LOCATION _____ SYSTEM _____

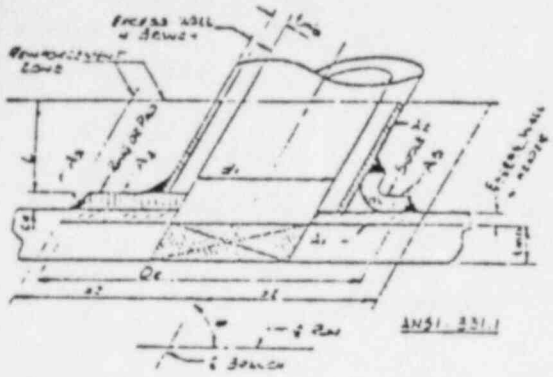
CALC. BY [illegible] | CH. BY J S Bucher

DATE 5-23-80 | DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75

Includes PS sheets 2500.2, 2500.3, 2500.4



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 2700 psi @ 650 °F

		HEADER		BRANCH
Nominal Size		3		1½
Outside Diameter	D_h	3.5	D_b	2.622
Nominal Wall	$\bar{T}_h$	.438	$\bar{T}_b$	.642
Actual or Min. Wall	T_h	.383	T_b	.581
Material Spec.		SA 106 B		SA 106
Allowable Stress	S_h	15000	S_b	17500
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	–	A_b	–
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{2700 \times 3.5}{2 \times 15000 \times 1 + 2 \times .4 \times 2700} + \ldots\ldots = .294$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{2700 \times 2.622}{2 \times 17500 \times 1 + 2 \times .4 \times 2700} + \ldots\ldots = .191$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.622 - 2 \times .581}{1} = 1.460$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .581 + .383 + 0.5 × 1.460 = 1.694

Select larger of the values, but not to exceed D_h. d_2 = 1.694

$L = 2.5(\bar{T}_b) = 2.5 \times .642 = 1.605$ 1.17

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .294 \times 1.460 \times (2 - 1) = .459$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times 1.694 - 1.460 (.383 - .294) = .172$

$A_2 = 2L(T_b - t_{mb}) = 2 \times 1.17 \times (.581 - .191) = .913$

$A_3 = t_f^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_1 + A_2 + A_3 = .172 + .913 - \ldots\ldots = 1.085$ sq. in. available. Additional Req'd: Yes ☐ No ☒

ADDITIONAL REINFORCEMENT:

$A_3' = (t_f')^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_4 = (D_e - d_1)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

or

$A_5 = (D_e - D_b)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

$(A_1 + A_2 + A_3) + A_3' + A_4$ (or A_5) =

$= \ldots\ldots + \ldots\ldots + \ldots\ldots = \ldots\ldots$

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

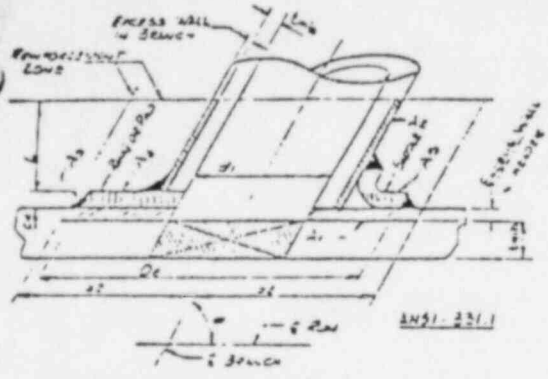
LOCATION _____ SYSTEM _____

CALC. BY EVA | CH. BY G.S. Buhl

DATE 5-23-80 | DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 2700. psi @ 650. °F

		HEADER		BRANCH
Nominal Size		4"		1½
Outside Diameter	D_h	4.5	D_b	2.622
Nominal Wall	$\bar{T}_h$	.531	$\bar{T}_b$	.642
Actual or Min. Wall	T_h	.465	T_b	.581
Material Spec.		SA106B		SA 105
Allowable Stress	S_h	15000	S_b	17500
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	–	A_b	–
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{2700 \times 4.5}{2 \times 15000 \times 1 + 2 \times .4 \times 2700} + \ldots\ldots = .378$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{2700 \times 2.622}{2 \times 17500 \times 1 + 2 \times .4 \times 2700} + \ldots\ldots = .191$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.622 - 2 \times .581}{1} = 1.460$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .581 + .465 + 0.5 × 1.460 = 1.776

Select larger of the values, but not to exceed D_h. d_2 = 1.776

L = 2.5 ($\bar{T}_b$) = 2.5 × .642 = 1.605 1.17

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

Area = 1.07 (t_{mh}) (d_1) (2 - sin α) = 1.07 × .378 × 1.460 × (2 - 1) = .570

A_1 = (2d_2 – d_1) (T_h – t_{mh}) = 2 × (1.776 - 1.460) (.465 - .378) = .182

A_2 = 2L (T_b – t_{mb}) = 2 × 1.17 × (.581 - .191) = .913

A_3 = t_f^2 = ( )^2 = ...

A_1+A_2+A_3 = .182 + .913 + ... = .1095 sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

A'_3 = (t'_f)^2 = ( )^2 = ...

A_4 = (D_p – d_1) t_p = (..... – .....) × ..... = ...

or

A_5 = (D_p – D_b) t_p = (..... – .....) × ..... = ...

(A_1+A_2+A_3) + A'_3 + A_4 (or A_5) =

= ..... + ... + ... = ...

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

LOCATION _____ SYSTEM _____

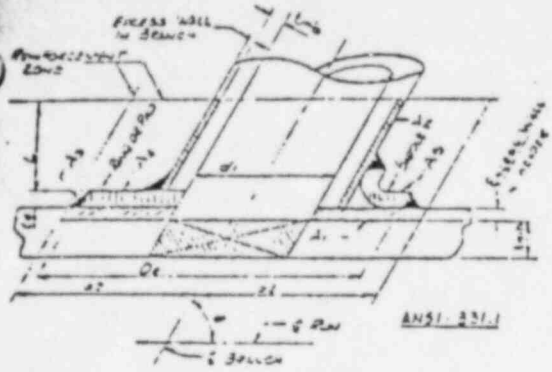
CALC. BY [illegible] CH. BY J.S. Burke

DATE 5-23-80 DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75

Includes PS sheets 2600.2, 2500.3, 2500.4



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 2700 psi @ 650 °F

		HEADER		BRANCH
Nominal Size		4"		2"
Outside Diameter	D_h	4.5	D_b	3.271
Nominal Wall	$\bar{T}_h$	.531	$\bar{T}_b$	.792
Actual or Min. Wall	T_h	.465	T_b	.719
Material Spec.		SA 106B		SA 105
Allowable Stress	S_h	15000	S_b	17500
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	–	A_b	–
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{2700 \times 4.5}{2 \times 15000 \times 1 + 2 \times .4 \times 2700} + \ldots\ldots = .378$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{2700 \times 3.271}{2 \times 17500 \times 1 + 2 \times .4 \times 2700} + \ldots\ldots = .238$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{3.271 - 2 \times .719}{1} = 1.833$$

$d_2 = d_1$ or $= T_b + T_h + 0.5d_1 = .719 + .465 + 0.5 \times 1.833 = 2.100$

Select larger of the values, but not to exceed D_h. $d_2 = 2.100$

$L = 2.5(\bar{T}_b) = 2.5 \times .792 = 1.980$ 1.54

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .378 \times 1.833 \times (2 - 1) = .741$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times 2.100 - 1.833 (.465 - .378) = .206$

$A_2 = 2L(T_b - t_{mb}) = 2 \times 1.54 \times (.719 - .238) = 1.481$

$A_3 = t_f^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_1 + A_2 + A_3 = 1.481 + .206 + \ldots\ldots = 1.687$ sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

$A'_3 = (t'_f)^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_4 = (D_e - d_1)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

or

$A_5 = (D_e - D_b)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

$(A_1 + A_2 + A_3) + A'_3 + A_4$ (or A_5) =

$= \ldots\ldots + \ldots\ldots + \ldots\ldots = \ldots\ldots$

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

LOCATION _____ SYSTEM _____

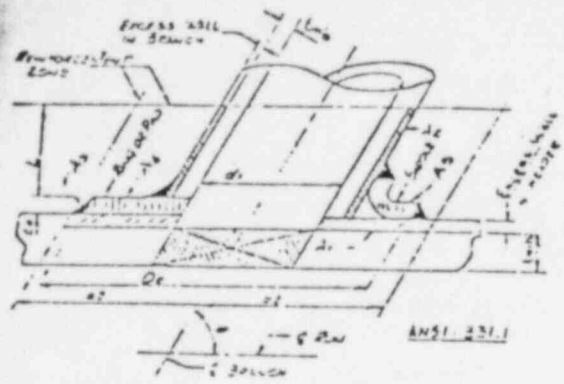
CALC BY DRA | CH. BY J.S. Burke

DATE 5-23-80 | DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75

Includes PS sheets 2500.2, 2500.3, 2500.4



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 2700. psi @ 650. °F

		HEADER		BRANCH
Nominal Size		6"		2"
Outside Diameter	D_h	6.625	D_b	2.771
Nominal Wall	$\bar{T}_h$	.718	$\bar{T}_b$	.792
Actual or Min. Wall	T_h	.628	T_b	.719
Material Spec.		SA 106 B		SA 105
Allowable Stress	S_h	15000	S_b	17500
Joint Efficiency	E_h	1	E_b	1
y-factor	Y_h	.4	Y_b	.4
Struct. Stab. Factor	A_h	—	A_b	—
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2Y_hP} + A_h = \frac{2700 \times 6.625}{2 \times 15000 \times 1 + 2 \times .4 \times 2700} + \ldots\ldots = .556$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2Y_bP} + A_b = \frac{2700 \times 3.271}{2 \times 17500 \times 1 + 2 \times .4 \times 2700} + \ldots\ldots = .238$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{3.271 - 2 \times .719}{1} = 1.833$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .719 + .628 + 0.5 × 1.833 = 2.264

Select larger of the values, but not to exceed D_h. d_2 = 2.264

L = 2.5 ($\bar{T}_b$) = 2.5 × .792 = 1.98 1.54

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

A_{req} = 1.07 (t_{mh}) (d_1) (2 · sin α) = 1.07 × .556 × 1.833 × (2 - 1) = 1.0911

A_1 = $(2d_2 - d_1)(T_h - t_{mh})$ = 2 × (2.264 - 1.833) (.628 - .556) = .194

A_2 = $2L(T_b - t_{mb})$ = 2 × 1.54 × (.719 - .238) = 1.481

A_3 = t_f^2 = ( )^2 = ...

$A_1 + A_2 + A_3$ = .194 + 1.481 + ... = 1.675 sq. in. available. Additional Req'd: Yes ☐ No ☒

ADDITIONAL REINFORCEMENT:

A_3' = $(t_f')^2$ = ( )^2 = ...

A_4 = $(D_e - d_1)\,t_e$ = (..... − .....) × ..... = ...

or

A_5 = $(D_e - D_b)\,t_e$ = (..... − .....) × ..... = ...

$(A_1 + A_2 + A_3) + A_3' + A_4$ (or A_5) =

= ..... + ... + ... = ...

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

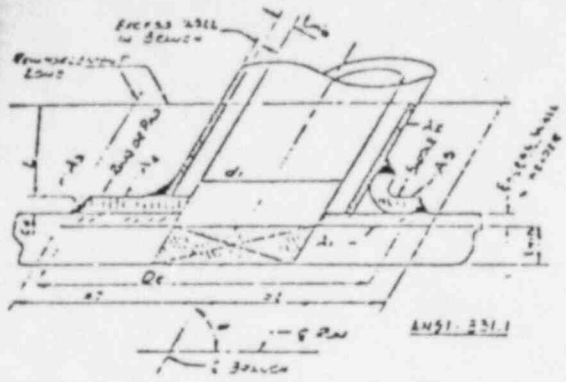
LOCATION _____ SYSTEM _____

CALC. BY EBA | CH. BY J.S. Burke

DATE 5-23-80 | DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 2725 psi @ 700 °F

		HEADER		BRANCH
Nominal Size		3"		1½"
Outside Diameter	D_h	3.5	D_b	2.622
Nominal Wall	$\bar{T}_h$	.438	$\bar{T}_b$	.642
Actual or Min. Wall	T_h	.383	T_b	.581
Material Spec.		SA 376 304		SA 182 F304
Allowable Stress	S_h	15900	S_b	15900
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	–	A_b	–
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{2725 \times 3.5}{2 \times 15900 \times 1 + 2 \times .4 \times 2725} + \ldots\ldots = .281$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{2725 \times 2.622}{2 \times 15900 \times 1 + 2 \times .4 \times 2725} + \ldots\ldots = .210$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.622 - 2 \times .581}{1} = 1.460$$

$d_2 = d_1$ or $= T_b + T_h + 0.5d_1 = .581 + .383 + 0.5 \times 1.460 = 1.694$

Select larger of the values, but not to exceed D_h. $d_2 = 1.694$

$L = 2.5(\bar{T}_b) = 2.5 \times .642 = 1.605$ 1.17

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .281 \times 1.460 \times (2 - 1) = .438$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times 1.694 - 1.460 (.383 - .281) = .198$

$A_2 = 2L(T_b - t_{mb}) = 2 \times 1.17 \times (.581 - .210) = .868$

$A_3 = t_f^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_1 + A_2 + A_3 = .198 + .868 + \ldots\ldots = 1.066$ sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

$A_3' = (t_f')^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_4 = (D_e - d_1)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

or

$A_5 = (D_e - D_b)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

$(A_1 + A_2 + A_3) + A_3' + A_4$ (or A_5) =

$= \ldots\ldots + \ldots\ldots + \ldots\ldots = \ldots\ldots$

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

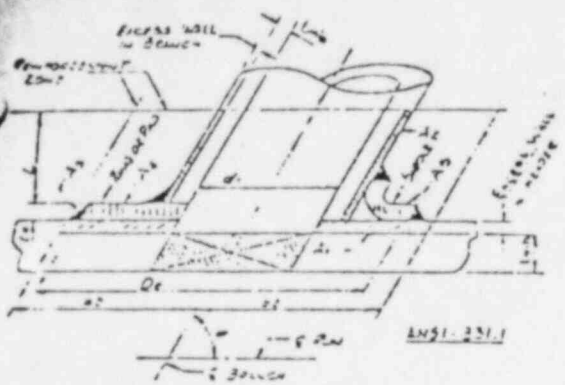
LOCATION _____ SYSTEM _____

CALC BY DBS CH. BY A.S. Bube

DATE 5-23-80 DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 2725 psi @ 200 °F

		HEADER		BRANCH
Nominal Size		4"		1½"
Outside Diameter	D_h	4.5	D_b	2.622
Nominal Wall	$\bar{T}_h$	.631	$\bar{T}_b$	.642
Actual or Min. Wall	T_h	.465	T_b	.581
Material Spec.		SA 376 304		SA 182 304
Allowable Stress	S_h	15900	S_b	15900
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	–	A_b	–
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{2725 \times 4.5}{2 \times 15900 \times 1 + 2 \times .4 \times 2725} + \ldots\ldots = .361$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{2725 \times 2.622}{2 \times 15900 \times 1 + 2 \times .4 \times 2725} + \ldots\ldots = .210$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.622 - 2 \times .581}{1} = 1.460$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .581 + .465 + 0.5 × 1.460 = 1.776

Select larger of the values, but not to exceed D_h. d_2 = 1.776

L = 2.5 ($\bar{T}_b$) = 2.5 × .642 = ~~1.605~~ 1.17

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

Area = 1.07 (t_{mh}) (d_1) (2 · sin α) = 1.07 × .361 × 1.460 × (2 - .1) = .564

A1 = (2d_2 – d_1) (T_h – t_{mh}) = 2 × 1.776 - 1.460 (.465 - .361) = .217

A2 = 2L (T_b – t_{mb}) = 2 × 1.17 × (.581 - .210) = .868

A3 = t_f^2 = (.....)² = ...

A1+A2+A3 = .217 + .868 + ... = 1.085 sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

A_3' = (t_f')² = (.....)² = ...

A_4 = (D_e – d_1) t_e = (..... – .....) × ..... = ...

or

A_5 = (D_e – D_b) t_e = (..... – .....) × ..... = ...

(A1+A2+A3) + A_3' + A_4 (or A_5) =

= ..... + ... + ... = ...

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

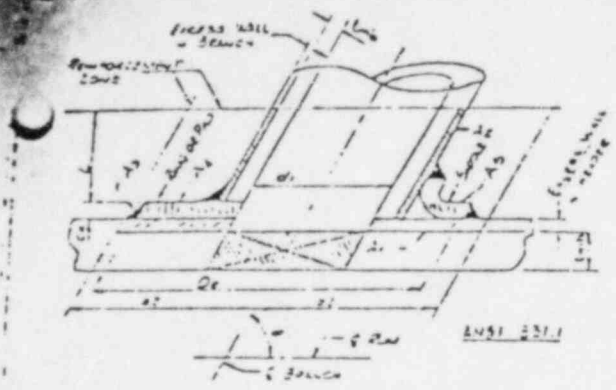
LOCATION _____ SYSTEM _____

CALC. BY DRS CH. BY G.S. Burke

DATE 5-23-80 DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 2725 psi @ 700 °F

		HEADER		BRANCH
Nominal Size		4"		2"
Outside Diameter	D_h	4.5	D_b	3.271
Nominal Wall	$\bar{T}_h$	.531	$\bar{T}_b$	.792
Actual or Min. Wall	T_h	.465	T_b	.719
Material Spec.		SA 376 304		304
Allowable Stress	S_h	15900	S_b	15900
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	–	A_b	–
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{2725 \times 4.5}{2 \times 15900 \times 1 + 2 \times .4 \times 2725} + \ldots\ldots = .361$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{2725 \times 3.271}{2 \times 15900 \times 1 + 2 \times .4 \times 2725} + \ldots\ldots = .262$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{3.271 - 2 \times .719}{1} = 1.833$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .719 + .465 + 0.5 × 1.833 = 2.100

Select larger of the values, but not to exceed D_h. d_2 = 2.100

L = 2.5 ($\bar{T}_b$) = 2.5 × .792 = 1.980 1.54

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

A_{req} = 1.07 (t_{mh}) (d_1) (2 - sin α) = 1.07 × .361 × 1.833 × (2 - 1) = .708

A_1 = (2d_2 – d_1) (T_h – t_{mh}) = 2 × (2.100 - 1.833) (.465 - .361) = .246

A_2 = 2L (T_b – t_{mb}) = 2 × 1.54 × (.719 - .262) = 1.408

A_3 = t_f^2 = (. . . . .)^2 = ...

$A_1 + A_2 + A_3$ = .246 + 1.408 + ... = 1.654 sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

A_3' = (t_f')^2 = (. . . . .)^2 = ...

A_4 = (D_e – d_1) t_e = (. . . . . – . . . . .) × . . . . . = ...

or

A_5 = (D_e – D_b) t_e = (. . . . . – . . . . .) × . . . . . = ...

($A_1 + A_2 + A_3$) + A_3' + A_4 (or A_5) =

= . . . . . + ... + ... = ...

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. _____ FOR _____

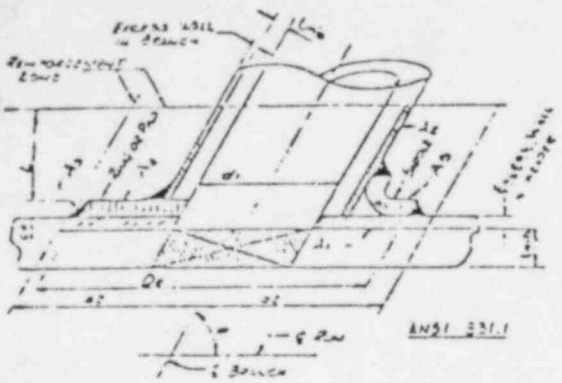
LOCATION _____ SYSTEM _____

CALC BY DSS | CH. BY G.S. Buke

DATE 5-23-80 | DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1.75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

Area A_5 – metal in saddle along run

DESIGN CONDITIONS: 2725 psi @ 700°F

		HEADER		BRANCH
Nominal Size		6"		2"
Outside Diameter	D_h	6.625	D_b	3.271
Nominal Wall	$\bar{T}_h$	.718	$\bar{T}_b$	.792
Actual or Min. Wall	T_h	.628	T_b	.719
Material Spec.		SA 376 304		SA 182 304
Allowable Stress	S_h	15900	S_b	15900
Joint Efficiency	E_h	1	E_b	1
y-factor	y_h	.4	y_b	.4
Struct. Stab. Factor	A_h	–	A_b	–
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{2725 \times 6.625}{2 \times 15900 \times 1 + 2 \times .4 \times 2725} + \ldots\ldots = .531$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{2725 \times 3.271}{2 \times 15900 \times 1 + 2 \times .4 \times 2725} + \ldots\ldots = .262$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{3.271 - 2 \times .719}{1} = 1.833$$

$d_2 = d_1$ or $= T_b + T_h + 0.5d_1 = .719 + .628 + 0.5 \times 1.833 = 2.264$

Select larger of the values, but not to exceed D_h. $d_2 = 2.264$

$L = 2.5(\bar{T}_b) = 2.5 \times .792 = 1.980$ 1.540

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 \cdot \sin\alpha) = 1.07 \times .531 \times 1.833 \times (2 - 1) = 1.042$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times 2.264 - 1.833 (.628 - .531) = .261$

$A_2 = 2L(T_b - t_{mb}) = 2 \times 1.540 \times (.719 - .262) = 1.408$

$A_3 = t_f^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_1 + A_2 + A_3 = .261 + 1.408 + \ldots\ldots = 1.669$ sq. in. available. Additional Req'd: Yes ☐ No ☑

ADDITIONAL REINFORCEMENT:

$A_3' = (t_f')^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_4 = (D_e - d_1)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

or

$A_5 = (D_e - D_b)\,t_e = (\ldots\ldots - \ldots\ldots) \times \ldots\ldots = \ldots\ldots$

$(A_1 + A_2 + A_3) + A_3' + A_4$ (or A_5) =

$= \ldots\ldots + \ldots\ldots + \ldots\ldots = \ldots\ldots$

Additional reinforcement adequate: Yes ☐ No ☐

ORDER NO. ____ FOR ____

LOCATION ____ SYSTEM ____

CALC. BY [illegible] CH. BY Jeff S. Burke

DATE 5-23-80 DATE 8-12-80

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75

ATTACHMENT 3

CERTIFICATION OF ENGINEERING CALCULATION

Station and Unit Number Catawba Nuclear - Unit 1

Title of Calculation Fabricated Tee Reinforcement Verification For Internal Pressure - RN System

Calculation Number CNC-1206.00-02-1024 Originally consisting of Pages 1 through 26.

These Engineering Calculations cover QA CONDITION 1 & 4 items. In accordance with established procedures, the quality has been assured and I certify that the above calculation has been performed, checked or approved as noted below:

Performed by J. S. Bulbe Date 2-21-83

Checked by R. D. Ellington Date 2-21-83

Approved by W. D. McDaniel Date 2-21-83

Issued to General Services Division _____ Date _____

Received by General Services Division _____ Date _____

Revision/Addenda Log:

No.	Pages Revised	Pages Deleted	Pages Added	Performed By / Date	Checked By / Date	Approved By / Date	Issue Date / Rec'd Date

Form 101.1/Revision 6

ATTACHMENT 3

CERTIFICATION OF ENGINEERING CALCULATION

Station and Unit Number Catawba Nuclear - Unit 1

Title of Calculation Fabricated Tee Reinforcement Verification For Internal Pressure - RN System

Calculation Number CNC-1206.00-02-1024 Originally consisting of Pages 1 through 26.

These Engineering Calculations cover QA CONDITION 1 & 4 items. In accordance with established procedures, the quality has been assured and I certify that the above calculation has been performed, checked or approved as noted below:

Performed by J. S. Bulbe Date 2-21-83

Checked by R D Ellington Date 2-21-83

Approved by W. W. McDaniel Date 2-21-83

Issued to General Services Division _____ Date _____

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Revision/Addenda Log:

No.	Pages Revised	Pages Deleted	Pages Added	Performed By / Date	Checked By / Date	Approved By / Date	Issue Date / Rec' Date

Form 101.1/Revision 6

FABRICATED TEE REINFORCEMENT VERIFICATION

FOR INTERNAL PRESSURE

1) Statement of Problem

Commerically available fittings have an internal pressure stress verification already performed on them. Field fabricated tees also require this verification in order to guarantee their pressure retaining capabilities. This calculation covers fabricated tees as shown on isometrics listed on page 5, which constitutes all the fabricated branches in the Catawba Unit 1 Nuclear Service Water (RN) system.

2) Relation to Applicable QA Condition

Piping involved in the attached calculations is Duke Classes C and F (QA Condition 1 and condition 4), found in piping procurement specification CNS-1206.00-02-1002. See Index of Calculation for corresponding Pipe Spec.

3) Design Method Employed

When an opening is made into a header pipe for a fabricated branch connection, a reinforcement calculation is required to assure that adequate metal reinforcement (for internal pressure) exists within the limits of reinforcement. This additional material may be acquired from any of the following:

A) Excess metal (not required for internal pressure) in header and branch pipe, (to the limits of reinforcement) may be used for reinforcing material.

B) A saddle, ring or pad may be placed over the header at the connection to replace the removed material.

C) A combination of items A and B can be used.

The methods used to verify adequate reinforcement material at the connection are described in the following:

A) Workplace Procedure PPDS-PDC-110 paragraph 5.0B and Appendix D.

B) ASME Boiler and Pressure Vessel Code, Section III, Subsection ND, Section ND-3643.3, paragraph C.

C) ANSI B31.1 section 104.3.1, paragraph D.

4) Applicable Codes and Standards

A) ASME Boiler and Pressure Vessel Code Section III, Subsection ND, 1974 edition including the S'74 addendum.

4) Applicable Codes and Standards (continued)

B) ASME Boiler and Pressure Vessel Code Section III Appendices, 1977 edition.

C) ANSI B31.1, Power Piping Code, 1977 edition.

5) Other Design Criteria

A) Branch connections which are accepted by the Branch Selection Chart, (Appendix E of the Piping Procurement Specification CNS-1206.00-02-1002) are excluded from this calculation.

6) PSAR and FSAR applicability

The applicability of these reports is the same as given in section 4.

7) Assumptions Employed

Those assumptions which are employed in the performance of this calculation are as follows:

A) When a fabricated branch line is made onto a header, it is assumed that by replacing the same amount of metal that is removed, the connection is as good as the original header pipe. (Replacement metal can be derived from excess wall material in header or branch, or addition of a ring or saddle.)

B) When determining actual or minimum wall thicknesses of header and branch pipe, 87.5% of nominal wall is used for conservative purposes. (Piping is assumed to be fabricated to the minimum requirements.)

C) Fillet weld material is not considered in the calculation, but this weld material does add additional reinforcement.

D) These calculations only take credit for the material necessary to reinforce the branch connection. Any additional material is of no consequence to the calculation and adds to the installed factor of safety at the branch connection.

E) Any further assumptions made, would be specifically stated as such on the calculation.

Any assumptions which are made are intended to add to the conservatism of this calculation.

8) Sources of Information

A) ASME Boiler and Pressure Vessel Code Section III, Appendices 1977 edition. (Allowable Stress Factor)

B) ANSI B31.1, Power Piping Code, 1977 edition (allowable stress factor)

C) Piping Procurement Specification CNS-1206.00-02-1002 (Nominal wall, material specification)

D) PPDS-PDC-110 (Joint efficiency , Y factor).

NOTE: Joint efficiency per R. L. Williams' letter MG-82-333, file CK-1206.03-01 dated August 17, 1982 does give specific Catawba criteria

E) ANSI B36.10 (nominal size, outside diameter, nominal wall)

F) Piping isometrics as listed in the Index of Calculations (line size, pipe specification, pipe class, angle of branch line)

G) RN System flow diagrams - CN-1574 series (Temperature, pressure)

9) Calculation

See Page #5 - Index of Calculations

10) Conclusions

Pads specified on isometric are minimum requirements. The actual pad installed may exceed these requirements. The excess is of no consequence.

The reinforcing material is normally identical to that of the header; however a substitution may be made as long as the allowable stress factor is equal to or greater than the header material.

Calculation 1RN1 - The 42 x 20 fabricated tees on the associated isometrics are acceptable with the additional reinforcement pads as specified on 1RN1 sheets 2 and 3.

Calculation 1RN2 - The 42 x 18 fabricated tees on the associated isometrics are acceptable with the additional reinforcement pads as specified on 1RN2 sheets 2, 3 and 4.

Calculation 1RN3 - The 42 x 4 fabricated tee on isometric CN-1492-RN076 is acceptable with the addition of the reinforcing pad as specified on 1RN3 sheet 2.

10) Conclusions (continued)

Calculation 1RN4 through 1RN15 - Are acceptable as is and require no additional reinforcement.

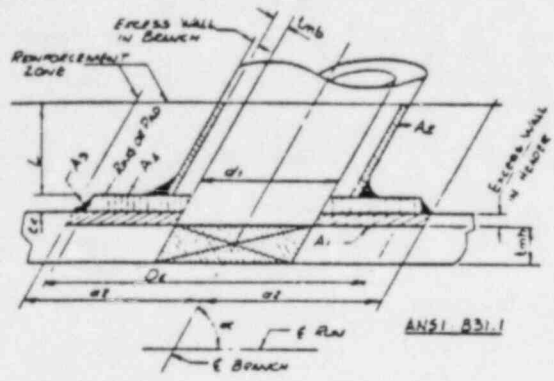
INDEX OF CALCULATIONS

Iso No.	Calc. No.	Pipe Spec.	ASME/ANSI Code	Size
CN-1492-RN016	1RN4	150.3	ASME	30 x 4
CN-1492-RN028	1RN4	150.3	ASME	30 x 4
CN-1492-RN041	1RN4	150.3	ASME	30 x 4
CN-1492-RN042	1RN4	150.3	ASME	30 x 4
CN-1492-RN049	1RN4	150.3	ASME	30 x 4
	1RN5	150.3/151.3	ASME	30 x 4
CN-1492-RN050	1RN8	150.3	ASME	24 x 4
CN-1492-RN051	1RN4	150.3	ASME	30 x 4
	1RN5	150.3/151.3	ASME	30 x 4
CN-1492-RN052	1RN8	150.3	ASME	24 x 4
	1RN7	150.3	ASME	24 x 6
	1RN6	150.3	ASME	24 x 8
CN-1492-RN054	1RN10	150.4	ANSI	20 x 6
CN-1492-RN060	1RN14	150.3	ASME	18 x 4
CN-1492-RN067	1RN14	150.3	ASME	18 x 4
CN-1492-RN076	1RN1	150.3	ASME	42 x 20
	1RN2	150.3	ASME	42 x 18
	1RN3	150.6	ANSI	42 x 4
CN-1492-RN077	1RN2	150.3	ASME	42 x 18
CN-1492-RN078	1RN9	150.3	ASME	20 x 8
	1RN11	150.3	ASME	20 x 4
CN-1492-RN080	1RN14	150.3	ASME	18 x 4
CN-1492-RN090	1RN9	150.3	ASME	20 x 8
	1RN11	150.3	ASME	20 x 4
CN-1492-RN117	1RN6	150.3	ASME	24 x 8
CN-1492-RN122	1RN15	150.4	ANSI	12 x 8
	1RN13	150.4	ASNI	18 x 6
CN-1492-RN125	1RN7	150.3	ASME	24 x 6
CN-1492-RN131	1RN14	150.3	ASME	18 x 4
CN-1492-RN134	1RN1	150.3	ASME	42 x 20
	1RN2	150.3	ASME	42 x 18
CN-1492-RN154	1RN12	150.4	ANSI	18 x 8

CN-1472-RN134
120
76

PS 150.3
class C

By: JS Burke
CK: RG Elliston



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: ..... psi @ ..... °F

		HEADER		BRANCH
Nominal Size		42"		20"
Outside Diameter	D_h	42"	D_b	20"
Nominal Wall	$\bar{T}_h$	0.375"	$\bar{T}_b$	0.375
Actual or Min. Wall (a)	T_h	.3271	T_b	0.37-1
Material Spec.		SA-155		SA-106
Allowable Stress (b)	S_h	17,5[illegible]	S_b	15[illegible]
Joint Efficiency (c)	E_h	1.0	E_b	1.0
y-factor (d)	y_h	0.4	y_b	0.4
Struct. Stab. Factor (e)	A_h	—	A_b	—
Intersection Angle	α	90		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{.165 \times .42}{2 \times .17[illegible] \times 1.0 + 2 \times .04 \times .165} + \ldots\ldots = .1[illegible]$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{.165 \times .20}{2 \times 15[illegible] \times 1.0 + 2 \times .04 \times .165} + \ldots\ldots = 0.[illegible]$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{.37 - 2 \times .3271}{\ldots\ldots} = 19.344$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = 0.3271 + .3271 + 0.5 x 19.344 = 19.[illegible]

Select larger of the values, but not to exceed D_h. d_2 = 19.344

L = 2.5 ($\bar{T}_b$) = 2.5 x 0.375 = 0.9375

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

A_{req} = 1.07 (t_{mh}) (d_1) (2 - sin α) = 1.07 x .19.19. x 19.[illegible] x (2 - .1....) = [illegible]

A_1 = ($2d_2 - d_1$) ($T_h - t_{mh}$) = 2x .1....1 - .....1) (0.32[illegible] - .1....) = 2.[illegible]

A_2 = $2L(T_b - t_{mb})$ = 2 x 0.9375 x (0.375 - .....) = ...

A_3 = t_f^2 = (.....)^2 = ...

$A_1 + A_2 + A_3$ = 2.[illegible] + ...+ ..... = 2.[illegible] sq. in. available. Additional Req'd: Yes ☒ No ☐

Pad Size (See note f) THIS IS FOR MAXIMUM PAD SEE SHEETS 2 AND 3 FOR ACTUAL PAD.

Height = L = [illegible]

Width = $2d_2$ = 2x [illegible] = 3.68[illegible]

$A_4 = L(2d_2 - d_1)$ = [illegible] ([illegible] - 19.[illegible]) = 19.2[illegible]

$A_1 + A_2 + A_3 + A_4$ =

[illegible] + [illegible] + [illegible] + [illegible] = [illegible]

Additional reinforcement adequate: Yes ☒ No ☐

Plant/Unit Catawba 1 / 1

System RN Calc # IRN1

CALC. BY [illegible] CH. BY RG Elliston

DATE [illegible] DATE 12-21-82

NOZZLE REINFORCEMENT

WORK SHEET WS-1-75

REG. GUIDE

Dev./Station CATAWBA NUCLEAR STATION Unit 1 File No.

Subject

By RG Clifton Date 2-7-83

Sheet No. 2 of 3 Problem No. 1RN1 Checked By JS Burke Date 2-8-83

CN-1492-RN076
CN-1492-RN120

PRESSURE PAD SPECIFIED: HEIGHT = L = .500 (42" SCH. XS PIPE)
O.D. = d_e = 34.00"
I.D. = 20.00" (O.D. OF BRANCH)
MATERIAL = SA 155 cl. 1 - KC 70

$A_4 = L(d_e - d_i) = .500\ (34.00 - 19.344) = 7.328\ in.^2$

$A_1 + A_2 + A_3 + A_4 = 2.53 + 0.41 + 0 + 7.328 = 10.268\ in.^2$

$A_{AVAIL.} = 10.268\ in.^2$
$A_{req.} = 4.084\ in.^2$
$A_{EXCESS} = 6.184\ in.^2$

Dev./Station CATAWBA NUCLEAR STATION Unit 1 File No.

Subject

By RG Clinton for Date 2-7-83

Sheet No. 3 of 3 Problem No. 1RN1 Checked By J.S Burke Date 2-9-83

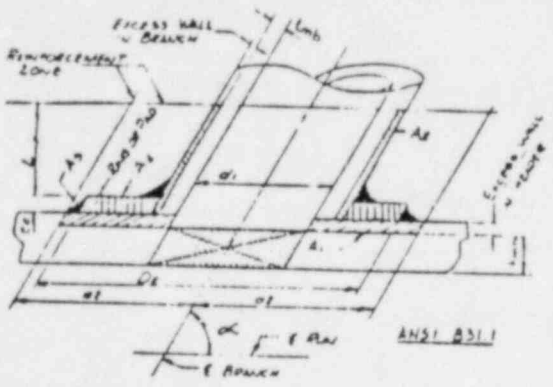
CN-1492-RN134

PRESSURE PAD SPECIFIED: HEIGHT = L = .375" (42" sch. STD PIPE)
O.D. = d_e = 34.00"
I.D. = 20.00" (O.D. OF BRANCH)
MATERIAL = SA 155 cl. 1 -KC70

$A_4 = L(d_e - d_i) = .375\,(34.00" - 19.344) = 5.496\ in^2$

$A_1 + A_2 + A_3 + A_4 = 2.53 + 0.41 + 0 + 5.496 = 8.436\ in.^2$

$A_{AVAIL.} = 8.436\ in^2$
$A_{req.} = 4.084\ in^2$
$A_{EXCESS} = 4.352\ in^2$



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: ... psi @ ... °F

		HEADER		BRANCH	
Nominal Size		42"		18"	
Outside Diameter	D_h		D_b		
Nominal Wall	$\bar{T}_h$		$\bar{T}_b$		
Actual or Min. Wall (a)	T_h	0.3281	T_b		
Material Spec					
Allowable Stress (b)	S_h		S_b	15 K	
Joint Efficiency (b)	E_h		E_b	1.0	
y-factor (b)	y_h		y_b		
Struct. Stab. Factor	A_h		A_b		
Intersection Angle	α	90°			

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{\text{...} \times \text{...}}{2 \times \text{...} \times \text{...} + 2 \times \text{...} \times \text{...}} + \text{...} = \text{...}$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{\text{...} \times \text{...}}{2 \times \text{...} \times \text{...} + 2 \times \text{...} \times \text{...}} + \text{...} = \text{...}$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{\text{...} - 2 \times \text{...}}{\text{...}} = \text{...}$$

$d_2 = d_1$ or $= T_b + T_h + 0.5d_1 = \text{...} + \text{...} + 0.5 \times \text{...} = \text{...}$

Select larger of the values, but not to exceed D_h. $d_2 = \text{...}$

$L = 2.5(\bar{T}_b) = 2.5 \times \text{...} = \text{...}$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 \cdot \sin\alpha) = 1.07 \times \text{...} \times \text{...} \times (2 - \text{...}) = \text{...}$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times \text{...} - \text{...})(\text{...} - \text{...}) = \text{...}$ (See Note C)

$A_2 = 2L(T_b - t_{mb}) = 2 \times \text{...} \times (\text{...} - \text{...}) = \text{...}$

$A_3 = t_f^2 = (\text{...})^2 = \text{...}$

$A_1 + A_2 + A_3 = \text{...} + \text{...} + \text{...} = \text{...}$ sq. in. available. Additional Req'd: Yes ☒ No ☐

PAD SIZE: THIS IS FOR MAXIMUM PAD SEE SHEETS 2,3 AND 4 FOR ACTUAL PAD.

L = _____ min. height

De = $2d_2$ = 2x _____ = _____ min width

A_4 = LxDe = _____ x _____ = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☐ No ☒

Plant/Unit _____

System _____ Calc. # IRN2

CALC. BY _____ CHK. BY _____

DATE _____ DATE _____

NOZZLE REINFORCEMENT

WORK SHEET WS-1-75

REI

Dev./Station CATAWBA NUCLEAR STATION Unit 1 File No.

Subject

By R.G. Clifton Date 2-7-83

Sheet No. 2 of 4 Problem No. IRN2 Checked By J.S. Burke Date 2-8-83

CN-1492-RN077

PRESSURE PAD SPECIFIED: HEIGHT = L = .750"
O.D. = d_e = 30.00"
I.D. = 18.00" (O.D. OF BRANCH)
MATERIAL: SA 516 GR 70

$A_4 = L(d_e - d_i) = .750(30.00 - 17.344) = 9.492 \text{ in}^2$

$A_1 + A_2 + A_3 + A_4 = 2.2686 + 0.4303 + 0 + 9.492 = 12.191 \text{ in}^2$

$A_{AVAIL} = 12.191 \text{ in}^2$
$A_{req} = 3.662 \text{ in}^2$
$A_{EXCESS} = 8.529 \text{ in}^2$

Dev./Station CATAWBA NUCLEAR STATION Unit 1 File No.

Subject

By R.G. Clayton Date 2-7-83

Sheet No. 3 of 4 Problem No. 1RN2 Checked By J.S Burke Date 2-9-83

CN-1492-RN/31

PRESSURE PAD SPECIFIED: HEIGHT = L = .500 (42" sch. XS PIPE)

O.D. = d_e = 30.00"

I.D = 18.00

MATERIAL = SA 155 cl. 1 KC70

$A_4 = L(d_e - d_1) = .500(30.00 - 17.344) = 6.328\ in^2$

$A_1 + A_2 + A_3 + A_4 = 2.2686 + 0.4303 + 0 + 6.328 = 9.027\ in^2$

$A_{AVAIL} = 9.027\ in^2$

$A_{req.} = 3.662\ in^2$

$A_{EXCESS} = 5.365\ in^2$

Dev./Station CATAWBA NUCLEAR STATION Unit 1 File No.

Subject

By RCClayton Date 2-7-83

Sheet No. 4 of 4 Problem No. 1RN2 Checked By JS Burke Date 2-9-83

CN-1492-RN 134

PRESSURE PAD SPECIFIED: HEIGHT = L = .375 (42" sch. STD PIPE)

O.D. = d_e = 32.00"

I.D. = 18.00"

MATERIAL = SA 155 cl. 1 KC 70

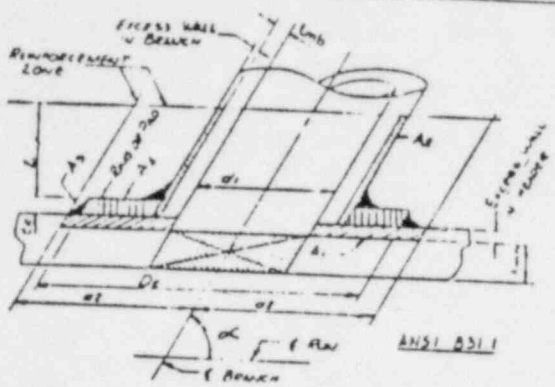
$A_4 = L(d_e - d_i) = .375(32.00 - 17.344) = 5.496\ in^2$

$A_1 + A_2 + A_3 + A_4 = 2.2686 + 0.4303 + 0 + 5.496 = 8.195\ in^2$

$A_{AVAIL} = 8.195\ in^2$

$A_{req} = 3.662\ in^2$

$A_{EXCESS} = 4.533\ in^2$



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: 165 psi @ 150 °F

		HEADER		BRANCH	
Nominal Size			42		4
Outside Diameter	D_h		42	D_b	4.5
Nominal Wall	$\bar{T}_h$		0.375	$\bar{T}_b$	.237
Actual or Min. Wall (a)	T_h		.341	T_b	.207
Material Spec.			A-155 CL2		A-106
Allowable Stress (b)	S_h		13.7K	S_b	
Joint Efficiency (b)	E_h		1.0	E_b	
y-factor (b)	y_h		.4	y_b	
Struct. Stab. Factor	A_h		—	A_b	—
Intersection Angle	α		90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{165 \times 42}{2 \times 13{,}700 \times 1.0 + 2 \times .4 \times 165} + \ldots\ldots = .252$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{165 \times 4.5}{2 \times 13{,}700 \times 1.0 + 2 \times .4 \times 165} + \ldots\ldots = .0240$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{4.5 - 2 \times .237}{1.0} = 4.09$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .237 + .341 + 0.5 × 4.09 = 2.93

Select larger of the values, but not to exceed D_h. d_2 = 4.09

$L = 2.5(\bar{T}_b) = 2.5 \times .237 = .593$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .252 \times 4.09 \times (2 - 1.0) = 1.102$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times (4.09 - 4.09)(.341 - .252) = .311$ (See Note C)

$A_2 = 2L(T_b - t_{mb}) = 2 \times .593 \times (.237 - .0240) = 2.168$

$A_3 = t_1^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_1 + A_2 + A_3 = .311 + 2.168 + \ldots\ldots = 2.528$ sq. in. available. Additional Req'd: Yes ☒ No ☐

PAD SIZE:

L = .593 min. height

De = $2d_2$ = 2 × 4.09 = 8.18 min width

A_4 = L × De = .592 × 8.18 = 4.85

$A_1 + A_2 + A_3 + A_4$ =

.311 + .2168 + 0 + 4.85 = 5.2578

Additional reinforcement adequate: Yes ☒ No ☐

Plant/Unit

System Calc. # 1RN3

CALC. BY DATE

CK'D BY DATE 1-4-93

NOZZLE REINFORCEMENT

WORK SHEET WS-1.75

Dev./Station CATAWBA NUCLEAR STATION Unit 1 File No.

Subject

By R.D. Elliston Date 2-7-83

Sheet No. 2 of 2 Problem No. Checked By J.S. Burke Date 2-8-83

CN-1492-RN076

PRESSURE TAP SPECIFIED: HEIGHT = L = .500 (42" sch. XS PIPE)

O.D = d_2 = 9.00

ID = 4.5

MATERIAL = SA155 cl.1 KC-70

$A_4 = L(d_2 - d_1) = .500(9.00 - 4.09) = 2.455$

$A_1 + A_2 + A_3 + A_4 = 0.311 + 0.2168 + 0 + 2.455 = 2.983 \text{ in}^2$

$A_{AVAIL} = 2.983 \text{ in}^2$

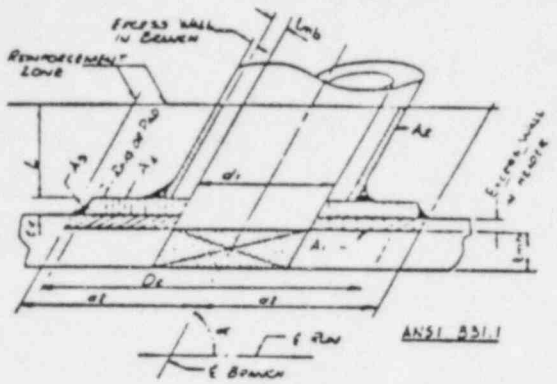
$A_{req.} = 1.102 \text{ in}^2$

$A_{EXCESS} = 1.881 \text{ in}^2$

By: JSB Date CK'd RGH Date

CN 1492-RN 51
49
42
41
28
16

150.3
Item C



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: 115 psi @ 150 °F

		HEADER		BRANCH
Nominal Size		30"		4"
Outside Diameter	D_h	30"	D_b	4.5
Nominal Wall	$\bar{T}_h$	.375	$\bar{T}_b$	0.237
Actual or Min. Wall	T_h	.3271	T_b	0.2074
Material Spec.		SA 516		A 106
Allowable Stress	S_h	17.5K	S_b	15K
Joint Efficiency	E_h	1.0	E_b	1.0
y-factor	y_h	0.4	y_b	0.4
Struct. Stab. Factor	A_h	–	A_b	–
Intersection Angle	α		90°	

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{115 \times 30}{2 \times 17500 \times 1.0 + 2 \times 0.4 \times 115} + \ldots\ldots = .0983$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{115 \times 4.5}{2 \times 15000 \times 1.0 + 2 \times 0.4 \times 115} + \ldots\ldots = .0172$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{4.5 - 2 \times .2074}{1} = 4.09$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .2074 + .3271 + 0.5 × 4.09 = 2.56

Select larger of the values, but not to exceed D_h. d_2 = 4.09

$L = 2.5(\bar{T}_b) = 2.5 \times .237 = .593$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .0983 \times 4.09 \times (2 - 1) = .43$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times (4.09 - 4.09)(.3271 - .0983) = .94$

$A_2 = 2L(T_b - t_{mb}) = 2 \times .593 \times (.2074 - .0172) = .23$

$A_3 = t_f^2 = (\ldots)^2 = 0$

$A_1 + A_2 + A_3 = .94 + .23 + 0 = 1.17$ sq. in. available. Additional Req'd: Yes ☐ No ☒

Pad Size (See note f)

Height = L = _____

Width = $2d_2$ = 2x_____ = _____

$A_4 = L(2d_2 - d_1)$ = _____ (_____ - _____) = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☒ No ☐

Plant/Unit Oconee 1

System RN Calc # IRN4

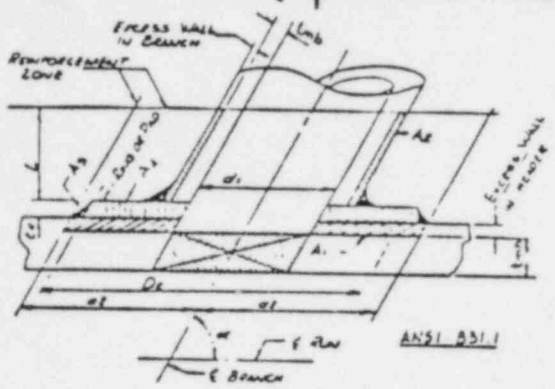
CALC. BY _____ CH. BY _____

DATE 1/4/83 DATE 1-5-83

NOZZLE REINFORCEMENT

WORK SHEET WS-1-75

Benj. J. S. Burke CN-1422-PH051,049 PG 151.3 PG 151.3



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: 1115 psi @ 150 °F

		HEADER		BRANCH
Nominal Size		30		+
Outside Diameter	D_h	30	D_b	4.5
Nominal Wall	$\bar{T}_h$	0.375	$\bar{T}_b$	0.237
Actual or Min. Wall	T_h	0.3281	T_b	0.2074
Material Spec.		SA-155		SA 312
Allowable Stress	S_h	17.5	S_b	17.8
Joint Efficiency	E_h	1.0	E_b	1.0
y-factor	y_h	0.4	y_b	0.4
Struct. Stab. Factor	A_h	—	A_b	—
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{.115 \times 30}{2 \times 17500 \times 1.0 + 2 \times 0.4 \times 115} + \ldots\ldots = 0.0983$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{.115 \times 4.5}{2 \times 17,800 \times 1.0 + 2 \times 0.4 \times 115} + \ldots\ldots = 0.0145$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{4.5 - 2 \times .2074}{1} = 4.0852$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .2074 + .3281 + 0.5 × 4.0852 = 2.5781

Select larger of the values, but not to exceed D_h. d_2 = 4.0852

$L = 2.5(\bar{T}_b) = 2.5 \times .237 = .5925$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .0983 \times 4.0852 \times (2 - 1) = .4297$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times 4.0852 - 4.0852 (.3281 - .0983) = .9388$

$A_2 = 2L(T_b - t_{mb}) = 2 \times 5.925 \times (.2074 - .0145) = .2286$

$A_3 = t_1^2 = \ldots\ldots^2 = \ldots\ldots$

$A_1 + A_2 + A_3 = .9387 + .2286 + 0 = 1.16$ sq. in. available. Additional Req'd: Yes ☐ No ☐

Pad Size (See note f)

Height = L = _____

Width = $2d_2$ = 2x _____ = _____

$A_4 = L(2d_2 - d_1)$ = _____ (_____ - _____) = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☐ No ☐

Plant/Unit CRYSTAL RIVER

System PD Calc # IRN5

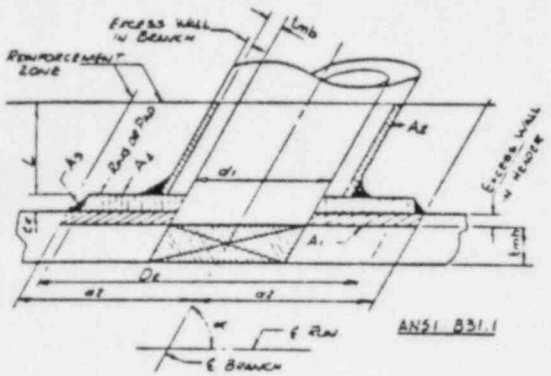
CALC. BY David M. Lovell CH. BY K. S. Elliott

DATE 12/14/82 DATE 1-4-83

NOZZLE REINFORCEMENT

WORK SHEET WS-1.75

By: JSB
Ck: RCC



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: 1600 psi @ 150 °F

		HEADER		BRANCH	
Nominal Size		24"		2"	
Outside Diameter	D_h	24"	D_b	2.375	
Nominal Wall	$\bar{T}_h$	0.375	$\bar{T}_b$		
Actual or Min. Wall (a)	T_h	.375	T_b		
Material Spec.		SA 106		SA 106	
Allowable Stress (b)	S_h	15K	S_b	15K	
Joint Efficiency (c)	E_h	1.0	E_b	1.0	
y-factor (d)	y_h	0.4	y_b	0.4	
Struct. Stab. Factor (e)	A_h	—	A_b	—	
Intersection Angle	α	90°			

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{.165 \times 24}{2 \times 15{,}000 \times 1.0 + 2 \times 0.4 \times .165} + 0 = .175$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{.165 \times 2.375}{2 \times 15{,}000 \times 1.0 + 2 \times 0.4 \times .165} + 0 = .018$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{2.375 - 2 \times .218}{1.0} = 1.939$$

$d_2 = d_1$ or $= T_b + T_h + 0.5d_1 = .218 + .375 + 0.5 \times 1.939 = 1.562$

Select larger of the values, but not to exceed D_h. $d_2 = 1.939$

$L = 2.5(\bar{T}_b) = 2.5 \times .218 = .545$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .175 \times 1.939 \times (2 - 1.0) = .363$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times (3.125 - 1.939)(.375 - .175) = .474$

$A_2 = 2L(T_b - t_{mb}) = 2 \times .545 \times (.218 - .018) = .218$

$A_3 = t_f^2 = (\quad)^2 =$

$A_1 + A_2 + A_3 = .474 + .218 + 0 = .692$ sq. in. available. Additional Req'd: Yes ☐ No ☒

Pad Size (See note f)

Height = L = _____

Width = $2d_2$ = 2x _____ = _____

$A_4 = L(2d_2 - d_1)$ = _____ (_____ - _____) = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☐ No ☐

Plant/Unit _____

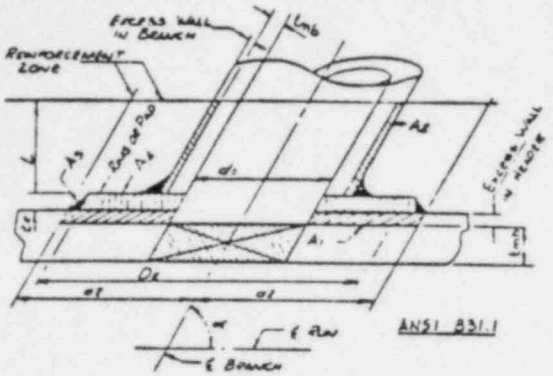
System RN Calc # IRN6

CALC. BY Dinesh Patel CH. BY _____

DATE 12-2-82 DATE 12-1-82

NOZZLE REINFORCEMENT

WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: ..165... psi @ ..150..... °F

		HEADER		BRANCH	
Nominal Size			24"		6"
Outside Diameter	D_h	24"		D_b	6.625"
Nominal Wall	$\bar{T}_h$	.562		$\bar{T}_b$	.432
Actual or Min. Wall (a)	T_h	.531		T_b	.432
Material Spec.		A-106 B			
Allowable Stress (b)	S_h			S_b	
Joint Efficiency (c)	E_h	1.0		E_b	1.0
y-factor (d)	y_h	.4		y_b	
Struct. Stab. Factor (e)	A_h	—		A_b	—
Intersection Angle	α	90°			

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{..2.5.. \times .24..}{2x.15000 \times .1.0.. + 2x.2.1.. \times .165..} + ...0..... = ...0.331.....$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{.165. \times .6.625}{2x.15000 \times .1.0.. + 2x.2.4.. \times .165..} + ...0..... = ...0.331.....$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{.6.625 - 2x.432}{.....1.....} = ...1.125.....$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .245. + .3281 + 0.5x .....1.125..... = ...1.041.....

Select larger of the values, but not to exceed D_h. d_2 = ...1.125.....

L = 2.5 ($\bar{T}_b$) = 2.5 x .432... = ...1.08.....

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

A_{req} = 1.07 (t_{mh}) (d_1) (2 - sin α) = 1.07 x .1314 x 1.125 x (2 - .....1.....) = ...2.....

A_1 = ($2d_2 - d_1$) ($T_h - t_{mh}$) = 2x (.....2.250 - .....1.125.....) (.....531 - .....0331.....) = ...0.207.....

A_2 = 2L($T_b - t_{mb}$) = 2 x .1.08... x (.432 - .0331) = ...0.812.....

A_3 = t_f^2 = ~~(.....)^2 = ...~~

$A_1+A_2+A_3$ = ...0.207 + .2812 + ... = ...1.5..... sq. in. available. Additional Req'd: Yes ☐ No ☒

Pad Size (See note f)

Height = L = _____

Width = $2d_2$ = 2x _____ = _____

A_4 = L($2d_2 - d_1$) = _____ (_____ - _____) = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☐ No ☐

Plant/Unit Catawba 1 & 2

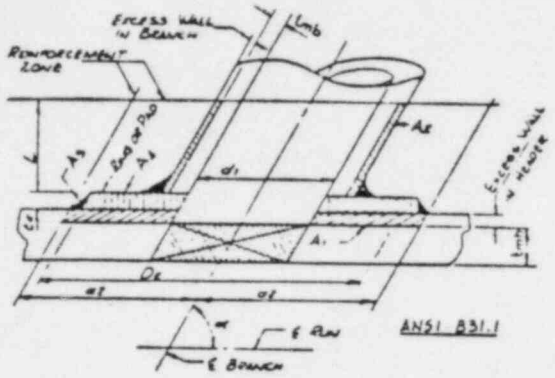
System RN Calc # IRN7

CALC. BY [illegible] CH. BY [illegible]

DATE 12-8-82 DATE 12-22-82

NOZZLE REINFORCEMENT

WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: ..[illegible].. psi @ ..[illegible].. °F

		HEADER		BRANCH
Nominal Size		24"		4"
Outside Diameter	D_h	24	D_b	4.5
Nominal Wall	$\bar{T}_h$	0.375	$\bar{T}_b$	.237
Actual or Min. Wall (a)	T_h	0.3281	T_b	.237
Material Spec.		A-106		A-106
Allowable Stress (b)	S_h	[illegible]	S_b	15.0
Joint Efficiency (c)	E_h	1.0	E_b	1.0
y-factor (d)	y_h	0.4	y_b	0.4
Struct. Stab. Factor (e)	A_h	—	A_b	—
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{..[illegible].. \times .24..}{2\times..[illegible]..\times..1.0.. + 2\times..0.4..\times..[illegible]..} + ... = ...$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{..[illegible].. \times ..4.5.}{2\times..[illegible]..\times..1.0.. + 2\times..0.4..\times..[illegible]..} + ... = ...$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{..4.5.. - 2\times..2374}{...1....} = ..4.09$$

$d_2 = d_1$ or $= T_b + T_h + 0.5d_1$ = ..[illegible].. + ..[illegible].. + 0.5 x ..4.09 = ...

Select larger of the values, but not to exceed D_h. d_2 = ..4.09

$L = 2.5(\bar{T}_b) = 2.5 \times .237.. = ..593$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha)$ = 1.07 x ..[illegible].. x ..4.09.. x (2 - ...1...) = ...

$A_1 = (2d_2 - d_1)(T_h - t_{mh})$ = 2x ..4.09..-..4.09..)(.3281..-..[illegible]..) = .805

$A_2 = 2L(T_b - t_{mb})$ = 2 x ..593.. x (..2374 - ..[illegible]..) = ..[illegible]..

$A_3 = t_f^2 = (.....)^2$ = ...

$A_1 + A_2 + A_3$ = ..805 + ..[illegible].. + ... = 1.022 sq. in. available. Additional Req'd: Yes ☐ No ☒

Pad Size (See note f)

Height = L = _____

Width = $2d_2$ = 2x _____ = _____

$A_4 = L(2d_2 - d_1)$ = _____ (____ - ____) = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☒ No ☐

Plant/Unit Oyster Creek 1

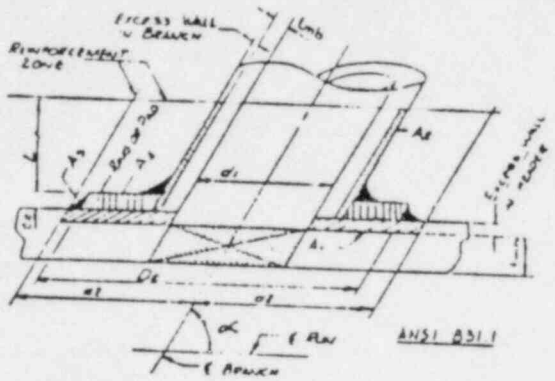
System RN Calc # IRN8

CALC. BY [illegible] CHK. BY RE Ellefson

DATE [illegible] DATE 1-4-83

NOZZLE REINFORCEMENT

WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: 165 psi @ 150 °F

		HEADER		BRANCH	
Nominal Size			20		8"
Outside Diameter		D_h	20"	D_b	8.625
Nominal Wall		$\bar{T}_h$	.375	$\bar{T}_b$	.322
Actual or Min. Wall (a)		T_h	.375	T_b	.2818
Material Spec.			A-106		A-106
Allowable Stress (b)		S_h	15K	S_b	15K
Joint Efficiency (b)		E_h	1.0	E_b	1.0
y-factor (b)		y_h	0.4	y_b	0.4
Struct. Stab. Factor		A_h	—	A_b	—
Intersection Angle		α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{165 \times 20}{2 \times 15{,}000 \times 1.0 + 2 \times 0.4 \times 165} + 0 = .1945$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{165 \times 8.625}{2 \times 15{,}000 \times 1.0 + 2 \times 0.4 \times 165} + 0 = .0474$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{8.625 - 2 \times .322}{1} = 8.0614$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .2818 + .3750 + 0.5 × 8.0614 = 4.64

Select larger of the values, but not to exceed D_h. d_2 = 8.0614

$L = 2.5(\bar{T}_b) = 2.5 \times .322 = .805$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 \cdot \sin\alpha) = 1.07 \times .1945 \times 8.0614 \times (2 - 1) = 1.6944$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times (8.0614 - 8.0614)(.375 - .1945) = 1.7614$ (See Note C)

$A_2 = 2L(T_b - t_{mb}) = 2 \times .805 \times (.2818 - .0474) = .3777$

$A_3 = t_1^2 = (\quad)^2 =$

$A_1 + A_2 + A_3 = 1.7614 + .3777 + 0 = 2.14$ sq. in. available. Additional Req'd: Yes ☐ No ☒

PAD SIZE:

L = _____ min. height

De = $2d_2$ = 2x _____ = _____ min width

A_4 = LxDe = _____ x _____ = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☐ No ☐

Plant/Unit [illegible]

System RN Calc. # IRN9

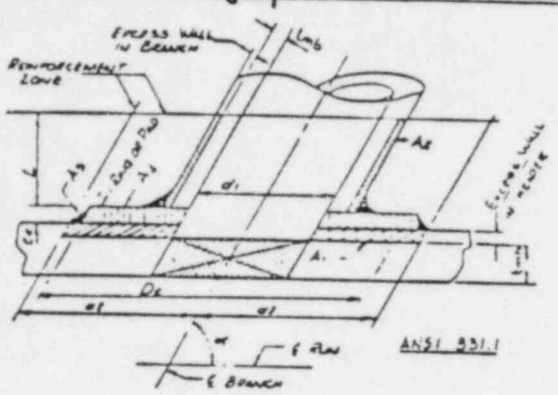
CALC. BY Anna M. Pierce BY R.G. Ellyson

DATE _____ DATE 12-22-82

NOZZLE REINFORCEMENT

WORK SHEET WS-1.75

By: JS Beale Ck: RG Ellington CN-1492-FM054 [illegible] F



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: 165 psi @ 150 °F

		HEADER		BRANCH
Nominal Size		20		6
Outside Diameter	D_h	20	D_b	6.625
Nominal Wall	$\bar{T}_h$	.375	$\bar{T}_b$	.280
Actual or Min. Wall	T_h	.328	T_b	.245
Material Spec.		A-106		A-106
Allowable Stress	S_h	[illegible]	S_b	[illegible]
Joint Efficiency	E_h	[illegible]	E_b	[illegible]
y-factor	Y_h	0.4	Y_b	0.4
Struct. Stab. Factor	A_h	—	A_b	—
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2Y_hP} + A_h = \frac{.165 \times 20}{2 \times 15{,}000 \times 1.0 + 2 \times 0.4 \times .165} + 0 = .11$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2Y_bP} + A_b = \frac{.165 \times 6.625}{2 \times 15{,}000 \times 1.0 + 2 \times 0.4 \times .165} + 0 = .0363$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{6.625 - 2 \times .245}{\ldots\ldots} = 6.135$$

$$d_2 = d_1 \text{ or } = T_b + T_h + 0.5d_1 = .245 + .328 + 0.5 \times 6.135 = 3.641$$

Select larger of the values, but not to exceed D_h. $d_2 = 6.135$

$$L = 2.5(\bar{T}_b) = 2.5 \times .280 = .7$$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .11 \times 6.135 \times (2 - 1) = .722$$

$$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times (6.135 - 6.135)(.328 - .11) = 1.337$$

$$A_2 = 2L(T_b - t_{mb}) = 2 \times .70 \times (.245 - .0363) = .30$$

$$A_3 = t_f^2 = (\ldots\ldots)^2 = \ldots\ldots$$

$A_1 + A_2 + A_3 = 1.337 + .30 + \ldots\ldots = 1.67$ sq. in. available. Additional Req'd: Yes ☐ No ☒

Pad Size (See note f)

Height = L = _____

Width = $2d_2$ = 2x_____ = _____

$A_4 = L(2d_2 - d_1)$ = _____ (_____ - _____) = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☐ No ☐

Plant/Unit CATAWBA / 1

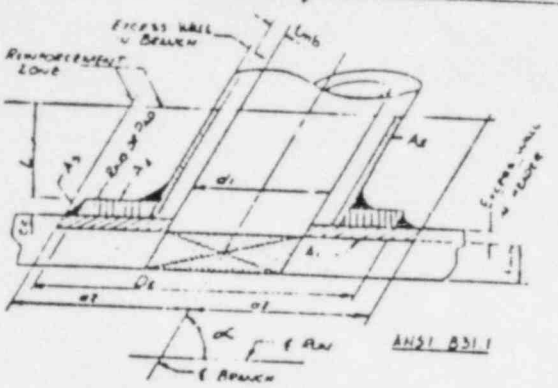
System RN Calc # IRN10

CALC. BY [illegible] BY [illegible]

DATE 12/28/82 DATE 1-5-83

NOZZLE REINFORCEMENT

ANSI B31.1 WORK SHEET WS-1.25



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: ..165.. psi @ ..150.. °F

		HEADER		BRANCH	
Nominal Size			20		4
Outside Diameter	D_h		20	D_b	4.5
Nominal Wall	$\bar{T}_h$			$\bar{T}_b$	.237
Actual or Min. Wall (a)	T_h		.375	T_b	.2079
Material Spec.			24-C		
Allowable Stress (b)	S_h		15	S_b	
Joint Efficiency (b)	E_h		1.0	E_b	
Y-factor (b)	Y_h		.4	Y_b	
Struct. Stab. Factor	A_h		—	A_b	—
Intersection Angle	α		90		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2Y_hP} + A_h = \frac{.165 \times .20}{2 \times 15.00 \times 1.0 + 2 \times .4 \times .165} + \ldots\ldots = \ldots\ldots$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2Y_bP} + A_b = \frac{.165 \times .45}{2 \times 15.00 \times 1.0 + 2 \times .4 \times .165} + \ldots\ldots = .0247$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{.45 - 2 \times .2079}{1.0} = .409$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .237 + .375 + 0.5 × .409 = 2.655

Select larger of the values, but not to exceed D_h. d_2 = .409

$L = 2.5(\bar{T}_b) = 2.5 \times .237 = .5925$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .0247 \times .409 \times (2 - 1.0) = .0101$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times (.409 - .409)(.375 - .0247) = .0000$ (See Note C)

$A_2 = 2L(T_b - t_{mb}) = 2 \times .5925 \times (.2079 - .0247) = .2172$

$A_3 = t_1^2 = (.1875)^2 = .0352$

$A_1 + A_2 + A_3 = .0000 + .2172 + .0352 = .2524$ sq. in. available. Additional Req'd: Yes ☐ No ☐

PAD SIZE:

L = _____ min. height

De = $2d_2$ = 2x _____ = _____ min width

A_4 = LxDe = _____ x _____ = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☐ No ☐

Plant/Unit _____

System _____ Calc. # IRN11

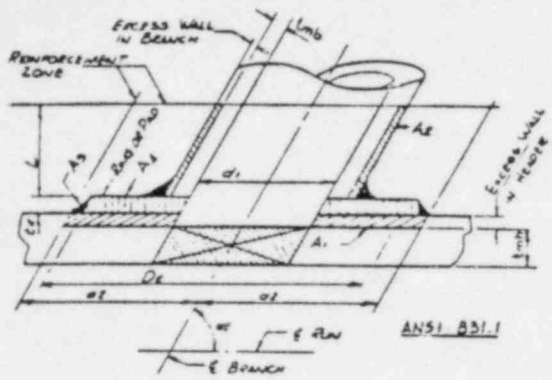
CALC. BY [illegible] CH. BY R.C. White

DATE _____ DATE 1-4-83

NOZZLE REINFORCEMENT

WORK SHEET WS-1-75

REL



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: ...1[illegible]... psi @ ...150... °F

		HEADER		BRANCH	
Nominal Size			12		6
Outside Diameter		D_h	12.75	D_b	6.625
Nominal Wall		$\bar{T}_h$	[illegible]	$\bar{T}_b$	[illegible]
Actual or Min. Wall	(a)	T_h	.32	T_b	.28
Material Spec.			[illegible]		[illegible]
Allowable Stress	(b)	S_h		S_b	
Joint Efficiency	(c)	E_h	[illegible]	E_b	1.0
y-factor	(d)	y_h	.4	y_b	.4
Struct. Stab. Factor	(e)	A_h	—	A_b	—
Intersection Angle		α			

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{\text{[illegible]} \times \text{[illegible]}}{2\times\text{[illegible]}\times\text{[illegible]} + 2\times\text{[illegible]}\times\text{[illegible]}} + \text{[illegible]} = \text{[illegible]}$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{\text{[illegible]} \times \text{[illegible]}}{2\times\text{[illegible]}\times\text{[illegible]} + 2\times\text{[illegible]}\times\text{[illegible]}} + \text{[illegible]} = \text{[illegible]}$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{\text{[illegible]} - 2\times\text{[illegible]}}{\text{[illegible]}} = 8.0614$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = [illegible] + [illegible] + 0.5 × [illegible] = [illegible]

Select larger of the values, but not to exceed D_h. d_2 = [illegible]

$L = 2.5(\bar{T}_b) = 2.5 \times$ [illegible] = [illegible]

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07\,(t_{mh})\,(d_1)\,(2 - \sin\alpha)$ = 1.07 × [illegible] × 8.0614 × (2 - [illegible]) = [illegible]

$A_1 = (2d_2 - d_1)\,(T_h - t_{mh})$ = 2 × [illegible] × ([illegible] - [illegible]) = [illegible]

$A_2 = 2L(T_b - t_{mb})$ = 2 × [illegible] × ([illegible] - [illegible]) = [illegible]

$A_3 = t_f^2$ = ([illegible])^2 = [illegible]

$A_1 + A_2 + A_3$ = [illegible] + [illegible] + [illegible] = [illegible] sq. in. available. Additional Req'd: Yes ☐ No ☐

Pad Size (See note f)

Height = L = _____

Width = $2d_2$ = 2x_____ = _____

$A_4 = L(2d_2 - d_1)$ = _____ (_____ - _____) = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☐ No ☐

Plant/Unit _____

System [illegible] Calc # IBN12

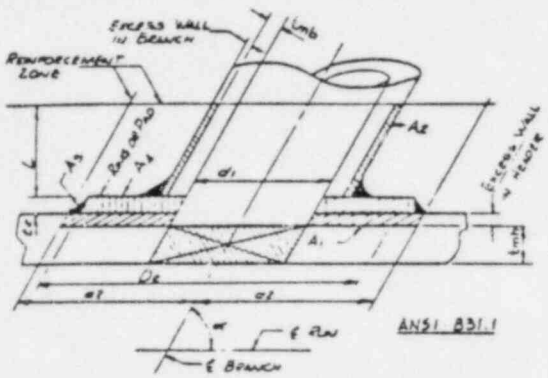
CALC. BY [illegible] CHK BY [illegible]

DATE _____ DATE [illegible]

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75

By: JS Burke
CK: RL Ellington



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: .165... psi @ ..152...°F

		HEADER		BRANCH	
Nominal Size			18		6
Outside Diameter		D_h	18	D_b	6.625
Nominal Wall		$\bar{T}_h$	.375	$\bar{T}_b$	.09
Actual or Min. Wall	(a)	T_h	.3281	T_b	.245
Material Spec.			A 106		A 106
Allowable Stress	(b)	S_h	15k	S_b	15k
Joint Efficiency	(c)	E_h	1.0	E_b	1.0
y-factor	(d)	y_h	.4	y_b	.4
Struct. Stab. Factor	(e)	A_h	—	A_b	—
Intersection Angle		α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{.165 \times 18}{2 \times 15{,}000 \times 1.0 + 2 \times .4 \times .165} + \ldots\ldots = .0996$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{.165 \times 6.625}{2 \times 15{,}000 \times 1.0 + 2 \times .4 \times .165} + \ldots\ldots = .0363$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{6.625 - 2 \times .245}{1} = 6.135$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .245 + .3281 + 0.5 × 6.135 = 3.641

Select larger of the values, but not to exceed D_h. d_2 = 6.135

$L = 2.5(\bar{T}_b) = 2.5 \times .25 = .7$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07\,(t_{mh})\,(d_1)\,(2 \cdot \sin\alpha)$ = 1.07 × .0996 × 6.135 × (2 − 1) = .6538

$A_1 = (2d_2 - d_1)\,(T_h - t_{mh})$ = 2 × (6.135 − 6.135) × (.3281 − .0996) = .000

$A_2 = 2L(T_b - t_{mb})$ = 2 × .7 × (.245 − .0363) = .2926

$A_3 = t_f^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_1 + A_2 + A_3$ = .000 + .2926 + ... = .7 sq. in. available. Additional Req'd: Yes ☐ No ☒

Pad Size (See note f)

Height = L = _____

Width = $2d_2$ = 2x _____ = _____

$A_4 = L(2d_2 - d_1)$ = _____ (_____ − _____) = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☐ No ☐

Plant/Unit Crystal River 3

System CN Calc # IRN13

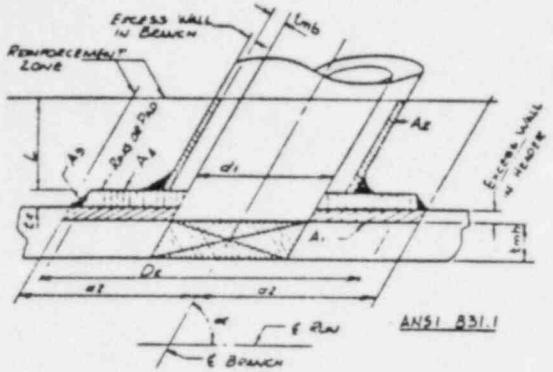
CALC. BY [illegible] CH. BY RL Ellington

DATE _____ DATE 12-21-82

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75

PEF



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: .165. psi @ .150. °F

		HEADER		BRANCH
Nominal Size		18"		4
Outside Diameter	D_h	18	D_b	4.5
Nominal Wall	$\bar{T}_h$	.375	$\bar{T}_b$	.237
Actual or Min. Wall (a)	T_h	.3281	T_b	.2074
Material Spec.		SA-106		SA-106
Allowable Stress (b)	S_h	15K	S_b	15K
Joint Efficiency (c)	E_h	1.0	E_b	1.0
y-factor (d)	y_h	0.4	y_b	0.4
Struct. Stab. Factor (e)	A_h	—	A_b	—
Intersection Angle	α	90°		

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{.165 \times .18}{2\times 15{,}000 \times 1.0 + 2\times .4 \times .165} + \ldots\ldots = .0006$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{.165 \times .45}{2\times 15{,}000 \times 1.0 + 2\times .4 \times .165} + \ldots\ldots = .0014$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{.45 - 2\times .2074}{\ldots 1 \ldots} = .4.09$$

d_2 = d_1 or = $T_b + T_h + 0.5d_1$ = .2074 + .3281 + 0.5 x 4.09 = 2.561

Select larger of the values, but not to exceed D_h. d_2 = 1.09

L = 2.5 ($\bar{T}_b$) = 2.5 x .237 = 1.593

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

A_{req} = 1.07 (t_{mh}) (d_1) (2 - sin α) = 1.07 x .0006 x 1.09 x (2 - .....) = .0013

A_1 = $(2d_2 - d_1)(T_h - t_{mh})$ = 2x (4.09 - 4.09) (.3281 - .0006) = .0000

A_2 = $2L(T_b - t_{mb})$ = 2 x .593 x (.2074 - .0006) = .2452

A_3 = t_f^2 = (.....)^2 = ...

$A_1 + A_2 + A_3$ = .0000 + .2452 + ... = .2452 sq. in. available. Additional Req'd: Yes ☐ No ☒

Pad Size (See note f)

Height = L = _____

Width = $2d_2$ = 2x _____ = _____

$A_4 = L(2d_2 - d_1)$ = _____ (_____ - _____) = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☐ No ☐

Plant/Unit _____

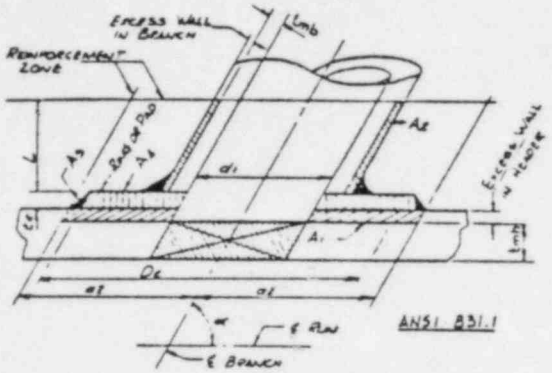
System CN Calc # IRN14

CALC. BY Dinesh M. CHK. BY R G Clifton

DATE 12-9-82 DATE 12-22-82

NOZZLE REINFORCEMENT

WORK SHEET WS-1-75



Required reinforcement area

Area A_1 – excess wall in header

Area A_2 – excess wall in branch

Area A_3 – fillet weld metal

Area A_4 – metal in ring or pad

DESIGN CONDITIONS: 165 psi @ 150 °F

		HEADER	BRANCH
Nominal Size		12	8
Outside Diameter	D_h / D_b	12.75	8.625
Nominal Wall	$\bar{T}_h$ / $\bar{T}_b$	.375	.322
Actual or Min. Wall (a)	T_h / T_b	.3281	0.219
Material Spec.		A106	A106
Allowable Stress (b)	S_h / S_b	15,000	15,000
Joint Efficiency (c)	E_h / E_b	1.0	1.0
y-factor (d)	y_h / y_b	0.4	0.4
Struct. Stab. Factor (e)	A_h / A_b	—	—
Intersection Angle	α	90°	

REQUIRED THICKNESS:

$$t_{mh} = \frac{PD_h}{2S_hE_h + 2y_hP} + A_h = \frac{165 \times 12.75}{2 \times 15{,}000 \times 1.0 + 2 \times 0.4 \times 165} + \ldots\ldots = .2035$$

$$t_{mb} = \frac{PD_b}{2S_bE_b + 2y_bP} + A_b = \frac{165 \times 8.625}{2 \times 15{,}000 \times 1.0 + 2 \times 0.4 \times 165} + \ldots\ldots = .1377$$

LIMITS OF REINFORCEMENT:

$$d_1 = \frac{D_b - 2T_b}{\sin\alpha} = \frac{8.625 - 2 \times .2815}{1} = 8.0619$$

$$d_2 = d_1 \text{ or } = T_b + T_h + 0.5d_1 = .2815 + .3281 + 0.5 \times 8.0619 = 4.2$$

Select larger of the values, but not to exceed D_h. d_2 = 8

$L = 2.5(\bar{T}_b) = 2.5 \times .322 = .805$

REQUIRED AND AVAILABLE REINFORCEMENT AREA:

Note: For A_h or $A_b \neq 0$, subtract value from appropriate T_h or T_b

$A_{req} = 1.07(t_{mh})(d_1)(2 - \sin\alpha) = 1.07 \times .2035 \times 8.0619 \times (2 - 1) = .6922$

$A_1 = (2d_2 - d_1)(T_h - t_{mh}) = 2 \times (8 - 8.0619)(.3281 - .2035) = \ldots\ldots$

$A_2 = 2L(T_b - t_{mb}) = 2 \times .805 \times (.2815 - .2035) = .1255$

$A_3 = t_f^2 = (\ldots\ldots)^2 = \ldots\ldots$

$A_1 + A_2 + A_3 = \ldots\ldots + .1255 + \ldots\ldots = \ldots\ldots$ sq. in. available. Additional Req'd: Yes ☐ No ☐

Pad Size (See note f)

Height = L = _____

Width = $2d_2$ = 2x _____ = _____

$A_4 = L(2d_2 - d_1)$ = _____ (_____ - _____) = _____

$A_1 + A_2 + A_3 + A_4$ =

_____ + _____ + _____ + _____ = _____

Additional reinforcement adequate: Yes ☐ No ☐

Plant/Unit _____

System _____ Calc # IRN15

CALC. BY _____ CH. BY _____

DATE _____ DATE 12-22-82

NOZZLE REINFORCEMENT

ANSI B31.1 | WORK SHEET WS-1-75