

Allowable Design Pressures
for
Various Branch Connection Configurations
to be used in the
ASME Section III Class 1 Piping
of the
CATAWBA Nuclear Power Station

Prepared for: DUKE POWER COMPANY

Prepared by: EDS NUCLEAR INC.
August, 1977

EDS Report No. PAD-77-118

EDS NUCLEAR INC.

REPORT APPROVAL COVER SHEET

Client: Duke Power Company

Project: - Catawba Nuclear Plant Job Number: 0930910

Report Title: Allowable Design Pressures for Various Branch Connection Configurations to be used in the ASME Section III Class 1 Piping of the Catawba Nuclear

Report Number: PAD-77-118 Rev. 5 Power Station

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: 8/30/77

Reviewed By: C.S. MacDonald Date: August 22, 1977

Approved By: John McCarthy Date: August 31, 1977

REVISION RECORD

Rev. No.	Prepared	Reviewed	Approved	Approval Date	Revision
1	John T. Branski	Vincent Yee	C.G. Ross	11/30/77	revised tables
2	John T. Branski	Vincent Yee	C.G. Ross	2/10/78	misc. revisions
3	Vincent Yee	William R. Arnold	C.G. Ross	3/22/78	misc. revisions
4	Ron P. Bates	K. Kawan	J.M. Duke	9/10/81	expanded tables
5	D.W. Litalo	K. Kawan	J.M. Duke	2/24/82	report certification

Revision 1

Revised tables to reflect nominal dimensions and deleted Special Welding Bosses where the run pipe wall thickness and/or nominal pipe size are below values shown on MDG-ES-2.

Revision 2

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. Example 2 revised to be consistent with the exclusions noted.
- d. Page numbers have been added to the text and tables.

Revision 3

Revision includes the following items:

- a. Table 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.
- b. Summary tables have been added to include the required r_2 values for 2,500 PSI pressure.

Revision 4

Revision includes the following items:

- a. Tables 1, 2 and 3 have been expanded to include a 1" special welding flow orifice boss attached to a 3" SCH 160 pipe. This fitting initially didn't appear in the tables because of insufficient run pipe thickness, a requirement due to fabricability (see Page 2 of this report, Page 8 and Appendix B of EDS Report No. PAD-77-117). Since Duke assured EDS that this fitting combination is fabricable there is no longer a restriction on run pipe thickness for the 1" SWFOB on the 3" SCH 160 pipe.

Revision 5

- a. Revision includes the addition of the ASME Code Certification page and renumbering of all pages in the report.

CERTIFICATION

The undersigned, a registered Professional Engineer, competent in the field of piping stress analysis, certifies that to the best of his knowledge and belief the analysis calculations for the subject components as presented in this report comply with the requirements of the applicable portions of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components.



David W. Peltola 2.3 Feb 82
Date

State of Georgia Registration No.: 12510

Explanatory Notes

The piping design criteria of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant 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, involving calculations, which guarantee the stress limit requirements of NB-3640 are satisfied for branch connections that meet the configurational requirements of the rules. Additionally, paragraph NB-3686 sets forth more restrictive configurational requirements in order for the stress indices of paragraph NB-3686 to be applicable to the branch connection. The allowable pressure values, for various branch connections, contained herein are based upon the requirements of NB-3643 and as modified by NB-3686. 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 1, 2, and 3. It should be noted that the limits set forth in Figure 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 must 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.

Documentation and certification of the pressure values contained in the tables is presented in EDS Nuclear report PAD-77-117.

Use of Tables

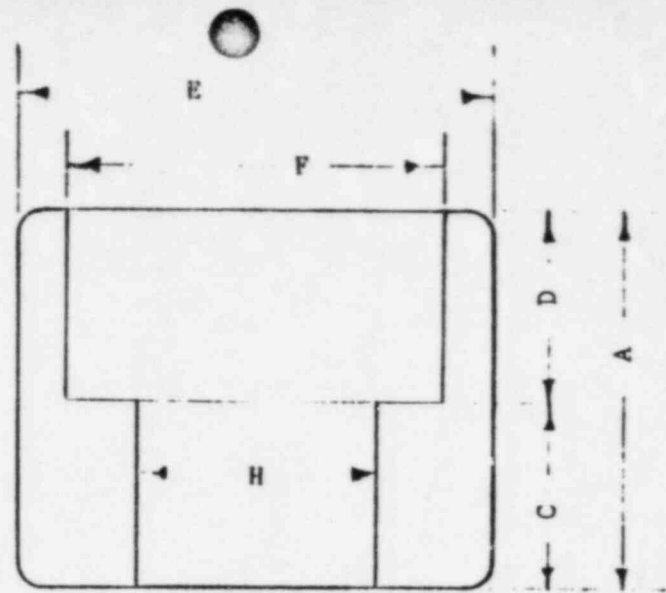
Each table is for a given design temperature and run, branch, and fitting material combination which is presented at the top of the table. The table is composed of a matrix of maximum allowable pressure for a given

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 schedule considered. 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. From the tables it should be noted that the branch pipe never controls the branch connection allowable pressure, the run pipe is always controlling for the special welding flow orifice boss branch connection, and the smaller the run pipe, the more likely that the run pipe controls.

While the tables contained within are for various temperatures to account for different allowable stress values, those branch connection configurations which have the same run and fitting stress allowable can be used to determine allowable pressures by taking the ratio of the new allowable stress to the stress allowable at the top of the table times the pressure in the matrix.

Examples

- 1) A 2 inch-6000# half coupling on a 14 inch run pipe at 600^oF requires a 2400 psi design pressure. From the 600^oF table, the 2 inch-6000# half coupling fitting is rated for 2360 psi which is less than the required design pressure. Since the 6000# half coupling results in an unacceptable design, an alternate design must be used. The 2 inch-SWB is rated at 2550 psi which means it is acceptable for use at the design pressure required.
- 2) A 1 inch-SWB on a 8 inch run pipe at 700^oF requires a 2400 psi design pressure. From the appropriate table, the 1 inch-SWB is rated for 3160 psi which makes the configuration acceptable. The table also indicates the 1 inch-6000# half coupling is acceptable since it is rated at 2970 psi versus the 2400 psi design pressure.
- 3) A 3/4 inch-6000# half coupling on a 14 inch run pipe at 650^oF requires a 2650 psi design pressure. From the table, the 3/4 inch half coupling is rated at 2550 psi and the 3/4 inch-SWB is rated at 2630 psi. Both fittings are unacceptable designs.

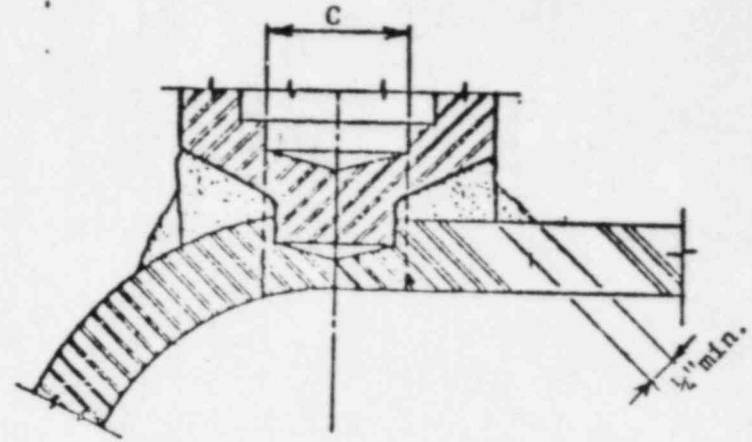
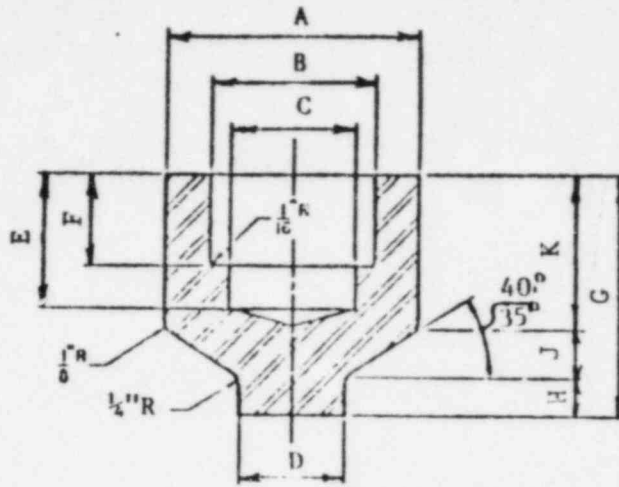


6000# HALF-COUPLING

<u>SIZE (Inches)</u>	<u>3/4"</u>	<u>1"</u>	<u>1-1/4"</u>	<u>1-1/2"</u>	<u>2"</u>
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	1.545 - minimum
D - Depth of Socket	.500	.500	.500	.500	.625 - minimum
E - Diameter	1.541	1.875	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 1 6000# HALF-COUPLING

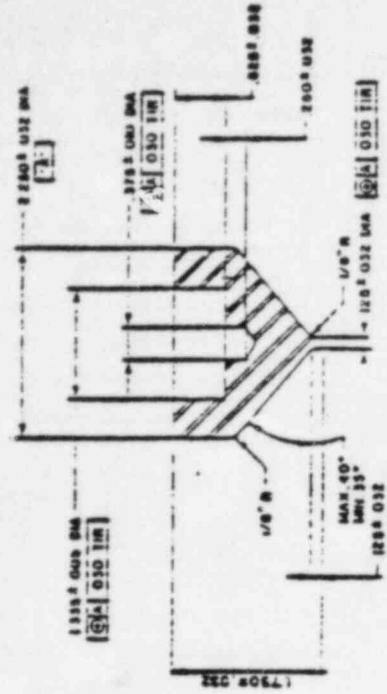


SPECIAL WELDING BOSS (SWB) (nominal dimensions)

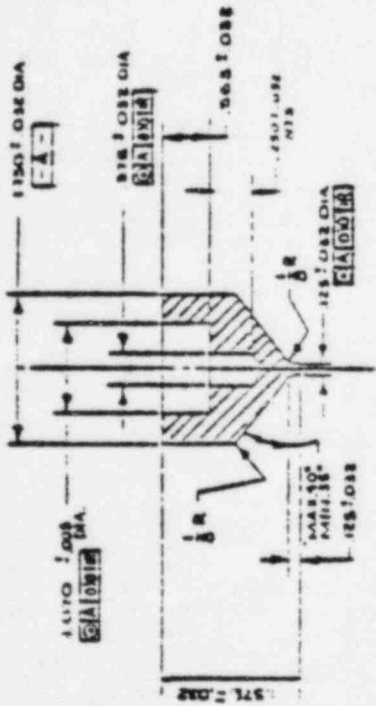
N. P. S.	A	B	C	D	E	F	G	H	J	K
	$\pm 0.032''$	$\pm 0.005''$	$\pm 0.032''$	$\pm 0.032''$	$\pm 0.032''$	$\pm 0.032''$	$\pm 0.032''$	$\pm 0.032''$	$\pm 0.065''$	$\pm 0.032''$
1/2"	1.500	0.860	0.438	0.313	0.750	0.500	1.375	0.188	0.438	0.750
3/4"	1.750	1.070	0.594	0.469	0.813	0.563	1.500	0.188	0.484	0.828
1"	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

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

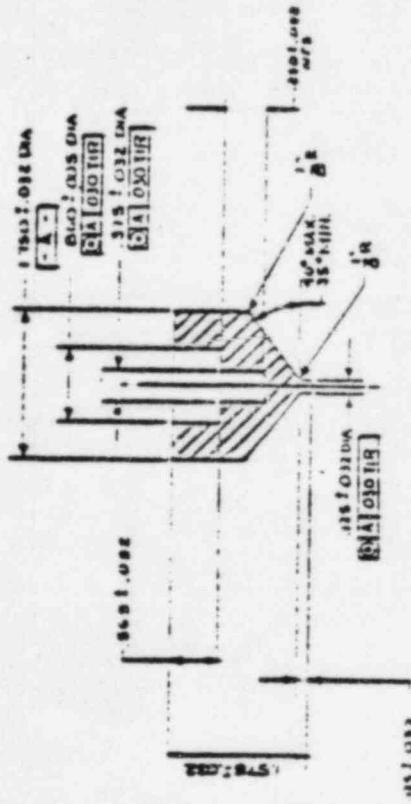
Figure 2 SPECIAL WELDING BOSS (SWB)



1" SWFOB



3/4" SWFOB



1/2" SWFOB

FIGURE 3 SPECIAL WELDING FLOW ORIFICE BOSS (SWFOB)

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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.
- (4) It is the responsibility of Duke Power Company to insure that fabrication requirements of the ASME Boiler & Pressure Vessel Code, 1974 Edition, Section III, Division I, Subsection NB-3686.1 'b' through 'h' are met.

APPLICABLE MATERIALS

TABLE 1

Fitting: SA 182 P304

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

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 (psf)					
Size & Schedule	Allowable Pressure (psf)		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
2 1/2 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
	2500	SWFOB ⁽⁴⁾	-	-	2500	-	-	-
4 In. Sch 160	3690	6000#HC	(3)	3690	3640	3330	3380	NR
		SWB	(2)	(2)	(2)	(2)	NR	
		SWFOB	(1)	(2)	(1)	(1)	(1)	
5 In. Sch 160	3500	6000#HC	(3)	3440	3390	3110	3120	3210
		SWB	(2)	(2)	(2)	(2)	(2)	
		SWFOB	(1)	(2)	(1)	(1)	(1)	
6 In. Sch 160	3360	6000#HC	(3)	3270	3220	2960	2970	3010
		SWB	(2)	(2)	(2)	(2)	(2)	
		SWFOB	(1)	(2)	(1)	(1)	(1)	
6 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 2500psf if a r_s value given in Appendix B can be met.

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BRANCH PIPE - Size, Schedule, and Allowable Pressure (psf)

RUN PIPE		FITTING PIPE (See Figures 1, 2, and 3)	BRANCH PIPE - Size, Schedule, and Allowable Pressure (psf)					
Size & Schedule	Allowable Pressure (psf)		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
2 in. Sch 160	4520	6000#HC	7430	6840	6180	4740	4650	4520
2 1/2 in. Sch 160	4040	6000#HC	(3)	4520	NR	NR	NR	NR
3 in. Sch 160	3860	6000#HC	(3)	4040	4040	NR	NR	NR
	2500	SWFOB ⁽⁴⁾	-	-	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 2500psf 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 3

TEMPERATURE: 700°F

Minimum Allowable Stress (S_m): 15,900

Corrosion Allowance: 0.0

RUN PIPE		PITTING 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
2 1/2 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
	2500	SWFOB ⁽⁴⁾	-	-	2500	-	-	-
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)

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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.

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Summary Tables of the Required r_2 Values for the 2,500 PSI Pressure

For easy reference purposes, tables 4 through 6 contain the required r_2 values for 2,500 PSI pressure corresponding to the asterisk (*) marks as shown on tables 1, 2, and 3. Each table is for a given design temperature.

TABLE 4
SUMMARY OF REQUIRED r_2 VALUES FOR 2,500 PSI PRESSURE

Size and Schedule	Run Pipe		Fitting Pipe	Branch Pipe Size and Schedule	Allowable Design Pressure (PSI)	Required r_2 For 2,500 PSI (Inches)
	Temperature (° F)	S_m (PSI)				
10 in. Sch 140	600	16,400	6,000# HC	1½ in. Sch 160	2,490	.514
10 in. Sch 140	600	16,400	6,000# HC	1½ in. Sch 160	2,480	.547
10 in. Sch 140	600	16,400	6,000# HC	2 in. Sch 160	2,480	.534
12 in. Sch 140	600	16,400	6,000# HC	1½ in. Sch 160	2,360	1.153
12 in. Sch 140	600	16,400	6,000# HC	1½ in. Sch 160	2,340	1.186
12 in. Sch 140	600	16,400	6,000# HC	2 in. Sch 160	2,340	1.166
12 in. Sch 140	600	16,400	SWB	1½ in. Sch 160	2,470	.649
14 in. Sch 140	600	16,400	6,000# HC	1½ in. Sch 160	2,390	1.152
14 in. Sch 140	600	16,400	6,000# HC	1½ in. Sch 160	2,370	1.211
14 in. Sch 140	600	16,400	6,000# HC	2 in. Sch 160	2,360	1.229
14 in. Sch 140	600	16,400	SWB	1½ in. Sch 160	2,490	.645

TABLE 5
SUMMARY OF REQUIRED r_2 VALUES FOR 2,500 PSI PRESSURE

Size and Schedule	Run Pipe		Fitting Pipe	Branch Pipe Size and Schedule	Allowable Design Pressure (PSI)	Required r_2 For 2,500 PSI (Inches)
	Temperature (°F)	S_m (PSI)				
10 in. Sch 140	650	16,100	6,000# HC	1½ in. Sch 160	2,450	.671
10 in. Sch 140	650	16,100	6,000# HC	1½ in. Sch 160	2,440	.700
10 in. Sch 140	650	16,100	6,000# HC	2 in. Sch 160	2,440	.677
12 in. Sch 140	650	16,100	6,000# HC	1 in. Sch 160	2,480	.630
12 in. Sch 140	650	16,100	6,000# HC	1½ in. Sch 160	2,310	1.354
12 in. Sch 140	650	16,100	6,000# HC	1½ in. Sch 160	2,300	1.380
12 in. Sch 140	650	16,100	6,000# HC	2 in. Sch 160	2,290	1.348
12 in. Sch 140	650	16,100	SWB	1½ in. Sch 160	2,430	.812
14 in. Sch 140	650	16,100	6,000# HC	1½ in. Sch 160	2,340	1.383
14 in. Sch 140	650	16,100	6,000# HC	1½ in. Sch 160	2,330	1.433
14 in. Sch 140	650	16,100	6,000# HC	2 in. Sch 160	2,310	1.436
14 in. Sch 140	650	16,100	SWB	1½ in. Sch 160	2,440	.832

TABLE 6

SUMMARY OF REQUIRED r_2 VALUES FOR 2,500 PSI PRESSURE

Run Pipe			Fitting Pipe	Branch Pipe	Allowable Design Pressure (PSI)	Required r_2 For 2,500 PSI (Inches)
Size and Schedule	Temperature (°F)	S_m (PSI)		Size and Schedule		
10 in. Sch 140	700	15,900	6,000# HC	1¼ in. Sch 160	2,420	.781
10 in. Sch 140	700	15,900	6,000# HC	1½ in. Sch 160	2,410	.806
10 in. Sch 140	700	15,900	6,000# HC	2 in. Sch 160	2,410	.778
12 in. Sch 140	700	15,900	6,000# HC	¾ in. Sch 160	2,490	.567
12 in. Sch 140	700	15,900	6,000# HC	1 in. Sch 160	2,450	.748
12 in. Sch 140	700	15,900	6,000# HC	1¼ in. Sch 160	2,280	1.493
12 in. Sch 140	700	15,900	6,000# HC	1½ in. Sch 160	2,270	1.515
12 in. Sch 140	700	15,900	6,000# HC	2 in. Sch 160	2,260	1.475
12 in. Sch 140	700	15,900	SWB	1¼ in. Sch 160	2,400	.925
12 in. Sch 140	700	15,900	SWB	1½ in. Sch 160	2,480	.605
12 in. Sch 140	700	15,900	SWB	2 in. Sch 160	2,480	.623

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TABLE 6
 (continued)
SUMMARY OF REQUIRED r_2 VALUES FOR 2,500 PSI PRESSURE

Run Pipe		Fitting Pipe	Branch Pipe Size and Schedule	Allowable Design Pressure (PSI)	Required r_2 For 2,500 PSI (Inches)
Size and Schedule	Temperature (°F)				
14 in. Sch 140	700	6,000# HC	1 in. Sch 160	2,470	.731
14 in. Sch 140	700	6,000# HC	1 1/4 in. Sch 160	2,310	1.544
14 in. Sch 140	700	6,000# HC	1 1/2 in. Sch 160	2,300	1.588
14 in. Sch 140	700	6,000# HC	2 in. Sch 160	2,280	1.581
14 in. Sch 140	700	SWB	1 1/4 in. Sch 160	2,410	.962
14 in. Sch 140	700	SWB	1 1/2 in. Sch 160	2,490	.646
14 in. Sch 140	700	SWB	2 in. Sch 160	2,480	.692