power grinder being the preferred method. The use of an oxy-fuel cutting torch or a welding electrode for removing excess weld metal is prohibited.

6. ELECTRICAL CHARACTERISTICS & TRAVEL SPEED

A Direct Current Reverse Polarity (DCRP), electrode positive, shall be used. The table below depicts the ranges that must be maintained throughout the procedure:

Rod Size	Rod Type	Amperage	Voltage	Travel Speed
3/32"	E6010	40-70	20-35	4-14
1/8"	E6010	65-130	20-35	4-14
	E7010	75-130		
5/32"	E6010	90-185	20-35	4-14
	E7010			
3/16"	E6010	140-225	25-35	4-14
	E7010			

7. FLAME CHARACTERISTICS

Not applicable

8. POSITION

The welding shall be performed with the pipe or assembly held stationary.

9. DIRECTION OF WELDING

The direction of the welding shall be downhill.

10. TIME BETWEEN PASSES

The maximum time interval between the completion of the stringer/root bead (first pass) and the beginning of the hot pass (second pass) is five (5) minutes. The maximum interval between the hot pass (second pass) and the next filler (third pass) shall not exceed ten (10) minutes. If for any reason the weld is not completed in a timely manner, and the weld has cooled below the temperatures outlined in Section 13 of this procedure (below), the weld shall be re-heated to the required pre-heat temperature before welding may be resumed. Additionally, the following rules shall apply:

a) Each pass shall be completed before the next pass is permitted to begin.
b) Two successive passes shall not begin at the same point.
c) A stripper or short bead shall be used to build up low areas

11. LINEUP CLAMPS

The pipe shall be supported so that there is no strain on the stringer/root bead throughout the welding process. When an external fixturing or support device is used, it shall remain in place until a maximum practical amount of the root pass is completed (a minimum of 50% of the root pass). However, where 50% of the root bead cannot be completed in equal segments on opposite sides of the joint without repositioning the fixturing/support device, tack welds can be used for alignment. Four tack welds shall be used, equally spaced around the circumference. Tack welds shall be at least three times the wall thickness in length.

12. CLEANING/GRINDING

All scale/slag, knots of filler metal (excessive metal on starts), and similar defects shall be removed with a power grinder. A combination of hand and power tools may be utilized to clean the weld metal and weld joint.

All coal tar coating shall be removed a minimum of 6" back from the beveled surface prior to welding. All remaining coatings shall be removed 4" back.

All moisture, rust, scale/slag, oil, paint, primer, coating, or other materials which may be detrimental to the finished weld shall be removed from the welding surface.

Where possible, beveling shall be performed with a machine tool or machine cutting device (oxy-acetylene torch, beveling machine). Flame cut surfaces should be smooth and regular. Power brushes shall be used for cleaning all beveled surfaces. If the beveled surface cannot be satisfactorily cleaned of foreign materials utilizing power brushes, then power sanding discs (60 grit or higher), grit blasting, or approved safety solvents may be utilized. Prior to welding, all residue left from the use of safety solvents shall be removed.

13. PRE-HEATING

Pre-heating of plain carbon steels is required under any of the following conditions:

a) When the ambient temperature is below 50°F and at the discretion of the welding inspector when the ambient temperature is above 50°F.
b) When the pipe is wet or damp for the purposes of drying the pipe prior to welding.
c) When the carbon content exceeds 0.28% (ladle analysis) or the carbon equivalent (CE) is 0.45% or greater.
d) When the percent of alloying elements will adversely affect weldability.
e) When pre-heating will alleviate existing conditions that would limit the welding technique or tend to adversely affect the quality of the weld.

During the pre-heat process, the temperature shall be maintained above 250°F and shall not exceed 375°F. Pre-heating may be achieved by the use of a gas ring, induction coil, resistance heater, or propane torch. Welding shall not begin until the required pre-heat temperature is achieved. A temperature indicating crayon, or other suitable method, shall be used to determine or verify when the required pre-heat temperature has been achieved.

The welding of a joint shall be continuous, with no interruptions, until half the depth of the welding groove has been filled. The pre-heat temperature shall be maintained until the welding is completed. If welding is interrupted, the joint shall be re-heated to the original pre-heat temperature before welding is resumed.

The minimum width of the pre-heat area on each side of the weld shall be equal to three times the pipe wall thickness or 2", whichever is greater.

There shall be no accelerated cooling of the weld joint.

14. POST-WELD HEAT TREATMENT

Not applicable.

15. GROUNDING

The ground clamp shall be designed to prevent arc burns on the pipeline. Welding of the ground clamp to the pipe is prohibited.

16. SHIELDING GAS & FLOW RATE

Not applicable.

17. SHIELDING FLUX

Not applicable.

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Welding Procedure WP-B42-1
API 1104, 20th Edition
SMAW Branch Connections & Fillet Welds
Grade B on X42, Branch Diameter < 2.375", Branch Wall Thickness < 0.188"

1. PROCESS

Shielded Metal Arc Welding (SMAW)

2. MATERIALS

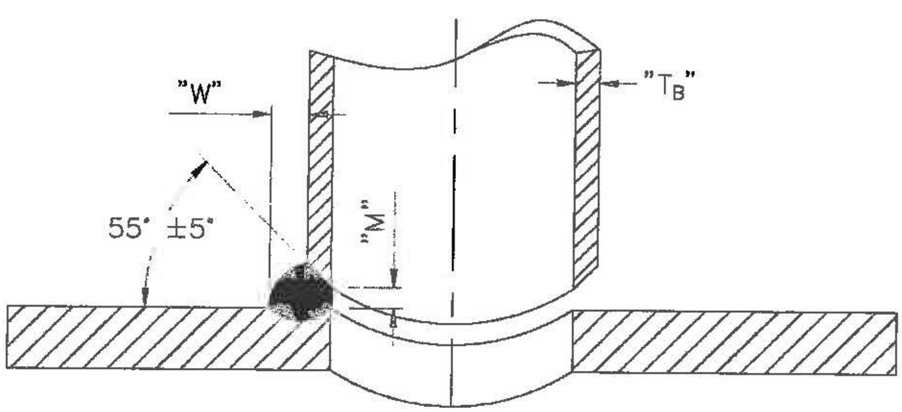
This procedure describes the welding of branch connections and fillet welds using a combination of materials manufactured to API 5L specifications or equivalent materials with similar chemical and physical properties (such as ASTM A106). This procedure is specifically written to address welding of API 5L Grade B (SMYS = 35,000) branch and fillet weld connections to API 5L X42 (SMYS = 42,000) pipe.

3. DIAMETERS & WALL THICKNESSES

Nominal Outside Diameters:	Branch < 2.375"	Run ≥ 2.375"
Nominal Wall Thicknesses:	Branch < 0.188"	Run = 0.154" – 0.750"

4. JOINT DESIGN

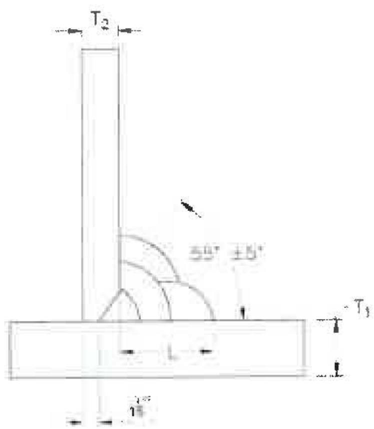
The following figures depict the joint design that shall be used for this procedure:



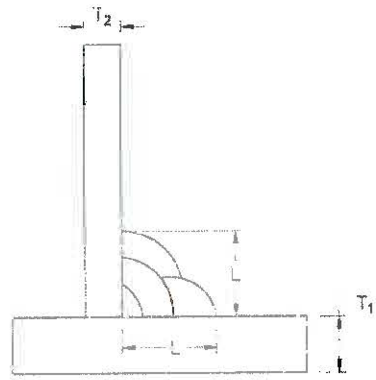
W = $\frac{3}{8}$" * T_B ($\frac{1}{4}$" MIN)
M = $\frac{1}{16}$" (MIN) – $\frac{3}{16}$" (MAX)

TYPICAL BRANCH CONNECTION

For fillet joints, the maximum dimension of L is 1.25 x T_1 or 1.25 x T_2, whichever is smaller:



TYPICAL BRANCH WELD



TYPICAL FILLET WELD

5. <u>FILLER METAL & NUMBER OF BEADS</u>

The following electrodes are approved for use with this procedure. The electrode sizes listed in the table below are the maximum diameter electrodes that shall be used. The total number of passes is the minimum number that shall be deposited. The number of passes depends upon the size of the fillet weld. The size of the fillet weld is the length of a side of the largest inscribed right triangle having two equal sides.

Material Grade	Branch Material Thickness	Rod Type	Rod Size				Minimum Passes
			Root Pass	Hot Pass	Filler Pass(s)	Cap Pass	
Grade B on X42	< 0.188	E6010	3/32	1/8			3

Tack welds are considered part of the stringer/root bead and shall be deposited with the pipe in the fixed position. Tacks welds shall be of sufficient number and length to maintain the stringer/root opening and pipe alignment. If a tack weld, or any part of the stringer/root bead, cracks or breaks, the weld shall be cut out, as a cylinder, and the pipe or fittings re-beveled. Tacks of excessive thickness shall be cut down with a power grinder, diamond point or round nosed chisel, with the power grinder being the preferred method. The use of an oxy-fuel cutting torch or a welding electrode for removing excess weld metal is prohibited.

6. ELECTRICAL CHARACTERISTICS & TRAVEL SPEED

A Direct Current Reverse Polarity (DCRP), electrode positive, shall be used. The table below depicts the ranges that must be maintained throughout the procedure:

Rod Size	Rod Type	Amperage	Voltage	Travel Speed
3/32"	E6010	40-70	20-35	4-14
1/8"	E6010	65-130	20-35	4-14

7. FLAME CHARACTERISTICS

Not applicable

8. POSITION

The welding shall be performed with the pipe or assembly held stationary.

9. DIRECTION OF WELDING

The direction of the welding shall be downhill.

10. TIME BETWEEN PASSES

The maximum time interval between the completion of the stringer/root bead (first pass) and the beginning of the hot pass (second pass) is five (5) minutes. The maximum interval between the hot pass (second pass) and the next filler (third pass) shall not exceed ten (10) minutes. If for any reason the weld is not completed in a timely manner, and the weld has cooled below the temperatures outlined in Section 13 of this procedure (below), the weld shall be re-heated to the required pre-heat temperature before welding may be resumed. Additionally, the following rules shall apply:

a) Each pass shall be completed before the next pass is permitted to begin.
b) Two successive passes shall not begin at the same point.
c) A stripper or short bead shall be used to build up low areas

11. LINEUP CLAMPS

The pipe shall be supported so that there is no strain on the stringer/root bead throughout the welding process. When an external fixturing or support device is used, it shall remain in place until a maximum practical amount of the root pass is completed (a minimum of 50% of the root pass). However, where 50% of the root bead cannot be completed in equal segments on opposite sides of the joint without repositioning the fixturing/support device, tack welds can be used for alignment. Four tack welds shall be used, equally spaced around the circumference. Tack welds shall be at least three times the wall thickness in length.

12. CLEANING/GRINDING

All scale/slag, knots of filler metal (excessive metal on starts), and similar defects shall be removed with a power grinder. A combination of hand and power tools may be utilized to clean the weld metal and weld joint.

All coal tar coating shall be removed a minimum of 6" back from the beveled surface prior to welding. All remaining coatings shall be removed 4" back.

All moisture, rust, scale/slag, oil, paint, primer, coating, or other materials which may be detrimental to the finished weld shall be removed from the welding surface.

Where possible, beveling shall be performed with a machine tool or machine cutting device (oxy-acetylene torch, beveling machine). Flame cut surfaces should be smooth and regular. Power brushes shall be used for cleaning all beveled surfaces. If the beveled surface cannot be satisfactorily cleaned of foreign materials utilizing power brushes, then power sanding discs (60 grit or higher), grit blasting, or approved safety solvents may be utilized. Prior to welding, all residue left from the use of safety solvents shall be removed.

13. PRE-HEATING

Pre-heating of plain carbon steels is required under any of the following conditions:

a) When the ambient temperature is below 50°F and at the discretion of the welding inspector when the ambient temperature is above 50°F.
b) When the pipe is wet or damp for the purposes of drying the pipe prior to welding.
c) When the carbon content exceeds 0.28% (ladle analysis) or the carbon equivalent (CE) is 0.45% or greater.
d) When the percent of alloying elements will adversely affect weldability.
e) When pre-heating will alleviate existing conditions that would limit the welding technique or tend to adversely affect the quality of the weld.

During the pre-heat process, the temperature shall be maintained above 250°F and shall not exceed 375°F. Pre-heating may be achieved by the use of a gas ring, induction coil, resistance heater, or propane torch. Welding shall not begin until the required pre-heat temperature is achieved. A temperature indicating crayon, or other suitable method, shall be used to determine or verify when the required pre-heat temperature has been achieved.

The welding of a joint shall be continuous, with no interruptions, until half the depth of the welding groove has been filled. The pre-heat temperature shall be maintained until the welding is completed. If welding is interrupted, the joint shall be re-heated to the original pre-heat temperature before welding is resumed.

The minimum width of the pre-heat area on each side of the weld shall be equal to three times the pipe wall thickness or 2", whichever is greater.

There shall be no accelerated cooling of the weld joint.

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Welding Procedure WP-IS
API 1104, 20th Edition
SMAW In-Service Welding
Grade ≤ X65, All Diameters, Wall Thickness ≤ 0.750"

1. PROCESS

Shielded Metal Arc Welding (SMAW)

2. MATERIALS

This procedure describes in-service welding for pipe and fittings manufactured to API 5L specifications with a specified minimum yield strength less than or equal to 65,000 psig and equivalent materials with similar chemical and physical properties (such as ASTM A106).

Furthermore, this procedure is broken down into the following material carbon equivalent ranges:

a) CE ≤ 0.50%
b) CE > 0.50%

Carbon equivalent (CE) is determined by the following:

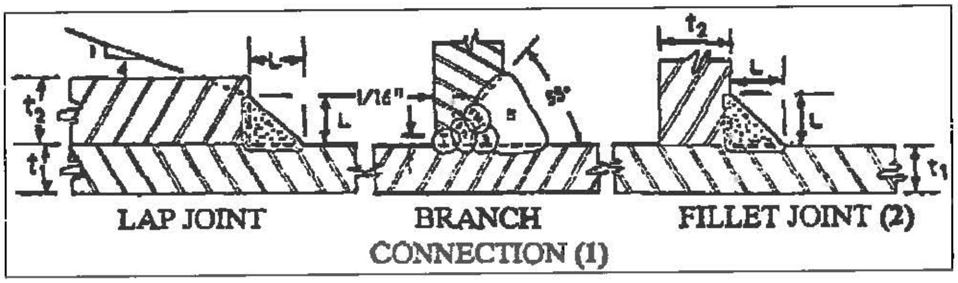
a) CE = C+Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15
    - Where C = Carbon, Mn = Manganese, Cr = Chromium, Mo = Molybdenum, V = Vanadium, Ni = Nickel, and Cu = Copper in weight percentages.
b) Where one or more of the elements in the CE equation are unknown, the CE can be estimated by the following:
    - $CE_{EST} = C + Mn/4$
c) The CE of pipe, sleeve materials, or fittings can be determined from mill test reports, when available.
d) If the CE cannot be determined from the above, it must be assumed as 0.50% for this procedure.

3. DIAMETERS & WALL THICKNESSES

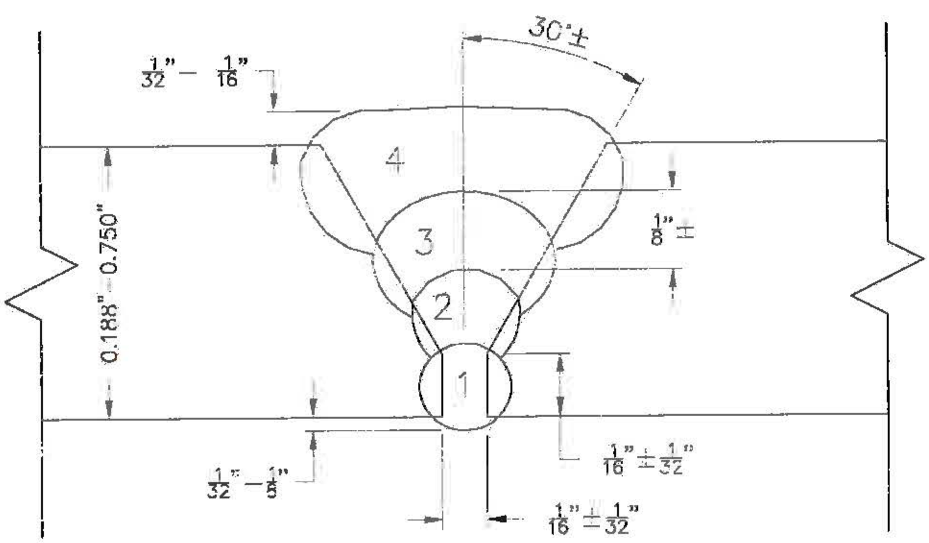
Nominal Diameters:	All diameters
Nominal Wall Thicknesses:	≤ 0.750"

4. JOINT DESIGN

The following figures depict the joint designs covered under this procedure. For full encirclement type lap joints, the maximum dimension of L is 1.25 x T_1 or 1.25 x T_2, whichever is smaller. If the pad thickness of a full encirclement type lap joint is greater than 1.25 x T_1, the pad shall be tapered 1 on 4 to a thickness of T_1 at the weld. For pad or saddle type lap joints, the maximum dimension of L is T_1 or T_2, whichever is smaller. If the thickness of a pad or saddle type lap joint is greater than T_1, it shall be tapered 1 on 4 to a thickness of T_1 at the weld. For fillet joints, the maximum dimension of L is 1.25 x T_1 or 1.25 x T_2, whichever is smaller.



Notes: (1) Tap for 2" tee and over shall have a bevel, space, and a full penetration bead.
(2) This design is to be used for < 2" diameter branch connections.



TYPICAL BUTT WELD

5. PIPELINE OPERATING CONDITIONS

Accelerated cooling rates on pressurized pipe under flowing conditions promote the formation of hard heat affected zone (HAZ) microstructures and make these welds susceptible to hydrogen cracking. Pipeline operating conditions that affect weld cooling rates include the pipeline contents, flow rate, pressure (gas only), pipe surface and ambient temperatures, and pipe wall thickness.

Procedure qualification welds were successfully made for this procedure under worst-case cooling conditions using flowing water. Therefore, for any carbon equivalent, if the cooling rate (heat sink capacity) is less than that of the WPS, this in-service procedure can be used for gas or oil pipelines at any flow rate, pressure, and pipe wall thickness.

The cooling rate (heat sink capacity) can be determined by measuring the drop in temperature for a given time after the pipe is preheated, during actual flowing conditions. It is determined as follows:

a) Using soapstone or chalk, scribe a 2" diameter circle on clean pipe surface.
b) Using an oxy-fuel torch heat the entire area of the circle to 500°F (do not exceed) using a circular motion.
c) Remove the torch and apply a contact pyrometer to the center of the circle.
d) While holding the pyrometer in contact with the pipe, measure the temperature drop in 30 seconds.

The results of this test may suggest the use of this procedure, as indicated in the following table:

Temperature Drop (° F)	Procedure
< 25°	Use regular (non in-service) welding procedure.
25° - 115°	Consider an in-service welding procedure unless pressure and/or flow rate can be reduced.
> 115°	Reduce pressure and/or flow rate and use an in-service procedure.

6. <u>FILLER METAL & NUMBER OF BEADS</u>

The following low-hydrogen electrodes are approved for use with this procedure. The electrode sizes listed in the table below are the maximum diameter electrodes that shall be used. The total number of passes is the minimum number that shall be deposited.

Material Grade	Material Thickness	Rod Type	Rod Size				Minimum Passes
			Root Pass	Hot Pass	Filler Pass(s)	Cap Pass	
≤ X52	≤ 0.187	E7018	3/32				3
	0.188 - 0.250	E7018	3/32				3
	0.251 - 0.375	E7018	3/32		1/8		4
	0.376 - 0.500	E7018	3/32		1/8		5
	0.501 - 0.625	E7018	3/32		1/8		6
	0.626 - 0.750	E7018	3/32		1/8		7
X52< Grade ≤ X65	≤ 0.187	E8018	3/32				3
	0.188 - 0.250	E8018	3/32				3
	0.251 - 0.375	E8018	3/32		1/8		4
	0.376 - 0.500	E8018	3/32		1/8		5
	0.501 - 0.625	E8018	3/32		1/8		6
	0.626 - 0.750	E8018	3/32		1/8		7

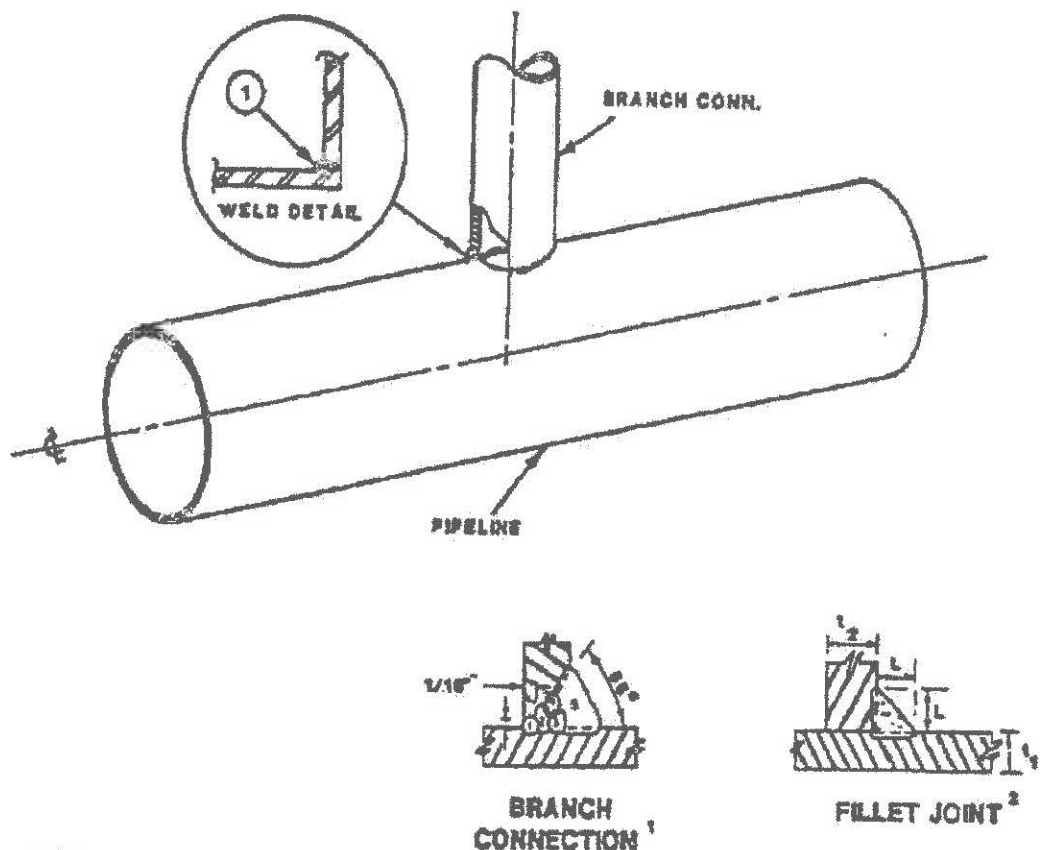
All low-hydrogen electrodes shall be purchased in sealed, 10-pound containers. The containers shall only be opened on the job site, immediately prior to commencement of the in-service welding.

The number of passes depends on the size of the fillet weld. The size of the fillet weld is the length of a side of the largest inscribed right triangle having two equal sides.

The pipe shall be supported so that there is no strain on the stringer/root bead throughout the welding process.

Tack welds are considered part of the stringer/root bead and shall be deposited with the pipe in the fixed position. Tacks welds shall be of sufficient number and length to maintain the stringer/root opening and pipe alignment. If a tack weld, or any part of the stringer/root bead, cracks or breaks, the weld shall be cut out, as a cylinder, and the pipe or fittings re-beveled. Tacks of excessive thickness shall be cut down with a power grinder, diamond point or round nosed chisel, with the power grinder being the preferred method. The use of an oxy-fuel cutting torch or a welding electrode for removing excess weld metal is prohibited.

The bead sequence is shown on the details provided below. In addition, in all cases requiring fittings with longitudinal seams (including spherical tees), both longitudinal seams shall be fully completed prior to starting fillet welding on end joints of the fitting. The weld on one end of the fitting shall be fully completed and allowed to cool in still air to a temperature of 200°F or less (verified using a temperature crayon or contact pyrometer) before welding is started on the remaining end of the fitting. This method is considerably less restraining to the fitting and will reduce tensile stresses greatly, thereby eliminating one of the causes of in-service cracking.



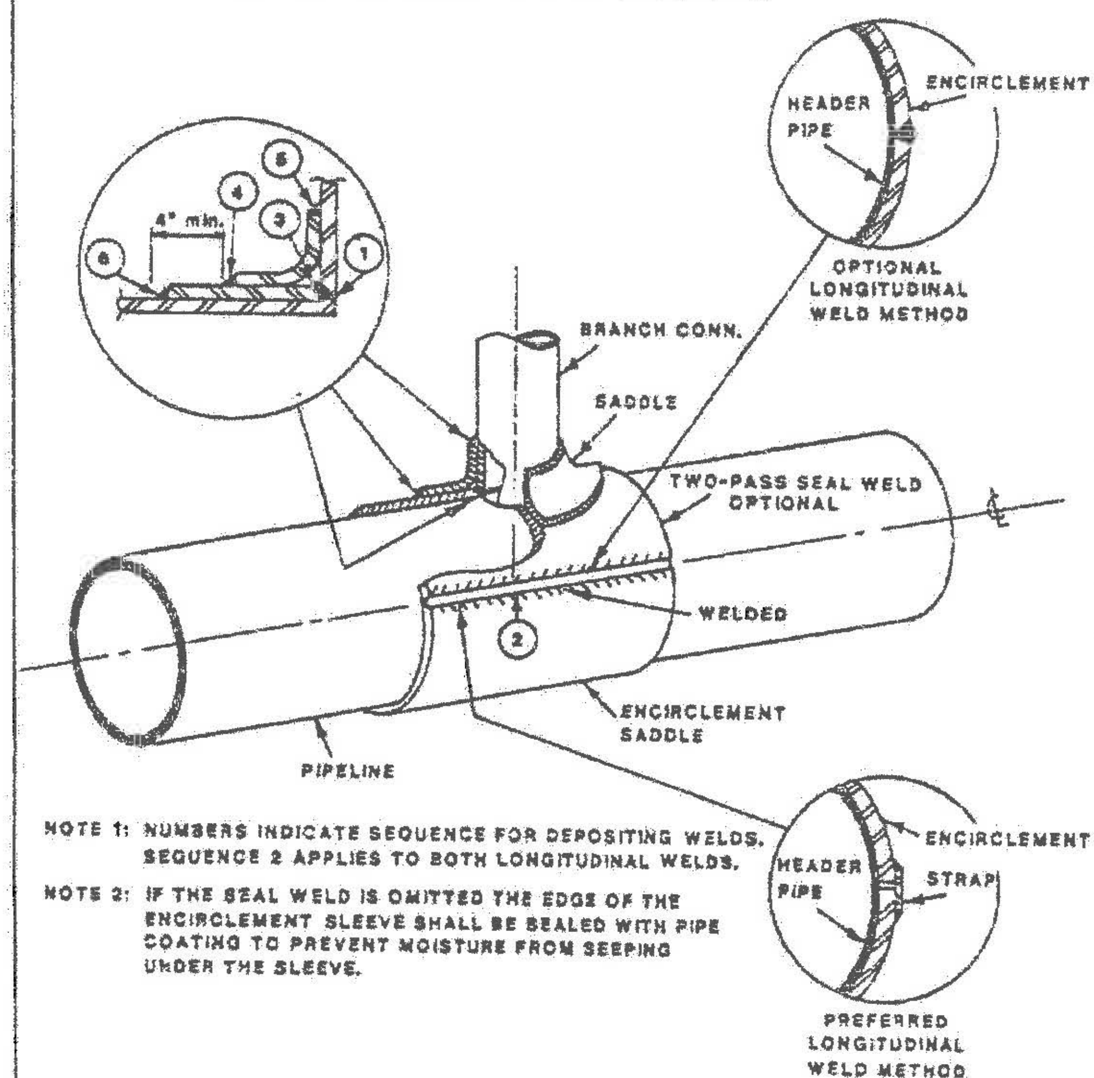
NOTES:

(1) TAP/OR/TEE 2" DIA. AND OVER SHALL HAVE A BEVEL, SPACE, AND A FULL PENETRATION BEAD.

(2) THIS DESIGN TO BE USED FOR UNDER 2" DIA. BRANCH CONNECTIONS.

WELDING SEQUENCE FOR UNREINFORCED BRANCH CONNECTIONS

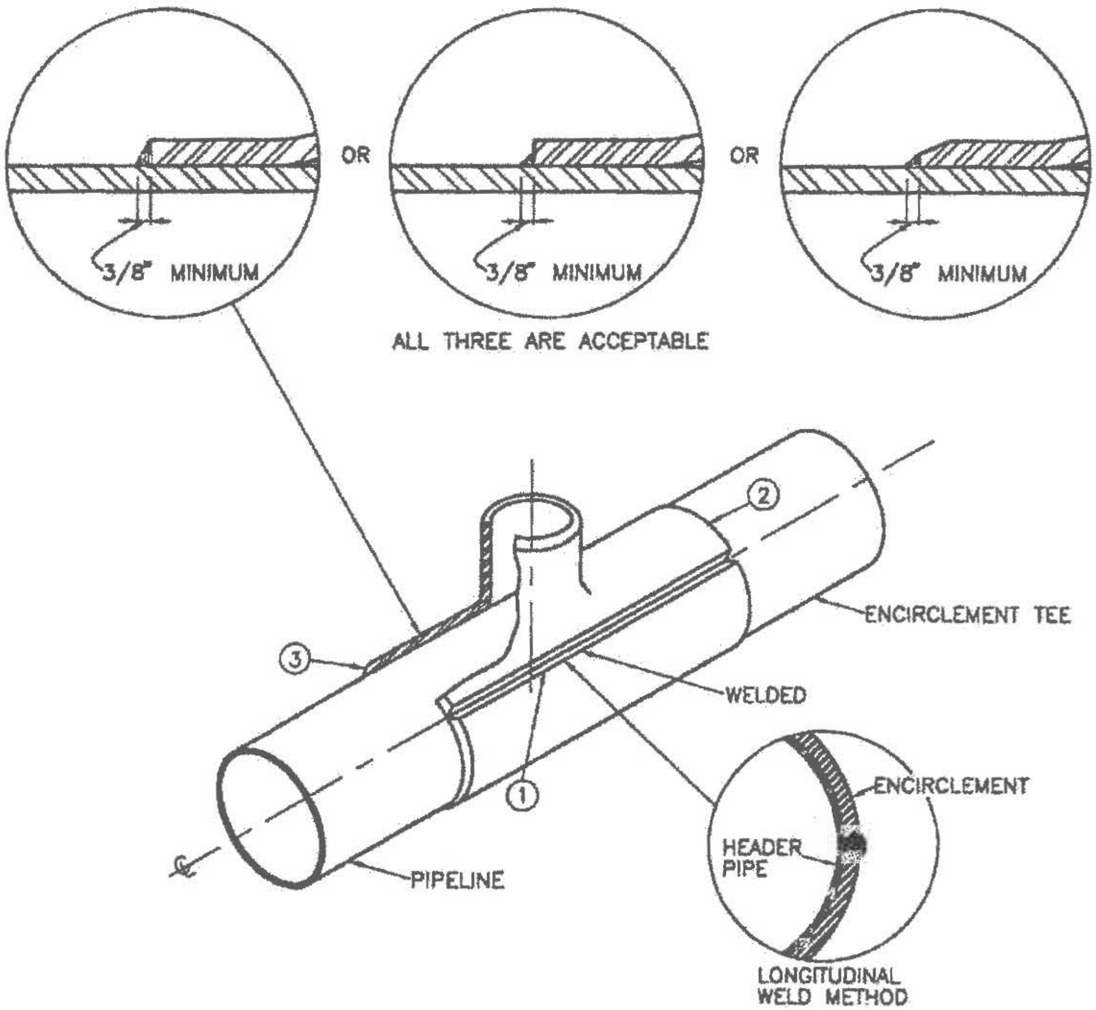
THIS WELD SHOULD BE BACKED UP WITH THIN SHEET METAL TO PREVENT PENETRATION INTO THE CARRIER PIPE.



NOTE 1: NUMBERS INDICATE SEQUENCE FOR DEPOSITING WELDS. SEQUENCE 2 APPLIES TO BOTH LONGITUDINAL WELDS.

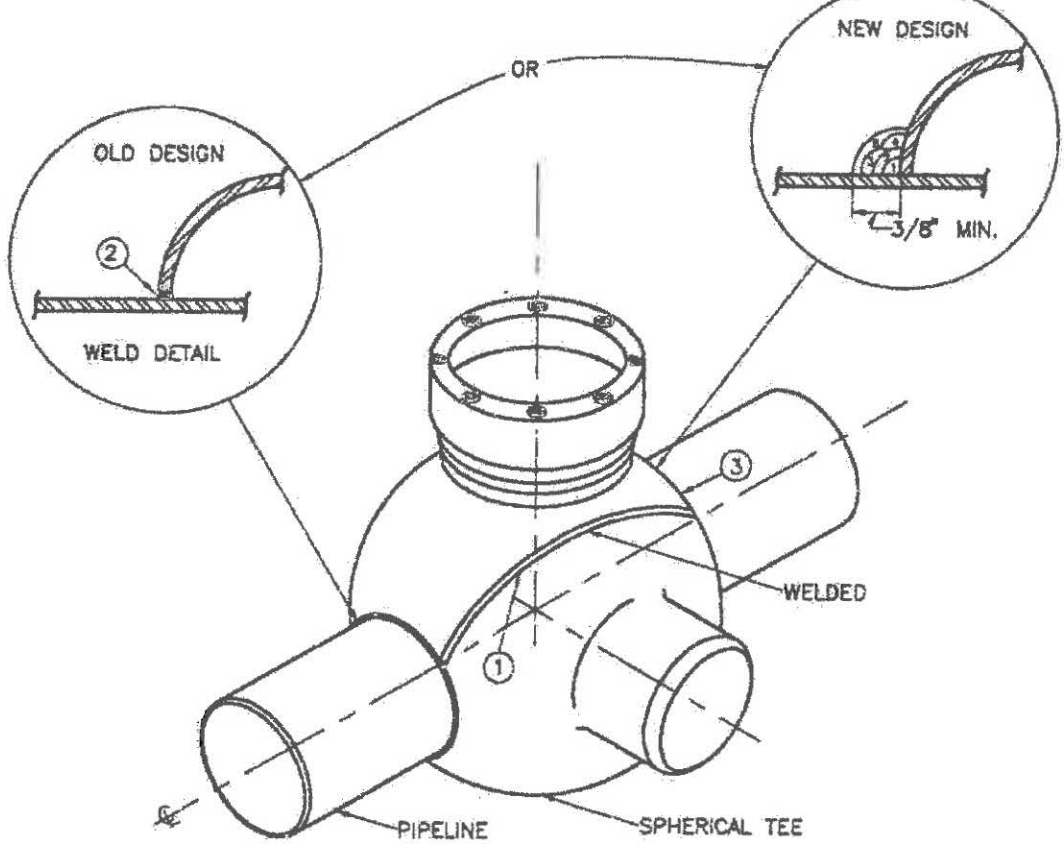
NOTE 2: IF THE SEAL WELD IS OMITTED THE EDGE OF THE ENCIRCLEMENT SLEEVE SHALL BE SEALED WITH PIPE COATING TO PREVENT MOISTURE FROM SEEPING UNDER THE SLEEVE.

WELDING SEQUENCE FOR BRANCH CONNECTIONS WITH ENCIRCLEMENT SLEEVES AND SADDLES



NOTE 1: NUMBERS INDICATE SEQUENCE FOR DEPOSITING WELDS.
SEQUENCE 1 APPLIES TO BOTH LONGITUDINAL WELDS.
NOTE 2: END WELDS SHALL NOT BE WELDED SIMUTANEOUSLY.

WELDING SEQUENCE FOR BRANCH CONNECTIONS WITH ENCIRCLEMENT TEE



NOTE 1: NUMBERS INDICATE SEQUENCE FOR DEPOSITING WELDS.
SEQUENCE 1 APPLIES TO BOTH LONGITUDINAL WELDS.
NOTE 2: END WELDS SHALL NOT BE WELDED SIMUTANEOUSLY.

WELDING SEQUENCE FOR BRANCH CONNECTIONS WITH SPHERICAL TEE

7. HEAT INPUT DURING WELDING

Weld heat input is the amount of heat generated by the arc as it travels around the weld joint depositing metal. Maintaining high heat input rates helps overcome accelerated cooling caused by flowing pipe contents. The following acceptable limits for the heat input rates, measured in Kilojoules/inch, have been established for carbon equivalent ranges based on research at Edison Institute:

- CE ≤ 0.50% => 19 – 25 KJ/in
- CE > 0.50% => 22 – 28 KJ/in

The heat rate should be kept above the minimum limit. Exceeding the maximum limit is not critical and can even be desirable in high flow situations as long as burn-through risks are considered. Higher heat rates equate to slower cooling rates, higher inter-pass temperatures, and lower risks of hydrogen cracking.

Welding heat input can be determined by measuring electrode usage during welding. Limits for the heat input rates are given in the attached Heat Input Tables for a given low hydrogen electrode size, measured electrode usage, and length of deposited weld.

For example, for a 3/32" electrode and a carbon equivalent of 0.50%, 6 inches of electrode was consumed to create a deposited weld length of 2-1/2 inches. From the table for a 3/32" electrode, the heat input is 22.9 KJ/in. This is in the range above for CE ≤ 0.50%. If the measured heat input was less than the minimum of the range, the input would have to be increased by slowing down the welding travel speed. If the measured heat input was higher than the maximum of the range, the input would have to be reduced by increasing the travel speed.

Pipe conditions conducive to hydrogen cracking include high flow rates, high pressures, low pipe surface and ambient temperatures, low pipe wall thicknesses, etc. Increased severity of these pipe conditions is indicated by a higher heat sink measurement in the previous section – high end of 25° to 115° temperature drop range. If these conditions exist, the weld heat input should be measured until the welder is consistently in the appropriate range. The extent of heat input measurements depends on the level of the welder's in-service welding experience.

3/32" Diameter SMAW Low-hydrogen Electrode
Heat Input Table

VERTICAL AXIS Length of Electrode Used, in.[1] / HORIZONTAL AXIS Length of Deposited Weld, in.	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8
4	25.4	19.1												
4 1/2	28.6	21.4	17.1											
5	31.8	23.8	19.1	15.9										
5 1/2	34.9	26.2	21.0	17.5										
6	38.1	28.6	22.9	19.1	16.3									
6 1/2	41.3	31.0	24.8	20.6	17.7	15.5								
7		33.3	26.7	22.2	19.1	16.7								
7 1/2		35.7	28.6	23.8	20.4	17.9	15.9							
8		38.1	30.5	25.4	21.8	19.1	16.9							
8 1/2		40.5	32.4	27.0	23.1	20.2	18.0	16.2						
9			34.3	28.6	24.5	21.4	19.1	17.1	15.6					
9 1/2			36.2	30.2	25.9	22.6	20.1	18.1	16.5					
10			38.1	31.8	27.2	23.8	21.2	19.1	17.3	15.9				
10 1/2			40.0	33.3	28.6	25.0	22.2	20.0	18.2	16.7	15.4			
11				34.9	29.9	26.2	23.3	21.0	19.1	17.5	16.1			
11 1/2				36.5	31.3	27.4	24.3	21.9	19.9	18.3	16.9	15.6		
12				38.1	32.7	28.6	25.4	22.9	20.8	19.1	17.6	16.3		
12 1/2				39.7	34.0	29.8	26.5	23.8	21.6	19.8	18.3	17.0	15.9	
13				41.3	35.4	31.0	27.5	24.8	22.5	20.6	19.1	17.7	16.5	15.5

Instructions:

1. The electrode used is the difference in length between the original length and the stub.
2. The heat input in Kilojoules/Inch is located at the intersection of these two lengths.

Note: Table was generated using published data from reference in 2.2.4.

1/8" Diameter SMAW Low-hydrogen Electrode
Heat Input Table

VERTICAL AXIS Length of Electrode Used, in.[1]								HORIZONTAL AXIS Length of Deposited Weld, in.						
	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8
4	41.2	30.9	24.7	20.6	17.6	15.4								
4 1/2	46.3	34.7	27.8	23.2	19.9	17.4	15.4							
5	51.5	38.6	30.9	25.7	22.1	19.3	17.2	15.4						
5 1/2	56.6	42.5	34.0	28.3	24.3	21.2	18.9	17.0	15.4					
6		46.3	37.1	30.9	26.5	23.2	20.6	18.5	16.8	15.4				
6 1/2		50.2	40.2	33.5	28.7	25.1	22.3	20.1	18.3	16.7	15.4			
7		54.1	43.2	36.0	30.9	27.0	24.0	21.6	19.7	18.0	16.6	15.4		
7 1/2			46.3	38.6	33.1	29.0	25.7	23.2	21.1	19.3	17.8	16.5	15.4	
8			49.4	41.2	35.3	30.9	27.5	24.7	22.5	20.6	19.0	17.6	16.5	15.4
8 1/2			52.5	43.8	37.5	32.8	29.2	26.3	23.9	21.9	20.2	18.8	17.5	16.4
9			55.6	46.3	39.7	34.7	30.9	27.8	25.3	23.2	21.4	19.9	18.5	17.4
9 1/2				48.9	41.9	36.7	32.6	29.3	26.7	24.5	22.6	21.0	19.6	18.3
10				51.5	44.1	38.6	34.3	30.9	28.1	25.7	23.8	22.1	20.6	19.3
10 1/2				54.1	46.3	40.5	36.0	32.4	29.5	27.0	24.9	23.2	21.6	20.3
11				56.6	48.5	42.5	37.8	34.0	30.9	28.3	26.1	24.3	22.7	21.2
11 1/2					50.7	44.4	39.5	35.5	32.3	29.6	27.3	25.4	23.7	22.2
12					52.9	46.3	41.2	37.1	33.7	30.9	28.5	26.5	24.7	23.2
12 1/2					55.2	48.3	42.9	38.6	35.1	32.2	29.7	27.6	25.7	24.1
13						50.2	44.6	40.2	36.5	33.5	30.9	28.7	26.8	25.1

Instructions:

1. The electrode used is the difference in length between the original length and the stub.
2. The heat input in Kilojoules/Inch is located at the intersection of these two lengths.

Note: Table was generated using published data from reference in 2.2.4.

5/32" Diameter SMAW Low-hydrogen Electrode
Heat Input Table

VERTICAL AXIS Length of Electrode Used, in.[1]								HORIZONTAL AXIS Length of Deposited Weld, in.						
	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8
4		48.3	38.6	32.2	27.6	24.1	21.4	19.3	17.5	16.1				
4 1/2		54.3	43.4	36.2	31.0	27.1	24.1	21.7	19.7	18.1	16.7	15.5		
5			48.3	40.2	34.5	30.2	26.8	24.1	21.9	20.1	18.6	17.2	16.1	
5 1/2			53.1	44.2	37.9	33.2	29.5	26.5	24.1	22.1	20.4	19.0	17.7	16.6
6				48.3	41.4	36.2	32.2	29.0	26.3	24.1	22.3	20.7	19.3	18.1
6 1/2				52.3	44.8	39.2	34.9	31.4	28.5	26.1	24.1	22.4	20.9	19.6
7					48.3	42.2	37.5	33.8	30.7	28.2	26.0	24.1	22.5	21.1
7 1/2					51.7	45.2	40.2	36.2	32.9	30.2	27.8	25.9	24.1	22.6
8					55.2	48.3	42.9	38.6	35.1	32.2	29.7	27.6	25.7	24.1
8 1/2						51.3	45.6	41.0	37.3	34.2	31.6	29.3	27.3	25.6
9						54.3	48.3	43.4	39.5	36.2	33.4	31.0	29.0	27.1
9 1/2							50.9	45.8	41.7	38.2	35.3	32.7	30.6	28.7
10							53.6	48.3	43.9	40.2	37.1	34.5	32.2	30.2
10 1/2								50.7	46.1	42.2	39.0	36.2	33.8	31.7
11								53.1	48.3	44.2	40.8	37.9	35.4	33.2
11 1/2								55.5	50.5	46.2	42.7	39.6	37.0	34.7
12									52.6	48.3	44.5	41.4	38.6	36.2
12 1/2									54.8	50.3	46.4	43.1	40.2	37.7
13										52.3	48.3	44.8	41.8	39.2

Instructions:

1. The electrode used is the difference in length between the original length and the stub.
2. The heat input in Kilojoules/Inch is located at the intersection of these two lengths.

Note: Table was generated using published data from reference in 2.2.4.

8. ELECTRICAL CHARACTERISTICS & TRAVEL SPEED

A Direct Current Reverse Polarity (DCRP), electrode positive, shall be used. The table below depicts the ranges that must be maintained throughout the procedure:

Rod Size	Carbon Equivalent	Heat Input	Rod Type	Amperage	Voltage	Travel Speed
3/32"	CE ≤ 0.50%	19-25 KJ/in	E7018	70-110	19-30	2-8
			E8018	60-110		
1/8"	CE ≤ 0.50%	19-25 KJ/in	E7018	90-160	19-30	2-8
			E8018	85-160		
3/32"	CE > 0.50%	22-28 KJ/in	E7018	70-110	19-30	2-8
			E8018	60-110		
1/8"	CE > 0.50%	22-28 KJ/in	E7018	90-160	19-30	2-8
			E8018	85-160		

9. FLAME CHARACTERISTICS

Not applicable

10. POSITION

This procedure covers all positions.

11. DIRECTION OF WELDING

The direction of the welding shall be vertical uphill.

12. TIME BETWEEN PASSES

The maximum time interval between the completion of the stringer/root bead (first pass) and the beginning of the hot pass (second pass) is five (5) minutes. The maximum interval between the hot pass (second pass) and the remaining beads is unlimited, but the weld should be completed in the same day or shift. Additionally, the following rules shall apply:

a) Each pass shall be completed before the next pass is permitted to begin.
b) Two successive passes shall not begin at the same point.
c) A stripper or short bead shall be used to build up low areas.

13. LINEUP CLAMPS

Not applicable.

14. CLEANING/GRINDING

All scale/slag, knots of filler metal (excessive metal on starts), and similar defects shall be removed with a power grinder. A combination of hand and power tools may be utilized to clean the weld metal and weld joint.

All coal tar coating shall be removed a minimum of 6" back from the beveled surface prior to welding. All remaining coatings shall be removed 4" back.

All moisture, rust, scale/slag, oil, paint, primer, coating, or other materials which may be detrimental to the finished weld shall be removed from the welding surface.

Where possible, beveling shall be performed with a machine tool or machine cutting device (oxy-acetylene torch, beveling machine). Flame cut surfaces should be smooth and regular. Power brushes shall be used for cleaning all beveled surfaces. If the beveled surface cannot be satisfactorily cleaned of foreign materials utilizing power brushes, then power sanding discs (60 grit or higher), grit blasting, or approved safety solvents may be utilized. Prior to welding, all residue left from the use of safety solvents shall be removed.

15. PRE-HEAT, POST-HEAT, & STRESS RELIEVING

Pre-heating requirements varies, based on the carbon equivalent of the material:

a) CE ≤ 0.50%

Prior to the start of welding, the pipe shall be heated to achieve a 200°F (minimum) to 250°F (maximum) pre-heat temperature. Heat may be applied utilizing either propane pre-heat torches or multi-flame oxy-acetylene torches. Preheat should continue for approximately 10 minutes for propane or 5 minutes for oxy-acetylene to allow the pipe to be fully warmed before beginning the initial welding pass.

b) CE > 0.50%

Prior to the start of welding, the pipe shall be heated to achieve a 250°F (minimum) to 300°F (maximum) pre-heat temperature. Heat may be applied utilizing either propane pre-heat torches or multi-flame oxy-acetylene torches. Preheat should continue for approximately 10 minutes for propane or 5 minutes for oxy-acetylene to allow the pipe to be fully warmed before beginning the initial welding pass.

Pre-heat and inter-pass temperatures should be verified using either temperature indicating crayons of appropriate heat numbers, a contact pyrometer, or a laser pyrometer.

The welding of a joint shall be continuous, with no interruptions, until half the depth of the welding groove has been filled. The pre-heat temperature shall be maintained until the welding is completed. If welding is interrupted, the joint shall be re-heated to the original pre-heat temperature before welding is resumed.

The minimum width of the pre-heat area on each side of the weld shall be equal to three times the pipe wall thickness or 2", whichever is greater. When steels with different pre-heat temperatures are being pre-heated for welding, the higher temperature must be used.

16. POST-WELD HEAT TREATMENT

Not applicable.

17. GROUNDING

The ground clamp shall be designed to prevent arc burns on the pipeline. Welding of the ground clamp to the pipe is prohibited.

18. SHIELDING GAS & FLOW RATE

Not applicable.

19. SHIELDING FLUX

Not applicable.

PRODUCT DATA SHEET

PROTAL 7200

Fast Cure, High Build Pipeline Coating

Description

Protal 7200 is a VOC free, 100% solids, 2 part epoxy coating specially formulated to compliment FBE coated pipe. It is a high build liquid coating that is brush or spray applied (referred to as Protal 7250 in Canada) in one coat in the field or shop. It cures very fast to allow quick handling and backfill times.

Uses

On-site protection of girth welds, tie-ins, welds for boring applications, repairs to FBE, push-rack applications, station piping, fittings and fabrication. Also used for main line pipe coating, sacrificial coating for directional drill and road bore pipe, and rehabilitation of existing pipelines.

Features

- Fast touch dry and set times
- High temperature resistance (up to 185°F)
- High build (up to 50 mils in one coat)
- Excellent adhesion (compliments FBE coated pipe)
- High abrasion resistance for drilling applications
- Safe and environmentally friendly
- Does not shield cathodic protection
- Can be applied with brush, roller or spray
- Available in a variety of packaging options

Application

Brush: Prepare surfaces by grit blasting to a clean near white finish, SSC-SP 10/NACE No. 2. Appropriate angular grit shall be used to achieve a 2.5 to 5 mil anchor profile. Initially stir the base and hardener. Add the hardener to base and mix at a slow speed until a constant color is achieved making sure all sides of container are scraped. Apply mixed material onto surface and brush, trowel or roll to required mil thickness. A wet film thickness gauge shall be used to measure mil thickness. If surface temperature falls below 50°F (10°C), surface should be preheated to achieve faster cure. Preheat may be achieved with a propane torch or induction coil. Resin and hardener component shall be kept warm, at a minimum of 60°F (15°C), to mix easily.

Spray: Prepare surfaces by grit blasting to a clean near white finish, SSC-SP 10/ NACE No. 2. The equipment should be a plural component airless spray unit with a proportioning pump capable of a volume mixing ratio of 3:1. Standard ancillary equipment should include minimum 10 gallon hoppers, 2 ea. static mixers, 25 ft. max x 1/4" whip hose, and mastic gun with a 19 to 27 thou tip. (Applicator should consult with Denso regarding recommended equipment). Part A should be heated to 140°F - 150°F and Part B heated to 100°F - 110°F. Hose bundle shall be set at 140°F - 150°F. A wet on wet spray technique should be used to achieve a minimum thickness of 20 mils. The coating thickness should be measured using a wet film thickness gauge.

For complete application instructions please refer to Protal 7200 application specifications.

Denso

Protal 7200

Technical Data

Properties	Value
Solids Content	100%
Base Component - (Unmixed) @ 77°F (25°C)	
Specific Gravity	1.63
Viscosity	255,000 cps
Color	White
Hardener - (Unmixed) @ 77°F (25°C)	
Specific Gravity	1.05
Viscosity	5,500 cps
Color	Dark Green
Mixed Material - (Mixed) @ 77°F (25°C)	
Specific Gravity	1.63
Viscosity	170,000 cps
Color	Green
Mixing Ratio (A/B) by Volume	3 Parts Base: 1 Part Hardener
Cure Times	
Pot Life @ 77°F (25°C)	14 - 17 Minutes
Pot Life @ 97°F (36°C)	7 - 8 Minutes
Handling Time @ 77°F (25°C)	2.5 - 3 Hours
Handling Time @ 117°F (47°C)	1 Hour
Handling Time @ 157°F (69°C)	20 Minutes
Recoat Window	
@ 57°F (14°C)	5 Hours
@ 77°F (25°C)	2 Hours
@ 97°F (36°C)	1 Hour
Theoretical Coverage	14 ft²/30 mils/liter
Thickness - Weld Joints / FBE Repairs	
Minimum/Maximum	20/60 mils
Recommended	25 - 30 mils
Thickness - Bore Pipe	
Minimum/Maximum	35/60 mils
Recommended	45 - 55 mils
Holiday Detection - based on min. mil. thickness specified	125 volts/mil
Cathodic Disbondment Test (ASTM G95)	
28 Days @ 77°F (25°C)	3 mm
28 Days @ 150°F (65°C)	4 mm
28 Days @ 175°F (80°C)	7 mm
Hardness (ASTM D-2240-02)	Shore D 85 +/-2
Impact Resistance (ASTM G14-88)	60.89 in-lbs.
Adhesion to Steel/FBE (ASTM D-4541-02)	3,200 psi
Application and Service Temperature	-30°F to 185°F (-34°C to 85°C) — Note: If temperature falls below 50°F (10°C), surface must be preheated.

STORAGE: Minimum 24 months when stored in original containers @ 40°F (4°C) to 105°F (41°C). On job site where temperatures are below 50°F (10°C) product should be kept warm to mix properly (65°F to 85°F optimal).

CLEANING: Clean equipment with MEK or equivalent solvent cleaner.

HEALTH AND SAFETY: Wear protective clothing and ensure adequate ventilation. Avoid contact with skin and eyes. See material safety data sheet for further information.

PACKAGING: 1, 1.5, 1.75 and 2 liter kits and 75 liter & 800 liter kits standard. Dual cartridge repair tubes (400 ml & 50 ml) and dispensing guns available for small repair areas.

Denso

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Protal 7200
Brush Application Specifications

1.0 Scope

1.1 This specification covers the external surface preparation and coating of pipeline applications such as weld joints, special pipe sections, fittings and fabrication.

2.0 Material and Storage

2.1 Material shall be Denso Protal 7200 coating system as manufactured by Denso North America, 9747 Whithorn Drive, Houston, TX 77095 (Tel) 281-821-3355 (Fax) 281-821-0304 or 90 Ironside Crescent Unit 12, Toronto, Ontario, Canada M1X1M3 (Tel) 416-291-3435 (Fax) 416-291-0898. E-mail: info@densona.com.

2.2 Material shall meet the physical properties of the attached product data sheet.

2.3 Storage: Material shall be stored in a warm, dry place between 40°F (4°C) to 105°F (41°C). Care shall be taken to insure the material is stored up right (arrows on boxes facing up). *Note: If the material is kept cold, it will become very viscous.*

3.0 Equipment

3.1 For mixing, use strong wooden stir sticks or power drills with appropiate mixing paddle.

3.2 For application, use 4" wide brushes, Denso applicator pads or Protal 9" roller.

3.3 Wet film thickness gauges.

4.0 Surface Preparation

4.1 All contaminants shall be removed from the steel surface to be coated. Oil and grease should be removed in accordance with SSPC SP-1 using non-oily solvent cleaner (i.e., xylene, MEK, ethanol, etc.).

4.2 Material for abrasive cleaning shall be the appropriate blend of grit to produce an angular surface profile of 2.5 - 5 mils (0.063 - 0.125 mm).

4.3 All surfaces to be coated shall be grit blasted to a near-white finish (SSPC SP-10, NACE No. 2 or Sa 2 1/2). *Note: Near-white finish is interpreted to mean that all metal surfaces shall be blast cleaned to remove all dirt, mill scale, rust, corrosion products, oxides, paint and other foreign matter. Very light shadow, very light streaks or slight discolorations shall be acceptable: however, at least 95% of the surface shall have the uniform gray appearance of a white metal blast-cleaned surface as defined by Swedish Pictorial Surface Preparation Standard Sa 2 1/2 or SSPC VIS-1.*

4.4 Edges of the existing coating shall be roughened by power brushing or by sweep blasting the coating for a distance of 1" (25 mm) minimum.

4.5 The Contractor shall check the surface profile depth by using a suitable surface profile gauge (Press-O-Film Gauge or equal).

4.6 Metal areas that develop flash rust due to exposure to rain or moisture shall be given a sweep blast to return them to their originally blasted condition.

5.0 Application

5.1 The surface shall have no condensation, precipitation or any other forms of contamination on the blasted surface prior to coating.

5.2 The substrate temperature range for application of Protal is 50°F (10°C) to 212°F (100°C). The substrate temperature must be a minimum of 5°F (3°C) above the dew point temperature before proceeding with the coating operation. Ambient temperature may be lower than 50°F (10°C) if the substrate is heated. Preheating may be accomplished with a propane torch or induction coil prior to abrasive blasting.

5.3 Protal shall be applied to the specified Dry Film Thickness (DFT) using a brush, Denso applicator pad or roller. Wet film measurements shall be performed to ensure close adherence to the thickness specification.

5.4 Mixing: Make sure the part A (Resin) and Part B (Hardener) components match in both material and size as specified on the containers. Mix the B component first, independent of the resin. Pour the contents into the part A (Resin) component. Mix at a slow speed so as not to create a vortex that could introduce air into the product until a uniform color is achieved making sure to scrape the bottom and sides of the container (approximately 2 minutes). No streaks shall be visible.

5.5 APPLICATION SHALL TAKE PLACE IMMEDIATELY AFTER MIXING. Apply the product onto the surface and spread down and around the surface in bands beginning from the leading edge of the material to as far under the pipe as can be reached. Overlap the bands and onto the existing coating a minimum of 1". Applicators shall use a brush to smooth out any obvious sags or rough edges, valleys, or drips. Special attention shall be given to weld buttons and bottom surfaces.

5.6 The thickness of Protal shall be checked periodically by wet film gauge to achieve the minimum and maximum wet film thickness specified. After the Protal has cured, the owner's representative and/or contractor's inspector should measure the film thickness by magnetic gauge and notify the applicator of their acceptance. Notification to the applicator of any inadequately coated sections must be made immediately.

5.7 Over-coating, when necessary, shall take place within 2 hours at 80°F (27°C). If recoat window has lapsed, the surface shall be roughed prior to application of the topcoat using 80 grit sand paper or by sweep blasting.

6.0 Inspection/Testing for Backfill

6.1 The finished coating shall be smooth and free of protuberances or holidays. All surfaces shall have the required minimum/maximum DFT. Inspection of brush application is best performed immediately after application.

6.2 Backfill time shall be determined by the "thumb nail test". The thumb nail test is defined by when one can no longer make a permanent indention in the coating with his or her thumb nail. *Note: A full and/or chemical cure may not be achieved by backfill time. Therefore, in wet soils or water the coating will need a full chemical cure.(refer to Section 6.3 for acceptable field test for chemical cure)*

6.3 An acceptable field test to check to see if the coating has a full chemical cure, a solvent such as Xylene, MEK or Toluene can be rubbed on to the coating. If the gloss/sheen is removed the coating is not fully cured.

6.4 Spark testing shall be performed to ensure proper film thickness and for holiday inspection. The voltage used for testing weld joints and field applications shall be equal to that used for testing the mainline coating in the field or 125 volts/mil. based on the specified min. mil. thickness.

6.5 Denso and/or the owner's representative immediately upon completion of the work shall make final inspection of the completed application. Notification of all defects must be made within a reasonable time frame from completion of the work to allow for all repairs within the allowed time frame for the project.

7.0 Repairs

7.1 Pinhole repairs may be repaired by using Protal Repair Cartridge. Areas shall be roughened a minimum 1 in. around holiday using Carborundum cloth or 80 grit sandpaper and wiped clean with a xylene soaked cloth prior to patching.

7.2 Areas larger than 0.15 sq. in. (0.3 sq. cm.), but less than 1.0 sq. ft. (100 sq. cm.) shall be repaired using a Protal Repair Cartridge. The surface to be coated shall be clean and dry prior to applying the coating. Surfaces below 40°F (4°C) shall be pre-heated in accordance with Section 5.2. Areas requiring repair shall be prepared with a surface grinder or by grit blasting prior to application of the coating. All edges of the surrounding area should be feathered prior to performing the repair.

7.3 Refer to "7200 Accelerated Cure Specifications for Repairs" for additional information.

8.0 Safety Precautions

8.1 Follow the guidelines detailed in the Material Safety Data Sheets (MSDS).

8.2 Keep containers closed when not in use. In case of spillage, absorb with inert material and dispose of in accordance with applicable regulations.

8.3 Always refer to project specifications as they may supercede Denso specifications.

Denso®

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DENSO NORTH AMERICA INC.

MATERIAL SAFETY DATA SHEET

SECTION 1 – PRODUCT IDENTIFICATION AND USE

Material
Denso Protal 7200 "A"

Manufacturer's Name: Denso North America Inc.	Supplier's Name: Denso North America Inc.
Street Address: 9747 Whithorn Drive	Street Address: 9747 Whithorn Drive
City, State: Houston, TX	Province/Country: USA
City, State: Houston, TX	Province/Country: USA
Postal Code: 77095	Emergency Telephone No.: 1-800-633-8253
Postal Code: 77095	Emergency Telephone #: 1-800-633-8253
Product Class: Epoxy	Chemical Family: Not Available
Manufacturer's Code: 64-7200	
Classification: DOT Non-Hazardous	Trade Name & Synonyms: Denso Protal 7200 "A"
Material Use: On-site Liquid Coating for Metal Pipes	

SECTION 2 – HAZARDOUS INGREDIENTS

Ingredients	%	CAS Number	LD50 of Material (Specific Species & Route)	LC50 of Material (Specific Species)
Epoxy Resin	10-30	25068-38-6	Oral> 5000mg/kg Rat	N/A = Not Available
Bisphenol F Epoxy	10-30	28064-14-4	N/A	N/A
Aliphatic Glycidyl Ether	3-20	30499-70-8	Oral> 4500mg/kg Rat	N/A

SECTION 3 – PHYSICAL DATA

Physical State: Gas ☐ Liquid ☒ Solid ☐	Odor and Appearance: Mild Odor, White Liquid	Odor Threshold (PPM): Not Available		
Vapour Pressure (mm Hg): Not Available	Vapour Density (air = 1): Not Available	Evaporation Rate: Not Available	Boiling Point (° C): 146°C	Freezing Point (° C): Not Available
% Volatile (by volume): 0.05	Solubility in Water (20° C): Slight	pH: Not Available	Specific Gravity: 1.62	Coeff Water/Oil Dist: Not Available

SECTION 4 – FIRE AND EXPLOSION DATA

Flammability: Yes ☐ No ☒ — If Yes, Under What Conditions?

Means of Extinction: Waterfog, CO2, Dry Chemical, Foam

Special Procedures:

Flashpoint (° C) and Method: 176°C (Setaflash Closed Cup)	Upper Explosion Limit (% by volume): Not Available	Lower Explosion Limit (% by volume): Not Available	
Auto Ignition Temperature (° C): Not Available	TDG Flammability Classification: Not Applicable	Hazardous Combustion Products: CO, CO2, Phenolics	
Sensitivity to Mechanical Impact: Not Applicable	Rate of Burning: Not Applicable	Explosive Power: Not Applicable	Sensitivity to Static Discharge: Not Applicable

SECTION 5 – REACTIVITY DATA

Chemical Stability: Yes ☒ No ☐ — If No, Under What Conditions?

Hazardous Polymerization: Yes ☒ No ☐ — May Occur with Greater Than 1lb of N-Aminoethylpiperazine See Part "B"

Reactivity, and Under What Conditions? Not Applicable

Hazardous Decomposition Products: Not Available

SECTION 6 – TOXICOLOGICAL PROPERTIES

Route of Entry
Skin Contact ☒ Skin Absorption ☒ Eye Contact ☒ Inhalation Acute ☒ Inhalation Chronic ☒ Ingestion ☒

Effects of Acute Exposure to Material
Contact of Material with Eyes will Result in Eye Irritation, Contact with Skin may Cause Dermatitis, Ingestion may Cause Abdominal Pain, Vomiting and Diarrhea, Inhalation will Result in Respiratory Tract Irritation.

Effects of Chronic Exposure to Material
Some Individuals may become Sensitized to the Material over Time. (See Below)

LD50 of Material Specify Species and Route	LC50 of Material Specify Species	Teratogenicity of Material	Mutagenicity of Material
Not Available	Not Available	Not Applicable	Not Applicable
Sensitization Capability of Material	**Carcinogenicity of Material**	**Reproductive Toxicity of Material**	**Synergistic Materials**
Skin and Respiratory	Not Applicable	Not Applicable	None Known

Exposure Limits of Material (TLV)
Crystalline Silica – TWA 10 mg/m3 (ACGIH), Talc – TWA 2 mg/m3 (ACGIH), Organophillic Clay – TWA 15 mg/m3 (OSHA), Titanium Dioxide – TWA 10 mg/m3 (ACGIH)

SECTION 7 – PREVENTATIVE MEASURES

Personal Protective Equipment
Wear Clean Long Sleeved, Body Covering Clothing, Use Impervious Gloves and Protective Clothing. Use Goggles and Full Face Shield. When Respiratory Protection is Required, Use an Approved Air Purifying Respirator. (See Below)

Gloves (Specify)	Respiratory (Specify)	Eye (Specify)
Impervious Type (Neoprene, PVC, Butyl)	Approved Air Purifying Respirator (Organic Vapour Cartridge)	Chemical Goggles
Footwear (Specify)	**Clothing (Specify)**	**Other (Specify)**
Work Boots	Clean Long Sleeved, Body Covering (Overalls, Tyvek Suit)	Full Face Shield

Engineering Controls (Specify e.g. Ventilation Enclosed Process)
Provide General Dilution of Local Exhaust in Volume and Pattern to Keep TLV of Hazardous Ingredients in Section 6 Below Acceptable Limits.

Leak and Spill Procedure
Remove All Sources of Ignition, Provide Adequate Ventilation. Avoid Prolonged Breathing of Vapours. Remove to a Container or Absorb with Clay, Diatomacious Earth or Other Inert Absorbent.

Waste Disposal **DO NOT INCINERATE CLOSED CONTAINERS**
Incineration or Landfill in an Approved Site in Accordance with Local and Federal Regulations.

Handling Procedure and Equipment
Avoid Inhalation, Skin and Eye Contact. Practice Good Personal Hygiene. Wash Repeatedly with Soap and Water After Use and Before Work Breaks.

Storage Requirements
Keep Containers Closed and in a Cool Dry Place.

Special Shipping Information

SECTION 8 – FIRST AID MEASURES

EYE CONTACT – Flush Thoroughly with Water for at Least 15 Minutes.
Get Immediate Medical Attention.

SKIN CONTACT – Wash the Exposed Areas with Soap and Water Immediately.
Call a Physician if Irritation Persists.

INHALATION – Remove to Fresh Air. If Breathing is Difficult Administer Oxygen.

INGESTION – Do Not Induce Vomiting. Transport to a Medical Facility.

Sources Used
H & S Data from Raw Material Suppliers.

Additional Information

DISCLAIMER AND LIMITATION OF LIABILITY

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SECTION 9 – PREPARATION OF THE MSDS

Prepared by (Group, Department, etc.)	Phone Number	Date
Denso North America Inc.	281-821-3355	April 15, 2011

DENSO NORTH AMERICA INC.

MATERIAL SAFETY DATA SHEET

SECTION 1 – PRODUCT IDENTIFICATION AND USE

Material **Denso Protal 7200 "B"**	TDG Classification Amines, Liquid, Corrosive, N.O.S.(N-Aminoethylpiperazine) UN2735, Class 8, PGIII		
Manufacturer's Name Denso North America Inc.		Supplier's Name Denso North America Inc.	
Street Address 9747 Whithorn Drive		Street Address 9747 Whithorn Drive	
City, State Houston, TX	Province/Country USA	City, State Houston, TX	Province/Country USA
Postal Code 77095	Emergency Telephone No. 1-800-633-8253	Postal Code 77095	Emergency Telephone # 1-800-633-8253
Product Class Amine	Chemical Family Not Available	Manufacturer's Code 64-7200	
TDG Classification Class 8, UN2735 Corrosive, PG III	Trade Name & Synonyms Denso Protal 7200 "B"	Material Use On-site Liquid Coating for Metal Pipes	

SECTION 2 – HAZARDOUS INGREDIENTS

Ingredients	%	CAS Number	LD50 of Material (Specific Species & Route)	LC50 of Material (Specific Species)
N-Aminoethylpiperazine	40-70	140-31-8	Oral> 2150mg/kg Rat	N/A = Not Available
Epoxy Novolac Resin	10-30	28064-14-4	Oral> 4000mg/kg Rabbit	N/A
Nonyl Phenol	2-20	25154-52-3	Oral> 580mg/kg Rat	N/A
Bisphenol "A"	3-10	60-05-7	Oral> 4100mg/kg Rat	N/A
Epoxy Resin	5-20	25068-38-6	Oral> 5000mg/kg Rat	N/A = Not Available

SECTION 3 – PHYSICAL DATA

Physical State Gas ☐ Liquid ☒ Solid ☐	Odor and Appearance Ammoniacal Odor, Green Liquid		Odor Threshold (PPM) Not Available	
Vapour Pressure (mm Hg) Not Available	Vapour Density (air = 1) Not Available	Evaporation Rate Not Available	Boiling Point (° C) Not Available	Freezing Point (° C) Not Available
% Volatile (by volume) 0.00	Solubility in Water (20° C) Slight	pH Not Available	Specific Gravity 1.08	Coeff Water/Oil Dist Not Available

SECTION 4 – FIRE AND EXPLOSION DATA

Flammability Yes ☐ No ☒	If Yes, Under What Conditions?		
Means of Extinction Water Spray, Water Fog, Foam, Dry Chemical, Foam			
Special Procedures			
Flashpoint (° C) and Method 95°C (Setaflash Closed Cup)	Upper Explosion Limit (% by volume) Not Available	Lower Explosion Limit (% by volume) Not Available	
Auto Ignition Temperature (° C) Not Available	TDG Flammability Classification Not Applicable	Hazardous Combustion Products CO, CO_2, Phenolics, Oxides of Nitrogen	
Sensitivity to Mechanical Impact Not Applicable	Rate of Burning Not Applicable	Explosive Power Not Applicable	Sensitivity to Static Discharge Not Applicable

SECTION 5 – REACTIVITY DATA

Chemical Stability Yes ☒ No ☐	If No, Under What Conditions?
Hazardous Polymerization	

Yes ☐ No ☒	Will Not Occur
Reactivity, and Under What Conditions?	Not Applicable
Hazardous Decomposition Products	Not Available

SECTION 6 – TOXICOLOGICAL PROPERTIES

Route of Entry
Skin Contact ☒ Skin Absorption ☒ Eye Contact ☒ Inhalation Acute ☒ Inhalation Chronic ☐ Ingestion ☒

Effects of Acute Exposure to Material
Contact of Material with Eyes will Result in Eye Irritation and Burns, Contact with Skin may Cause Irritation and Burns, Ingestion may Lead to Gastrointestinal Irritation or Ulceration, Inhalation may Result in Respiratory Tract Irritation and Burns.

Effects of Chronic Exposure to Material
Some Individuals may become Sensitized to the Material over Time. (See Below)

LD50 of Material Specify Species and Route	LC50 of Material Specify Species	Teratogenicity of Material	Mutagenicity of Material
Not Available	Not Available	Not Applicable	Not Applicable
Sensitization Capability of Material	**Carcinogenicity of Material**	**Reproductive Toxicity of Material**	**Synergistic Materials**
Skin and Respiratory	Not Applicable	Not Applicable	None Known

Exposure Limits of Material (TLV)

SECTION 7 – PREVENTATIVE MEASURES

Personal Protective Equipment
Wear Clean Long Sleeved, Body Covering Clothing, Use Impervious Gloves and Protective Clothing. Use Goggles and Full Face Shield. When Respiratory Protection is Required, Use an Approved Air Purifying Respirator. (See Below)

Gloves (Specify)	Respiratory (Specify)	Eye (Specify)
Impervious Type (Neoprene, PVC, Butyl)	Approved Air Purifying Respirator (Organic Vapour Cartridge)	Chemical Goggles
Footwear (Specify)	**Clothing (Specify)**	**Other (Specify)**
Work Boots	Clean Long Sleeved, Body Covering (Overalls, Tyvek Suit)	Full Face Shield

Engineering Controls (Specify e.g. Ventilation Enclosed Process)
Provide General Dilution of Local Exhaust in Volume and Pattern to Keep TLV of Hazardous Ingredients in Section 6 Below Acceptable Limits.

Leak and Spill Procedure
Remove All Sources of Ignition, Provide Adequate Ventilation. Avoid Prolonged Breathing of Vapours. Remove to a Container or Absorb with Clay, Diatomacious Earth or Other Inert Absorbent.

Waste Disposal **DO NOT INCINERATE CLOSED CONTAINERS**
Incineration or Landfill in an Approved Site in Accordance with Local and Federal Regulations.

Handling Procedure and Equipment
Avoid Inhalation, Skin and Eye Contact. Practice Good Personal Hygiene. Wash Repeatedly with Soap and Water After Use and Before Work Breaks.

Storage Requirements
Keep Containers Closed and in a Cool Dry Place.

Special Shipping Information

SECTION 8 – FIRST AID MEASURES

EYE CONTACT – Flush Thoroughly with Water for at Least 15 Minutes.
Get Immediate Medical Attention.

SKIN CONTACT – Wash the Exposed Areas with Soap and Water.
Call a Physician if Irritation Persists.

INHALATION – Remove to Fresh Air. If Breathing is Difficult Administer Oxygen.

INGESTION – Do Not Induce Vomiting. Administer Large Amounts of Milk or Water if Available.
Transport to a Medical Facility.

Sources Used
H & S Data from Raw Material Suppliers.

Additional Information

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SECTION 9 – PREPARATION OF THE MSDS

Prepared by (Group, Department, etc.)	Phone Number	Date
Denso North America Inc.	281-821-3355	April 15, 2011

RANBAR (Material) Safety Data Sheet

Ranbar Electrical Materials, Inc.

4205 Pipe Coating

SDS Number: 4205

Revision Date: 5/20/15

1 PRODUCT AND COMPANY IDENTIFICATION

Manufacturer

Ranbar Electrical Materials, Inc.
408 Manor-Harrison City Rd.
Harrison City, PA 15636

Vendor

Emergency:	Chemtrec 1-800-424-9300 CC# 18429
Phone:	724-864-8200
Fax:	724-864-8232
Web:	www.ranbar.com

Product Name:	4205 Pipe Coating
Revision Date:	5/20/15
Version:	1
SDS Number:	4205
Common Name:	Coating
Product Code:	4205
Product Use:	Paints and Varnishes

2 HAZARDS IDENTIFICATION

Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS):

Physical, Flammable Liquids, 4
Health, Aspiration hazard, 2
Environmental, Hazards to the aquatic environment - Acute, 3
Health, Skin corrosion/irritation, 2
Health, Serious Eye Damage/Eye Irritation, 2 A
Health, Specific target organ toxicity - Single exposure, 3

GHS Label elements, including precautionary statements

GHS Signal Word: WARNING

GHS Hazard Pictograms:

GHS Hazard Statements:

H227 - Combustible liquid
H305 - May be harmful if swallowed and enters airways
H402 - Harmful to aquatic life
H315 - Causes skin irritation
H319 - Causes serious eye irritation
H335 - May cause respiratory irritation

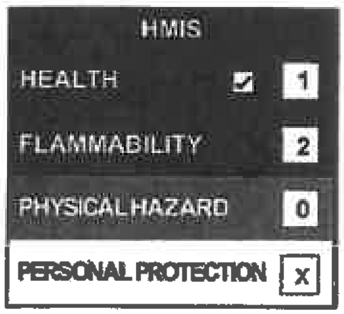
GHS Precautionary Statements:

P102 - Keep out of reach of children.
P273 - Avoid release to the environment.
P281 - Use personal protective equipment as required.
P302+350 - IF ON SKIN: Gently wash with soap and water.
P331 - Do NOT induce vomiting.

Hazards not otherwise classified (HNOC) or not covered by GHS

Route of Entry:	Eyes; Ingestion; Inhalation; Skin;
Target Organs:	Eyes; Skin; Respiratory system; Cental nervous system; Kidneys;
Inhalation:	Overexposure may cause respiratory irritation, resulting in central nervous system (CNS) depression
Skin Contact:	May cause irritation with symptoms of reddening, itching, and swelling.
Eye Contact:	May cause irritation with symptoms of reddening, tearing, stinging, and swelling. May cause temporary corneal injury. Prolonged vapor contact may cause conjunctivitis.
Ingestion:	May cause irritation. Symptoms may include abdominal pain, nausea, vomiting, and diarrhia. Aspiration hazard if swallowed.

NFPA: Health = 1, Fire = 2, Reactivity = 0, Specific Hazard = n/a
HMIS III: Health = 1(Chronic), Fire = 2, Physical Hazard = 0
HMIS PPE: X - Consult your supervisor for special instructions



3 COMPOSITION/INFORMATION ON INGREDIENTS

Ingredients:

Cas#	%	Chemical Name
0	50%	Alkyd Resin Proprietary
8052-41-3	50%	Mineral Spirits (Stoddard Solvent)

4 FIRST AID MEASURES

Inhalation:	Immediately move to an area free from exposure with fresh air. If not breathing, give artificial respiration. If breathing is difficult give oxygen.
Skin Contact:	If large skin area is affected, remove contaminated clothing. Wash with soap and water. Consult a physician if irritation continues. Use skin cream to counter any resulting dryness.
Eye Contact:	Immediately flush with clear water for 15 minutes, including under eyelids. Consult a doctor.
Ingestion:	Consult a physician. Do not induce vomiting. Do not give anything by mouth to an unconslous individual. Consult a physician.

5 FIRE FIGHTING MEASURES

Flammability:	Combustible Liquid
Flash Point:	>105 F (40.6 C)
Flash Point Method:	Closed Cup (Seta)
Autoignition Temp:	473 F (245 C)
LEL:	1%
UEL:	7%

Conditions to avoid: Heat, sparks, flame, red hot metal. Extinguishing Media: CO2, dry chemical, or universal aqueous film forming foam. Hazardous Combustion Products: Oxides of Carbon (CO, CO2), smoke and vapors. Unsuitable Extinguishing Media: Water Jet or water based fire extinguishers. Vapor within the flammable limits may be ingnited by a static discharge of sufficient energy. Use water spray to cool fire exposed containers as contents can rupture violently from heat developed pressure. Firemen should waar self contained breathing apparatus.

6 ACCIDENTAL RELEASE MEASURES

Use personal protection recommended for this material.
Isolate hazard area and deny entry to unnecessary and unprotected personnel.
Keep out of drains, sewers, ditches, and waterways. Avoid use of water.
Released content may be contained with oil/solvent absorbant pads, booms, and or absorbants.
Avoid breathing vapors and ventilate area well.
Remove sources of ignition and use non-sparking equipment.
Soak up material with inert absorbant and place in safety containers for proper disposal.
Prohibited Cleanup Materials: Combustible absorbent materials such as sawdust, and use of equipment that may cause sparking.
Report releases that reach surface water or groundwater in any amount.
Spills, leaks and overfills from underground regulated storage tanks should also be reported.
Reportable quantities for spills onto the ground depend on site conditions such as type of soil and material spilled.
Consult your local regulatory agency if unsure of reporting requirements.

7 HANDLING AND STORAGE

Handling Precautions: Avoid breathing vapors or mist. Avoid contact with eyes, skin, or clothing. Consider normal working hygiene. Do not expose containers to open flame, excessive heat, or direct sunlight.
Do not puncture or drop containers.
Handle with care and avoid spillage on the floor (slippage). Keep away from sources of ignition. Keep material out of reach of children. Launder contaminated clothing. Use approved containers only.

Storage Requirements: Use appropriate grounding when filling and transfering containers. For storage of all flammable materials, conform to NFPA 30 Flammable and Combustible Liquid. Keep away from heat, sparks, and flames. Keep containers tightly closed and stored in a well ventilated area. Use appropriate grounding when filling and transfering containers. When using spray application, conformances to NFPA 33 Spray Applications using Flammable and Combustible Materials is recommended.

8 EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls: Use with adequate ventilation. General ventilation (typically 10 air changes per hour) should be used. Rates should be matched to conditions. Local exhaust ventilation or an enclosed handling system may be necessary to control air contamination below that of the lowest OEL.

Personal Protective Equipment: HMIS PP, X | Consult your supervisor for special instructions
Chemical resistant gloves; Chemical safety glasses; NIOSH approved respirator; Organic vapor respirator with dust, mist, and fume filters;

Exposure Limits:

USA OSHA (TWA_8)/PEL): 500 ppm
ACGIH (TWA/TLV): 100 ppm
NIOSH REL: 350 mg/m3
NIOSH IDLH: 2000 mg/m3

9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Amber liquid.		
Physical State:	Liquid	**Odor:**	Petroleum distillate odor.
Spec Grav./Density:	Specific Gravity: 0.891 g/ml	**Solubility:**	Insoluble in water.

IMS Number: 53973

Viscosity:	Lightly viscous liquid.	**Percent Volatile:**	50%
Boiling Point:	340 F (171 C)	**Freezing/Melting Pt.:**	Not available.
Flammability:	Combustible.	**Flash Point:**	>105 F (40.6 C)
Partition Coefficient:	Not available.	**Vapor Density:**	4.9 (air = 1)
Vapor Pressure:	2 mm Hg @ 20 C	**VOC:**	3.75 lbs/gal
pH:	Not available.	**Auto-Ignition Temp:**	473 F (245 C)
Evap. Rate:	0.2 (n-butyl acetate = 1)		
Decomp Temp:	Not available.		

Weight per Gallon: 7.43 lbs/gal

10 STABILITY AND REACTIVITY

Stability:	Product is stable under normal conditions.
Conditions to Avoid:	Sources of ignition. Heat, sparks, flame, red hot metal.
Materials to Avoid:	Strong Oxidizing Agents.
Hazardous Decomposition:	Oxides of carbon (C0, CO2).
Hazardous Polymerization:	Will not occur.

11 TOXICOLOGICAL INFORMATION

Acute Toxicity: (Mineral Spirits (Stoddard Solvent)

Oral (LD 50): Not Available

Inhalation (LC 50): Not Available

Dermal (LD 50): 500 mg/kg, rabbit

Toxicity Data:

Eye Effects:	Eye irritant
Skin Effects:	Skin irritant
Accute Inhalation Effects:	Not Known.
Chronic Effects:	Not Known.
Carcinogenicity:	Not Known.
Mutagenicity:	Not Known.
Teratogenicity:	Not Known.

12 ECOLOGICAL INFORMATION

Elimination (persistency and degradability): Not available.

Do not allow to enter waters or soil.
May be toxic to the aquatic environment.
Does not contain any ozone depleting ingredients.

13 DISPOSAL CONSIDERATIONS

Hazard characteristics and waste stream classification can change with product use and location. It is the resposibility of the user to determine the proper storage, transportation, treatment, and/or disposal methodologies for spent materials and residues at the time of disposition. All waste material must be disposed of in compliance with respective national, federal, state, and local regulations. Consult with your local landfill to determine if empty small containers can be disposed of in regular trash pickup. Containers holding flammable or combustible liquid residues and vapors may be considered dangerous. Do not pressurize, weld, braze, cut, solder, drill, grind or expose such containers to heat, flame, sparks, static electricity or other sources of ignition. Empty drums should be completely drained, properly bunged, and promptly returned to a drum reconditioner. For disposal of large containers (10 gal or larger), or for containers not suitable for landfill, consult a local drum reconditioner. All other containers should be disposed of in accordance with governmental regulations.

14 TRANSPORT INFORMATION

NA1993, Combustible liquid, n.o.s., Combustible liquid, PGIII, (Mineral Spirits)

DOT Shipping Information:

United States (Domestic):

Bulk Quantities (119 gallons (450 liters)or greater):
NA1993, Combustible Liquid NOS (Mineral Spirits), Combustible Liquid, PGIII
ERG# 128

Drum Size Quantities (less that 119 gallons (450 liters)):
Non-Regulated Liquid

International and IATA Shipments:

Bulk:
UN1263, Paint, 3, PGIII

Drums:
Non-Regulated Liquid

15 REGULATORY INFORMATION

Component (CAS#) [%] - CODES

Alkyd Resin Proprietary (0) [50%] TSCA, DSL

Mineral Spirits (Stoddard Solvent) (8052-41-3) [50%] MASS, OSHAWAC, PA, TSCA, TXAIR, DSL

```
Regulatory CODE Descriptions
----------------------------------------------------------------
MASS = MA Massachusetts Hazardous Substances List
OSHAWAC = OSHA Workplace Air Contaminants
PA = PA Right-To-Know List of Hazardous Substances
TSCA = Toxic Substances Control Act
TXAIR = TX Air Contaminants with Health Effects Screening Level
DSL = Canadian Domestic Substances List
```

16 OTHER INFORMATION

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Designation: F2620 – 11

An American National Standard

Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings[1]

This standard is issued under the fixed designation F2620; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes procedures for making joints with polyethylene (PE) pipe and fittings by means of heat fusion joining in, but not limited to, a field environment. Other suitable heat fusion joining procedures are available from various sources including pipe and fitting manufacturers. This standard does not purport to address all possible heat fusion joining procedures, or to preclude the use of qualified procedures developed by other parties that have been proved to produce reliable heat fusion joints.

1.2 The parameters and procedures are applicable only to joining polyethylene pipe and fittings of related polymer chemistry. They are intended for PE fuel gas pipe per Specification D2513 and PE potable water, sewer and industrial pipe manufactured per Specification F714, Specification D3035, and AWWA C901 and C906. Consult with the pipe manufacturers to make sure they approve this procedure for the pipe to be joined (see Appendix X1).

NOTE 1—Information about polyethylene pipe and fittings that have related polymer chemistry is presented in Plastics Pipe Institute (PPI) TR-33 and TR-41.

1.3 Parts that are within the dimensional tolerances given in present ASTM specifications are required to produce sound joints between polyethylene pipe and fittings when using the joining techniques described in this practice.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 The text of this practice references notes, footnotes, and appendixes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the practice.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D2513 Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings

D3035 Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

F714 Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

F1056 Specification for Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings

2.2 *PPI Documents:*

TR-33 Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene[3]

TR-41 Generic Saddle Fusion Joining Procedure for Polyethylene Gas Piping[3]

2.3 *AWWA Documents:*

AWWA C901 Standard for Polyethylene (PE) Pressure Pipe and Tubing, ½ in. (13 mm) through 3 in. (76 mm), for Water Service[4]

AWWA C906 Standard for Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) through 63 in. (1575 mm), for Water Distribution and Transmission[4]

3. Summary of Practice

3.1 The principle of heat fusion joining of polyethylene (PE) pipe is to heat two prepared surfaces to a designated temperature, then fuse them together by application of a sufficient force. This force causes the melted materials to flow and mix, thereby resulting in fusion.

3.2 The heat-fusion procedures covered in this practice are socket fusion, butt fusion, and saddle fusion.

3.2.1 *Procedure 1, Socket Fusion*—The socket-fusion procedure involves simultaneously heating the outside surface of a pipe end and the inside of a fitting socket, which is sized to

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.20 on Joining.

Current edition approved Nov. 1, 2011. Published November 2011. Originally approved in 2006. Last previous edition approved in 2009 as F2620–09$^{\varepsilon 1}$. DOI: 10.1520/F2620-11.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

be smaller than the smallest outside diameter of the pipe. After the proper melt has been generated at each face to be mated, the two components are joined by inserting one component into the other. See Fig. 1. The fusion bond is formed at the interface resulting from the interference fit. The melts from the two components flow together and fuse as the joint cools. Optional alignment devices are used to hold the pipe and socket fitting in longitudinal alignment during the joining process; especially with pipe sizes IPS 3 in. (89 mm) and larger. Automated socket fusion is not addressed in this procedure.

3.2.2 *Procedure 2, Butt Fusion*—The butt-fusion procedure in its simplest form consists of heating the squared ends of two pipes, a pipe and a fitting, or two fittings, by holding them against a heated plate, removing the heater plate when the proper melt is obtained, promptly bringing the ends together, and allowing the joint to cool while maintaining the appropriate applied force.

3.2.2.1 An appropriately sized butt fusion machine is used to clamp, align and face the pipe or fitting ends and to apply the specified fusion force. See Fig. 2.

3.2.3 *Procedure 3, Saddle Fusion*—The saddle-fusion procedure involves melting the concave surface of the base of a saddle fitting, while simultaneously melting a matching pattern on the surface of the pipe, bringing the two melted surfaces together and allowing the joint to cool while maintaining the appropriate applied force. See Fig. 3.

3.2.3.1 An appropriately sized saddle fusion machine is used to clamp the pipe main and the fitting, align the parts and apply the specified fusion force.

4. Significance and Use

4.1 The procedures described in Sections 7-9 are primarily intended for (but not limited to) field joining of polyethylene (PE) pipe and fittings, using suitable equipment and appropriate environmental control procedures. When properly implemented, strong pressure/leak-tight joints are produced. When these joints are destructively tested, the failure occurs outside the fusion joined area.

4.2 Melt characteristics, average molecular weight and molecular weight distribution are influential factors in establishing suitable fusion parameters; therefore, consider the manufacturer's instructions in the use or development of a specific fusion procedure. See Annex A1.

4.3 The socket fusion, butt fusion, and saddle fusion procedures in this practice are suitable for joining PE gas pipe and fittings, PE water pipe and fittings, and PE general purpose pipes and fittings made to PE product specifications from organizations such as ASTM, AWWA, API, and ISO that are used in pressure, low pressure and non-pressure applications. For gas applications, qualification of the procedure by testing joints made using the procedure in accordance with regulations from the authority having jurisdiction are required.

5. Operator Experience

5.1 Skill and knowledge on the part of the operator are required to obtain a good quality joint. This skill and knowledge is obtained by making joints in accordance with proven procedures under the guidance of skilled operators. Evaluate operator proficiency by testing sample joints.

5.2 The party responsible for the joining of polyethylene pipe and fittings shall ensure that detailed procedures developed in conjunction with applicable codes and regulations and the manufacturers of the pipe, fittings, and joining equipment involved, including the safety precautions to be followed, are issued before actual joining operations begin.

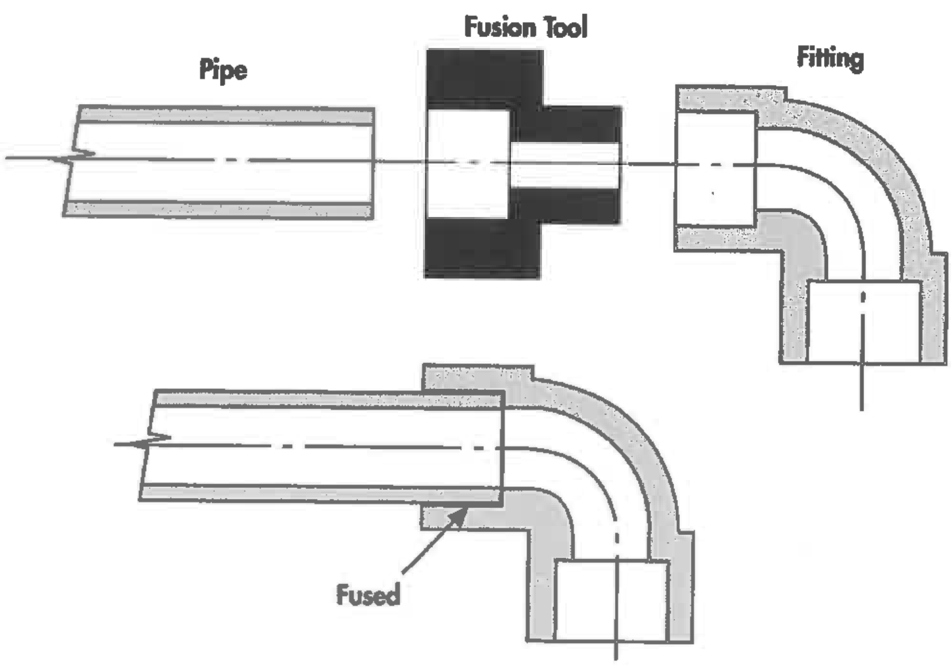


FIG. 1 Socket Fusion

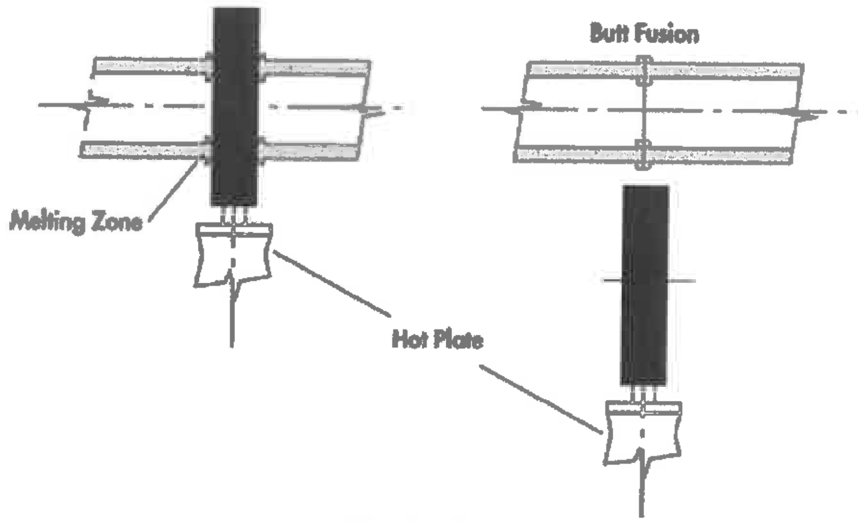


FIG. 2 Butt Fusion

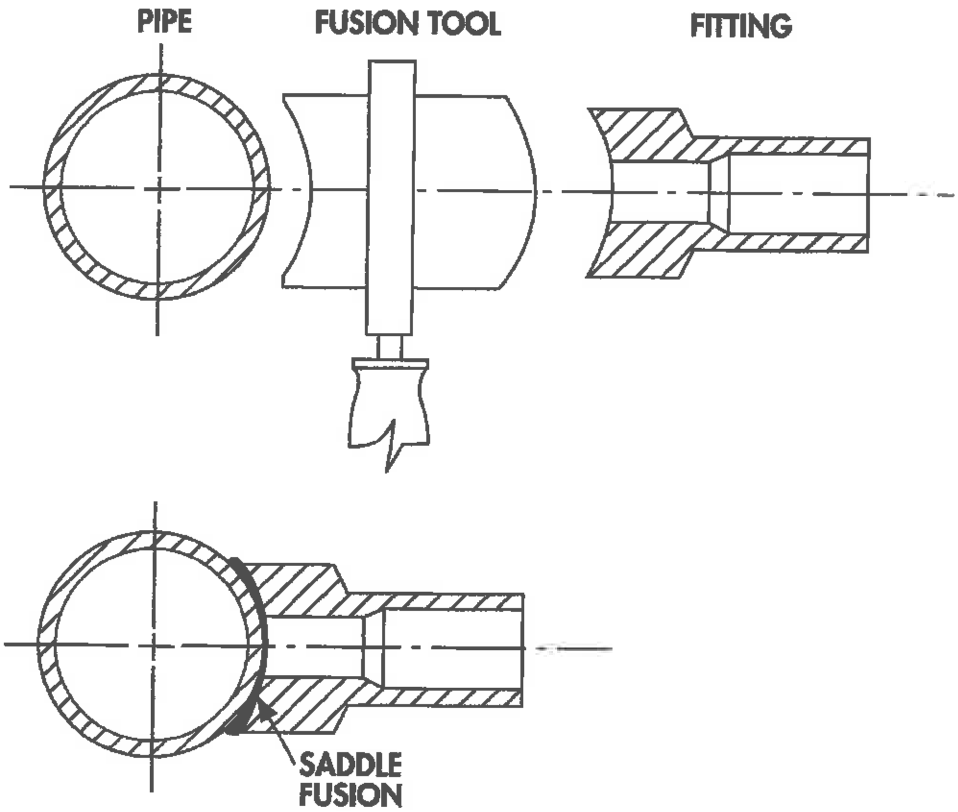


FIG. 3 Saddle Fusion

6. Apparatus—General Recommendations

6.1 *Heating Tool*—Electric heating tools come in a variety of sizes that match the fusion machines capabilities. They are designed with enough wattage and electronic control to maintain the specified heater face temperature required in this procedure. The range of the heater control shall be larger than the heating temperature specification (the typical control range is 50°F (30°C) above and below the maximum and minimum required heating tool surface temperatures. Electric heating plates maintain consistent fusion temperatures when provided with an adequate power source.

6.2 *Heating Tool Faces*—Heating tools may be made from materials such as aluminum, stainless steel, copper, or copper alloys. Polyethylene material may stick to hot metal heating surfaces. This sticking may be minimized by applying a non-stick coating to the heating surfaces or by fitting a high-temperature, non-stick fabric over the heating surfaces. The heating plate surfaces, coated or uncoated, shall be kept clean and free of contaminants such as dirt, grease and plastic build-up, which may cause excessive sticking and create unsatisfactory joints. Most of these contaminants are removed from the hot tool surfaces using a clean, dry, oil-free lint-free cloth. Do not use synthetic fabrics which may char and stick to the fusion surface. Some pigments, such as carbon black, may stain a heating surface and probably cannot be removed; such stains will not contaminate the joint interface.

6.2.1 After a period of time in service, non-stick coatings or fabrics will deteriorate and become less effective. Deteriorated fabrics shall be replaced, and worn, scratched, or gouged non-stick coatings shall be re-coated when they lose effectiveness. Heat fusion quality may be adversely affected by deteriorated non-stick surfaces. Spray-on chemicals, such as non-stick lubricants or oils shall not be applied to heating iron surfaces as they will contaminate the joint.

6.3 *Temperature Indicator*—Heating tools shall be equipped with a thermometer or other built-in temperature indicating device. This device indicates the internal temperature of the heating iron, which is usually higher than temperature of the heating tool surfaces. Use a pyrometer, or other temperature measuring device, on the first joint of the day and periodically during the day to verify the temperature of the tool face surfaces within the pipe or fitting contact area. Select multiple checkpoints to ensure uniform surface temperature. An infrared pyrometer is calibrated by comparison to a calibrated surface pyrometer and adjusted to agree on each heating tool.

NOTE 2—A significant temperature variation, that is, cold spots, on the heating tool surfaces may indicate a faulty heating iron which may need to be serviced before it can be used.

7. Procedure 1—Socket Fusion

7.1 *Apparatus*:

7.1.1 *Socket Fusion Tools*—Socket fusion tools consist of a heating tool, heating tool faces, rounding clamps (cold rings), depth gage/chamfer tools, and pipe/fittings made to ASTM specifications.

7.1.2 *Heating Tool*—In order to obtain a proper melt, it is necessary for a uniform temperature to be maintained across the heating tool faces. An electrical tool shall have sufficient wattage and control to maintain the specified surface temperature of the tool faces.

7.1.3 *Heating Tool Faces*—Consisting of two parts, a male end for the interior socket surface and a female end for the exterior pipe surface. Both parts shall be made to such tolerances as to cause an interference fit. Heating tool faces are produced to Specification F1056 dimensions, and are coated with a non-stick material to keep melted pipe and fitting material from sticking to the face.

7.1.4 *Alignment Jig*—The alignment jig is an optional tool which consists of two sets of devices holding the components in alignment to each other. One set of holding devices is fixed, and the other allows longitudinal movement for making the joint.

7.1.5 *Rounding Clamps*, (cold ring) to maintain roundness of the pipe and control the depth of pipe insertion into the socket during the joining operation.

7.1.6 *Depth Gage*, for proper positioning of the rounding clamp on the pipe.

7.1.7 *Chamfering Tool*, to bevel the end of the pipe.

NOTE 3—The depth gage and chamfering tool may be combined into a single tool.

7.1.8 *Tubing Cutter*, to obtain a square end cut on the pipe.

7.1.9 *Fitting Puller*, an optional tool to assist in the removal of the fitting from the heating tool and to hold the fitting during assembly.

7.2 *Procedure*:

7.2.1 Attach the proper size heater faces to the heating tool, and bring the surface temperature of the tool faces to 490 to 510°F (254 to 266°C). Use a pyrometer, or other temperature measuring device, on the first joint of the day and periodically during the day to verify the temperature of the tool face surfaces within the pipe or fitting contact area. Select multiple checkpoints to ensure uniform surface temperature. Heating tool thermometers measure the internal temperature of the heating tool, which is typically higher than the surface temperature of the heating tool faces.

7.2.2 Cut the pipe end squarely, and clean the pipe end and fitting, both inside and outside, by wiping with a clean, dry, oil-free, lint-free cloth.

7.2.3 Chamfer the outside edge of the pipe end slightly and fix the rounding clamp about the pipe as determined from the depth gage. (See Note 4.)

7.2.4 Push the socket fitting onto the preheated fitting tool face first, and then push the pipe into the pipe-side tool face until the rounding clamps make contact with the heating faces.

TABLE 1 Socket Fusion Time Cycles

Pipe Size	PE 2406/ PE 2708		PE 3408/ PE 3608/ PE 4710	
	Heating Time Seconds	Cooling Time Seconds	Heating Time Seconds	Cooling Time Seconds
½ in CTS	6-7	30	6-10	30
¾ in CTS	6-7	30	6-10	30
1 in. CTS	9-10	30	9-16	30
1 ¼ in.	10–12	30	10-16	30
½ in . IPS	6–7	30	6-10	30
¾ in. IPS	8–10	30	8-14	30
1 in. IPS	10-12	30	15-17	30
1¼ in. IPS	12-14	45	18-21	60
1½ in. IPS	14-17	45	20-23	60
2 in. IPS	16-19	45	24-28	60
3 in. IPS	20-24	60	28-32	75
4 in. IPS	24-29	60	32-37	75

7.2.5 Heat the pipe end and the fitting socket for the time required in Table 1.

7.2.6 At the end of the heating time, simultaneously remove the pipe and fitting straight out from the tool, using a snap action. Immediately insert the pipe straight into the socket of the fitting so the rounding clamp is flush against the end of the fitting socket. Hold or block the joint in place to cool for the time specified in Table 1. (For ambient temperatures 100°F and higher, additional cooling time may be needed.)

7.2.7 Remove the rounding clamp, and inspect the melt pattern at the end of the socket for a complete impression of the rounding clamp in the melt surface. There shall be no gaps, voids, or unbonded areas. Visually inspect and compare the joint against recommended appearance guidelines (see Appendix X2). Allow the joint to cool an additional five (5) minutes before exposing the joint to any type of stresses (that is, burial, testing or fusing the other end of the fitting.)

7.2.8 Allow for extremes in weather when making field joints. Heating times, dimensional changes, etc., are affected by extreme weather conditions.

NOTE 4—Some recommend using a 50-60 grit emery or garnet cloth to roughen the outside of the pipe and inside of the fitting as a means of minimizing any possible skin interface when making the fusion. Sandpaper is not recommended for this purpose, as it might disintegrate and contaminate the joint interface. If roughening is performed, first clean the surfaces before roughening with a clean cloth or water. Once the pipe or fitting surfaces have been roughened and clean material has been exposed, water cannot be used to clean the pipe surfaces. Clean dust and particles from the roughened surfaces afterwards by cleaning the pipe or fitting ends with a clean dry lint free cloth.

8. Procedure 2—Butt Fusion

8.1 *Apparatus*:

8.1.1 *Heating Tool*—The heating tool shall have sufficient area to adequately cover the ends of the size of pipe to be joined. This electrical tool shall have sufficient wattage and control to maintain the specified surface temperature of the tool faces. It shall also be equipped with heater faces that are coated with a non-stick material to prevent sticking to the pipe surface.

8.1.2 *Butt Fusion Machine*—A Butt Fusion Machine has three basic parts: *(1)* a stationary clamping fixture and a movable clamping fixture for aligning and holding each of the two parts to be fused. This may or may not include the power supply to operate the machine; *(2)* a facer for simultaneously preparing the ends of the parts to be joined (Note 5); and *(3)* appropriate inserts for clamping different pipe sizes or fitting shapes. Butt Fusion Machines are operated manually or hydraulically. Some have their own power supply and some require a separate generator. They are available in a variety of sizes to fuse pipe and tubing produced to ASTM and other industry specifications.

NOTE 5—A facer is a rotating cutting device used to square-off the pipe or fitting ends to obtain properly mating fusion surfaces. If so equipped, facing should continue until a positive mechanical stop on the butt fusion machine is reached.

8.1.3 *Pipe Support Stands*—Optional pipe support stands or racks are used to support the pipe at both ends of the butt fusion machine to assist with pipe loading and alignment.

8.2 *Setup*:

8.2.1 Butt fusion machine setup parameters are prescribed in Table 2.

8.2.2 An interfacial pressure of 60 to 90 psi (0.41 to 0.62 MPa) is used to determine the force required to butt fuse the pipe components. Multiply the interfacial pressure times the pipe area to calculate the fusion force required (lb). For manually operated fusion machines, enough force should be applied to roll the bead back to the pipe surface. A torque wrench may be used to apply the proper force. Manual fusion without a torque wrench has been used successfully by many gas utilities. For hydraulically operated fusion machines, the fusion force is divided by the total effective piston area of the movable carriage cylinders to give the theoretical butt fusion pressure in psig. The internal and external drag factors are added to this figure to obtain the actual fusion pressure in psig required by the machine. (The theoretical butt fusion pressure and the interfacial pressure are *not* the same value.) This drag pressure is found by bringing the faced pipe ends within 2 in. (50 mm) of each other and increase the pressure on the carriage until it starts moving. Back off the pressure until the carriage is barely moving and record the drag pressure in psig. Add this pressure to the theoretical butt fusion pressure to obtain the fusion machine gauge pressure in psig required for fusion.

NOTE 6—Interfacial pressure is used to determine butt fusion joining pressure settings for hydraulic butt fusion machines when joining specific pipe diameters and DR's. Interfacial pressure is *not* the gauge pressure.

TABLE 2 Butt Fusion Machine Setup Parameters

Setup Parameter		
Manual Butt Fusion Machine	Hydraulic Butt Fusion Machine	Required Condition
Set heating tool temperature and heat to specified temperature		The surface temperature of heating tool faces must be 400 to 450°F (204 to 232°C). (See X1.1.) A pyrometer or other surface temperature measuring device should be used periodically to insure proper surface temperature of the heating tool faces.
Install inserts	Install inserts	Install inserts for the pipe OD or the fitting being fused.
Electric power supply	Electric power supply	Check field generator for adequate power supply and fuel sufficient to complete the fusion joint.
Manual pressure	Set facing pressure	As required. Observe butt fusion machine manufacturer's instructions for setting facing pressure.
Manual pressure	Set heating pressure	Observe the pipe and butt fusion machine manufacturer's instructions for setting heating pressures.
Manual pressure (Drag a manual adjustment)	Set fusion joining pressure	Determine fusion joining pressure for the pipe OD and dimension ratio (DR) using 60 to 90 psi (414 to 621 kPa) interface pressure. Observe pipe and butt fusion machine manufacturer's instructions to determine the theoretical fusion joining pressure. Drag pressure is the amount of pressure required to get the carriage to move. Add this pressure to the theoretical fusion joining pressure to get the actual machine gage pressure to set.

8.3 *Procedure*:

8.3.1 Clean the inside and outside of the components (pipe or pipe and fitting) to be joined with a clean lint-free dry cloth. Remove all foreign matter from the piping component surfaces where they will be clamped in the butt fusion machine.

8.3.2 If applicable, place pipe support stands at both ends of the butt fusion machine and adjust the support stands to align the pipe with the fusion machine centerline. Install the pipes or fittings being joined in the stationary and movable clamps of the butt fusion machine. Leave enough pipe protruding through the clamps to allow for facing and clamp the pipe or fitting in the machine.

8.3.2.1 Take care when placing pipe or fittings in the butt fusion machine. Pipes shall be aligned before the alignment clamp is closed. Do not force the pipe into alignment by pushing it against the side of an open butt fusion machine clamp. Pipes that are freshly cut and molded fittings generally do not have toe-in, and when mated to old-cut pipe or fabricated fittings, removing toe-in can ease adjustment for high-low alignment.

8.3.3 Face the piping component ends until the facer bottoms out on the stops and is locked between the jaws to establish clean, parallel mating surfaces between the pipe/fitting ends (see Note 5). Open the jaws, remove the facer and all shavings and debris from the facing operation by brushing away with a clean, dry, lint-free cloth.

8.3.4 Check the pipe ends for high-low alignment and out-of-roundness. If adjustment is needed, adjust the high side down by tightening the high side clamp. Do not loosen the low side clamp or slippage may occur during fusion. Re-face the pipe or fitting ends if excessive adjustment is required (more than 180° rotation of the clamp knob) and remove any shavings from the re-facing operation with a clean, lint-free cotton cloth. The maximum OD high-low misalignment allowed in the butt fusion procedure is to be less than 10 % of the pipe minimum wall thickness.

8.3.5 Verify that the heater surface temperatures are in the specified temperature range 400 to 450°F (204 to 232°C). (See Appendix X1.) A pyrometer or other surface temperature measuring device should be used before the first joint of the day and periodically throughout the day to insure proper temperature of the heating tool face. All pyrometers are sensitive to usage techniques. Carefully follow the manufacturer's instructions for best results.

8.3.5.1 Place the heating tool in the butt fusion machine between the piping component ends and bring the pipe or fitting ends into full contact with the heating tool at fusion pressure. Briefly ensure full contact between piping component ends and the heating tool and then reduce the pressure to drag pressure but without breaking contact between the piping component ends and the heating tool. (On larger pipe sizes, (14 in. and larger) hold fusion pressure until a slight melt is observed around the circumference of the pipe or fitting before reducing pressure. This normally varies from about 10 s on 14 in. pipe and smaller and could be greater than 2 min on 36 and larger pipe sizes.)

8.3.5.2 Once the indication of melt is observed around the circumference of the pipe, begin the heat soak by reducing the pressure to maintain contact, without force, while a bead of molten polyethylene develops between the heater and the pipe or fitting ends. For 14 in. IPS pipe sizes and larger, maintain the heat soak for a minimum of 4.5 minutes for every inch (25.4 mm) of pipe wall thickness. (example: minimum heat soak time for a pipe with .50 in. (12.7mm) wall would be 2 min 15 s). Continue heating the pipe ends until the melt bead size has developed against the heater face per Table 3.

8.3.6 When the proper bead size is observed, quickly move the piping component ends away from the heating tool, remove the heating tool and quickly inspect the pipe ends.

8.3.6.1 Acceptable melt appears flat and smooth with no unmelted areas. Unacceptable melt appearance is any combination of a concave surface, unmelted areas, a bubbly pock-marked sandpaper-like surface or melted material sticking to heating tool surfaces (see Fig. X2.7). Low strength joints result from unacceptable melt appearance. Discontinue the joining procedure, allow the component ends to cool completely and restart from 8.3.1. (See Appendix X2.)

8.3.6.2 The maximum time allowed for opening the machine, removing the heater and bringing the pipe ends together is shown in Table 4. For tubing sizes that are generally butt fused with mechanical fusion machines (not hydraulically controlled) (½ CTS to 1 ½ in. IPS), the maximum open/close time is 4 s. The quicker you can safely do this process, the better. See A1.4.3.1 for guidance on butt fusion in cold temperatures. Do not slam the pipe ends together.

NOTE 7—A concave melt surface is caused by unacceptable pressure during heating.

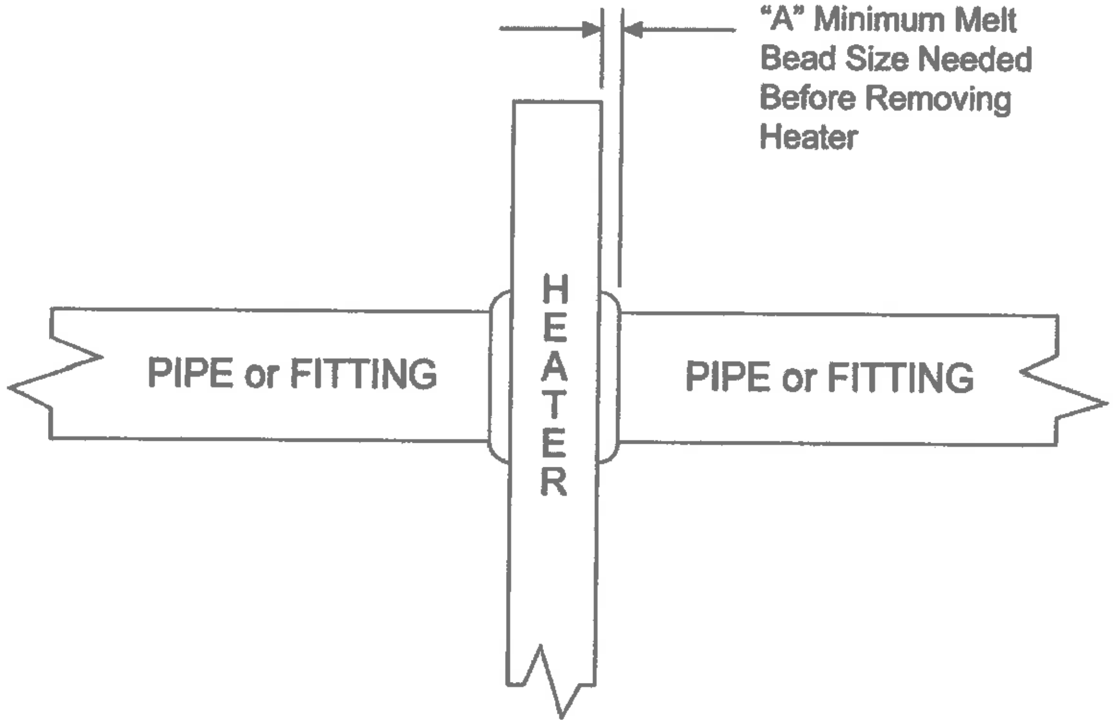
8.3.6.3 The correct fusion pressure rolls both melt beads over so that they touch the piping component OD surfaces. Do not use excessive or insufficient force (more than or less than the fusion interfacial pressure range). If the components are brought together with excessive force, molten material may be pushed out of the joint and cold material brought into contact forming a "cold" joint. If too little force is used, voids and weak bonded areas can develop in the joint as molten material cools and contracts.

8.3.7 Hold the molten joint immobile under fusion pressure until sufficiently cooled. Cooling under pressure before removal from the butt fusion machine is important in achieving joint integrity. Maintain fusion pressure against the piping component ends for a minimum of 11 minutes per inch (25.4 mm) of pipe wall. For ambient temperatures 100°F and higher, additional cooling time may be needed. Avoid high stress such as pulling, installation or rough handling for an additional 30 min or more after removal from the fusion machine (only 10 minutes additional cooling time is required for IPS 1 in. and smaller pipe sizes). Do not apply internal pressure until the joint and surrounding material have reached ambient air temperature. (See Appendix X1.)

NOTE 8—Pouring water or applying wet cloths to the joint to reduce cooling time is not acceptable. Applying chilled air is acceptable only as part of a controlled cooling cycle procedure where testing demonstrates that acceptable joints are produced using the controlled cooling cycle procedure.

8.3.7.1 Visually inspect and compare the joint against the butt fusion bead visual inspection acceptance guideline in Fig.

TABLE 3 Approximate Melt Bead Size



Pipe (OD) [Outside Diameter, in. (mm)]	"A" Minimum Bead Size, in. (mm)
< 2.37 (60)	1/32 (1)
≥ 2.37 (60) < 3.5 (89)	1/16 (1.5)
>3.5 (89) < 8.62 (219)	3/16 (5)
> 8.62 (219) to < 12.75 (324)	1/4 (6)
> 12.75 (324) to ≤ 24 (610)	3/8 (10)
> 24 (610) to < 36 (900)	7/16 (11)
> 36 (900) to ≤ 65 (1625)	9/16 (14)

TABLE 4 Maximum Heater Plate Removal Times

Field Applications Pipe Wall Thickness, in. (mm)	Max. Heater Plate Removal Time Seconds
0.20 to 0.36 (5 to 9)	8
>0.36 to 0.55 (9 to 14)	10
>0.55 to 1.18 (14 to 30)	15
>1.18 to 2.5 (30 to 64)	20
>2.5 to 4.5 (64 to 114)	25

4. The v-groove between the beads should not be deeper than half the bead height above the pipe surface. When butt fusing to molded fittings, the fitting-side bead may display shape irregularities such as minor indentations, deflections and non-uniform bead rollover from molded part cooling and knit lines. In such cases, visual evaluation is based mainly on the size and shape of the pipe-side bead. (See Appendix X2 for additional guidance.)

9. Procedure 3—Saddle Fusion

9.1 *Apparatus*:

9.1.1 *Heating Tool and Faces*—This electrical tool shall have sufficient wattage and control to maintain the specified surface temperature of the tool faces. The serrated or smooth faces are matched sets, by pipe size, of concave and convex blocks, which bolt or clamp onto a flat heating tool. The heating faces are coated with a non-stick material to prevent sticking to the pipe or fitting surfaces.

9.1.2 *Saddle Fusion Tool*—This tool clamps to the main, rounding and supporting the main for good alignment between the pipe and fitting. It holds the fitting, in correct alignment to the main. It also applies and indicates the proper force during the fusion process. A support or bolster is clamped to IPS 6 in. (168 mm) and smaller main pipe opposite the fitting installation area to support the main and assist in rounding the pipe.

9.1.3 *Optional Flexible Heat Shield*—A flexible heat resistant metal or insulated fabric pad used to help establish a melt pattern on larger mains before applying heat to the fitting.

9.2 *Saddle Fusion Terminology*:

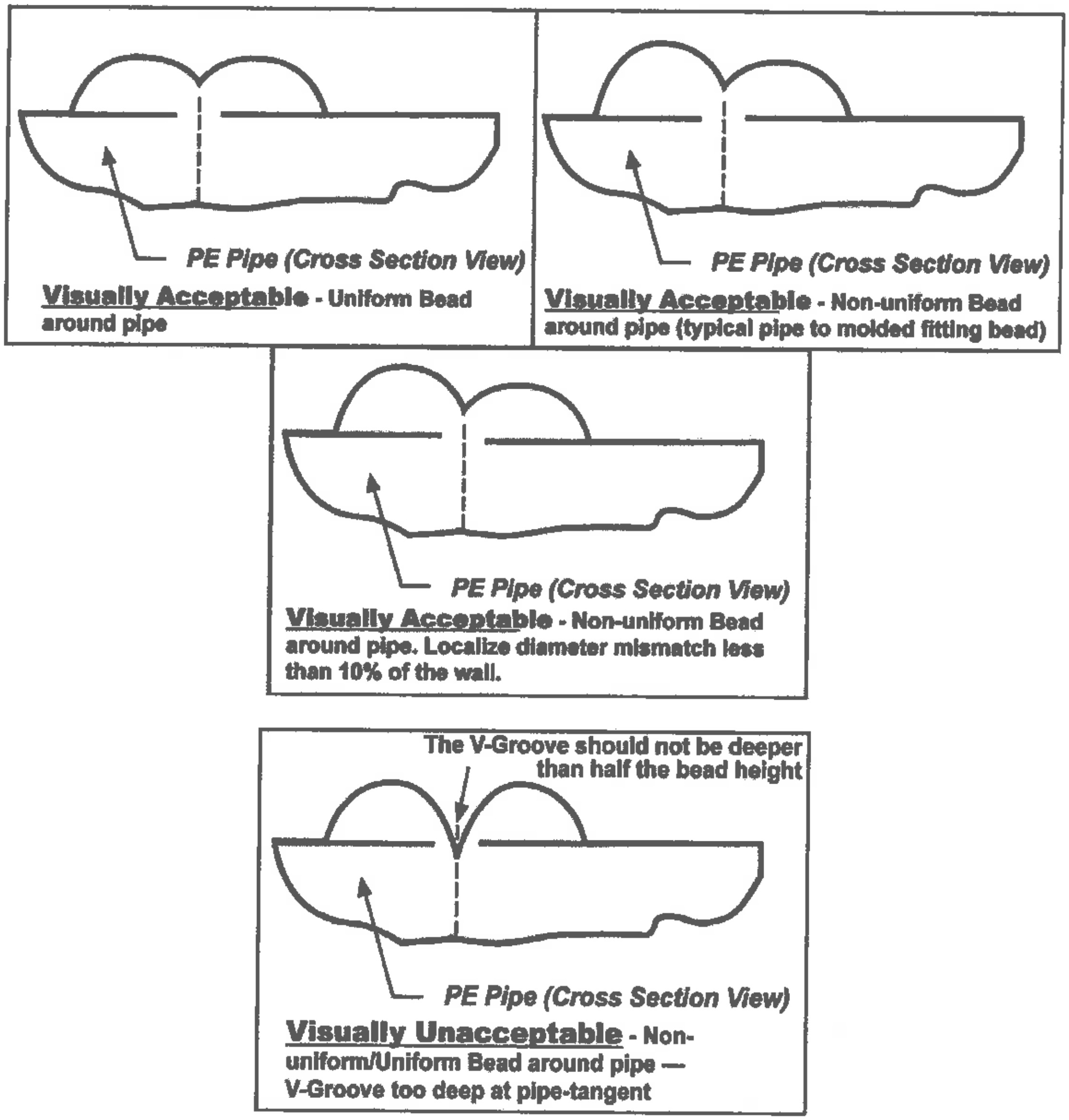


FIG. 4 Butt Fusion Bead Dimensional Guideline

9.2.1 *Initial Heat (Bead-up)*—The heating step used to develop an initial melt bead on the main pipe.

9.2.2 *Initial Heat Force (Bead-up Force)*—The force (lb) applied to establish an initial melt pattern on the main pipe. The Initial Heat Force is determined by multiplying the fitting base area (in.^{2}) by the initial interfacial pressure 60 (lb/in.^{2}).

9.2.3 *Heat Soak Force*—The force (lb) applied after an initial melt pattern is established on the main pipe. The Heat Soak Force is the minimum force (essentially zero pounds) that ensures that the fitting, heater and main stay in contact with each other.

9.2.4 *Fusion Force*—The force (lb) applied to establish the fusion bond between the fitting and the pipe. The fusion Force is determined by multiplying the fitting projected base area (in.^{2}) by the fusion interfacial pressure 30 (lb/in.^{2}).

9.2.5 *Total Heat Time*—A time that starts when the heater is placed on the main pipe and initial heat force is applied and ends when the heater is removed.

9.2.6 *Cool Time*—The time required to cool the joint to approximately 120°F (49°C). The fusion force must be maintained for 5 min on IPS 1¼ in. (42 mm) or 10 min for all other main sizes, after which the saddle fusion equipment can be removed. The joint must be allowed to cool undisturbed for an additional 30 min before tapping the main or joining to the branch saddle.

9.2.7 *Interfacial Area for Rectangular Base Fittings*—The major width times the major length of the saddle base, without taking into account the curvature of the base or sides, minus the area of the hole in the center of the base.

9.2.8 *Interfacial Area for Round Base Fittings*—The radius of the saddle base squared times π (3.1416) without taking into account the curvature of the base or sides, minus the area of the hole in the center of the base.

9.2.9 *Fitting Label*—The initial heat force, heat soak force and the fusion force will be listed on a fitting label in the lower right hand corner of the fitting for some manufacturer's saddle fusion fittings. This will eliminate the need to calculate the fusion forces in the field (for example, 180/0/90). The label is not mandatory, therefore the heat and fusion forces need to be calculated if the label is not present.

9.3 *Setup*:

9.3.1 Select and install the proper heating tool faces to the heating tool based on the main size and fitting base size. Consult the pipe, fitting or equipment manufacturer's recommendations.

9.3.2 Plug in the heating tool and bring the heating tool face surfaces to 490 to 510°F (254 to 266°C) (see Table 5). A pyrometer or other surface temperature measuring device is used to determine and periodically check the heating tool surface temperature. Heating tool thermometers measure the internal temperature of the heating tool which is typically higher than the surface temperature of the heating tool faces.

9.3.3 Install the proper clamps in the Saddle Fusion Tool for the main size to be fused. Install the proper fitting clamp for the fitting to be joined. Consult the pipe, fitting or equipment manufacturer's recommendations.

9.4 *Procedure*:

9.4.1 *Preparation*:

9.4.1.1 Install the Saddle Fusion Tool on the main according to the manufacturer's instructions. The tool should be centered over a clean, dry location where the fitting will be fused. Secure the tool to the main. A main bolster or support is recommended under the pipe on IPS 6 in. (168 mm) and smaller main pipe sizes.

9.4.1.2 Abrade or scrape the surface of the main, where the fitting will be joined, approximately 0.007 in. (.178mm) deep to remove any oxidation or contamination. This can be done before or after the Tool is attached to the main. The abraded/scraped area must be larger than the area covered by the fitting base. It is important that the pipe surface be free from any type of contaminates that may be spread before the scraping or abrading process begins. Marks can be made on the outer surface of the pipe to aid in visual indication of abrading/scraping coverage, however the marks should be made with a non-petroleum based fast drying marker. After abrading/scraping, clean the pipe or fitting ends with a clean dry lint free cloth. All markings on the pipe surface should be removed before beginning the heat cycle.

9.4.1.3 If the fitting is not protected in a clean plastic bag, abrade the fusion surface of the fitting with 50 to 60 grit utility cloth; remove all dust and residue with a clean dry lint free cloth. Insert the fitting in the Saddle Fusion Tool loosely. Using the Saddle Fusion Tool, move the fitting base against the main pipe and apply about 100 lbf to seat the fitting. Secure the fitting in the Saddle Fusion Tool.

9.4.2 *Heating Procedure for Small Fittings (<2 in. IPS)* (see Table 5):

9.4.2.1 Place the heating tool on the main centered beneath the fitting base. Immediately move the fitting against the heater faces, apply the Initial Heat Force (see fitting label), and start the heat time. Apply the Initial Heat Force until melt is first observed on the crown of the pipe main (Initial Heat is the term used to describe the initial heating (bead-up) step to develop a melt bead on the main pipe and usually is 3 to 5 s) and then reduce the force to the Heat Soak Force (Bead-up force) (see fitting label). Maintain the Heat Soak Force until the Total Heat Time is complete. Total Heat Time ends:

(1) When the Total Heating Time expires for a pressurized IPS 1¼ in. (42 mm) or IPS 2 in. (63 mm) main, or

(2) When a melt bead of about 1⁄16 in. (2 mm) is visible all around the fitting base for a IPS 1¼ in. (42 mm) or IPS 2 in. (63 mm) non-pressurized main, or a larger pressurized or non-pressurized main, (see Table 5).

9.4.2.2 At the end of the Total Heat Time, remove the fitting from the heater and the heater from the main with a quick snapping action. Quickly check for a complete and even melt pattern on the pipe main and fitting heated surfaces (no unheated areas).

9.4.3 *Heating Procedure for Large Fittings (>IPS 3 in.) and Large Mains (>IPS 6 in.)* (see Table 5):

9.4.3.1 Place the heating tool on the main centered beneath the fitting base, and then place the Flexible Heat Shield between the heating tool and the fitting base. (This step usually requires an assistant to handle the Flexible Heat Shield).

9.4.3.2 Move the fitting against the Flexible Heat Shield, apply Initial Heat Force, and observe melt bead formation on the main all around the heating tool faces. When a melt bead is first visible on the main all around the heating tool faces, in a quick continuous motion, release the Initial Heat Force, raise the fitting slightly, remove the Flexible Heat Shield, move the fitting against the heating tool face, apply Initial Heat Force and start the heat time. When a melt bead is first visible all around the fitting base (usually about 3 to 5 s) immediately reduce applied force to the Heat Soak Force (usually zero). Maintain the Heat Soak Force until the Table 5 Total Heat Time ends.

TABLE 5 Generic Saddle Fusion Parameters

Heater Adapter Surface Temperature	500 ± 10°F (260 ± 6°C)
Initial Interfacial Pressure	60 ± 6 psi (4.14 ± 0.41 bar)
Heat Soak Interfacial Pressure	0 psi
Fusion Interfacial Pressure	30 ± 3 psi (2.07 ± 0.20 bar)
Total Heating Time on Main—1¼ in. IPS Pressure Main	15 s max
Total Heating Time on Main—2 in. IPS Pressure Main	25 to 35 s max
Total Heating Time on non-pressure 1¼ in. IPS, 2 in. IPS mains, and on pressure or non-pressure 3 in. IPS and larger mains.	Look for a 1⁄16 in. (1.6 mm) bead around the fitting base

NOTE 9—During heating, hold the heating tool in position by lightly supporting the heating tool handle. If not supported, the heating tool can slip out of position or displace the main or fitting melt and result in a poor joint.

9.4.3.3 At the end of the Total Heat Time, remove the fitting from the heater and the heater from the main with a quick snapping action. Quickly check for a complete and even melt pattern on the pipe main and fitting heated surfaces (no unheated areas). A mirror may be needed to check the bottom of the fitting.

9.4.4 *Fusion and Cooling* (see Table 5):

9.4.4.1 Whether or not the melt patterns are satisfactory, press the fitting onto the main pipe very quickly (within 3 s) after removing the heater and apply the Fusion Force (see the fitting label). Maintain the Fusion Force on the assembly for 5 min on IPS 1¼ in. (42 mm) and for 10 min on all larger sizes, after which the saddle fusion equipment may be removed. (Fusion Force adjustment may be required during Cool Time, but never reduce the Fusion Force during cooling.)

9.4.4.2 Cool the assembly for an additional 30 min before rough handling, branch joining or tapping the main. (If the melt patterns were not satisfactory or if the fusion bead is unacceptable, cut off the saddle fitting above the base to prevent use, relocate to a new section of main, and make a new saddle fusion using a new fitting.)

NOTE 10—These procedures are based on tests conducted under controlled ambient temperature conditions. Environmental conditions on a job site could affect heating and cooling times. Regardless of job site conditions or ambient temperature, the prescribed heating tool temperature is required. Do not increase or decrease the heating tool temperature. When saddle fittings are fused to pipes that are under pressure, it is important that the surface melt be obtained quickly without too much heat penetration with out exceeding the time guidelines in Table 5. Otherwise, too much heat penetration could result in pipe rupture from internal pressure.

9.5 *Visual Inspection:*

9.5.1 Visually inspect and compare the joint against visual inspection guidelines. There shall be three beads, a melt bead around the fitting base, a bead on the main from the edge of the heating tool, and a main pipe melt bead. The fitting and pipe melt beads should be rounded and about ⅛ in. (3 mm) wide all around the fitting base. The heating tool edge bead should be visible all around the fitting base, but may be separate from the main pipe melt bead.

9.5.2 The saddle fusion joint in unacceptable for use if visual bead appearance is unacceptable or if the melted surfaces were unacceptable. To prevent use, cut the fitting off at or just above the base. (See Appendix X2.)

NOTE 11—Look in the lower right hand corner of the fitting label for the forces required for that fitting in pounds force (Initial Heat Force/Heat Soak Force/Fusion Force) (for example, 180/0/90).

10. Keywords

10.1 butt fusion; fitting; heat fusion; joining; pipe; polyethylene; polyolefin; saddle fusion; socket fusion

ANNEX

(Mandatory Information)

A1. COLD WEATHER PROCEDURES

A1.1 *Cold Weather Handling*:

A1.1.1 Pipe shall be inspected for damage. Polyolefin Polyethylene pipes have reduced impact resistance in sub-freezing conditions. Avoid dropping pipe in sub-freezing conditions. When handling coiled pipe at temperatures below 40°F (4.44°C), it is helpful to uncoil the pipe prior to installation and let it straighten out. Gradually uncoil the pipe and cover it with dirt at intervals to keep it from recoiling. Always use caution when cutting the straps on coils of pipe because the outside end of a coil may spring out when the strapping is removed.

A1.2 *Preparation for Socket, Saddle, and Butt Fusion Joining*:

A1.2.1 *Wind and Precipitation*—The heating tool shall be shielded in an insulated container to prevent excessive heat loss. Shield the pipe fusion area and fusion tools from wind, snow, blowing dust, and rain by using a canopy or similar device.

A1.2.2 *Pipe and Fitting Surface Preparation*—The pipe and fitting surfaces to be "joined" or held in clamps shall be dry and clean and free of ice, frost, snow, dirt, and other contamination. Regular procedures for preparation of surfaces to be joined, such as facing for butt fusion and roughening for saddle fusion shall be emphasized. After preparation, the surfaces shall be protected from contamination until joined. Contamination of the area to be fused will likely cause incomplete fusion. Frost and ice on the surfaces of the pipe to be clamped in either a cold ring or alignment jigs may cause slippage during fusion. Inspect coiled pipe to see if it has flattened during storage, which could cause incomplete melt pattern or poor fusion. It may be necessary to remove several inches at the pipe ends to eliminate such distortion. Pipe may have a slight toe-in or reduced diameter for several inches at the end of the pipe. The toe-in may need to be removed before butt fusing to a freshly cut pipe end, or to a fitting.

A1.2.3 *Heating*—Work quickly once pipe and fitting have been separated from the heating tool, so that melt heat loss is minimized, but still take time (no more than 3 s) to inspect both melt patterns. Keep the heater dry at all times. Check the temperature of the heating tool regularly with a pyrometer or other surface temperature measuring device. Keep the heating tool in an insulated container between fusions. Do not increase heating tool temperature above the specified temperature setting. Gas-fired heating tools are used only in above freezing conditions.

A1.3 *Socket Fusion*:

A1.3.1 *Pipe Outside Diameter*—Pipe outside diameter contracts when cold. This results in loose or slipping cold rings. For best results, clamp one cold ring in its normal position adjacent to the depth gage. Place shim material (that is, piece of paper or rag, etc.) around the inside diameter of a second rounding ring and clamp this cold ring directly behind the first cold ring to prevent slippage. The first cold ring allows the pipe adjacent to the heated pipe to expand to its normal diameter during the heating cycle.

A1.3.2 *Fitting Condition*—If possible, store socket fittings at a warm temperature, such as in a truck cab, prior to use. This will make it easier to place the fitting on the heating tool because fittings contract when cold.

A1.3.3 *Heating*—At colder temperatures the pipe and fitting contract, thus the pipe slips more easily into the heating tool. At very cold outdoor temperatures (particularly with IPS 2, 3, and 4-in. pipe), the pipe may barely contact the heating surface. Longer heating times are used so that the pipe first expands (from tool heat) to properly contact the heating tool, then develops complete melt. The length of time necessary to obtain a complete melt pattern will depend not only on the outdoor (pipe) temperature but wind conditions and operator variation. Avoid cycles in excess of that required to achieve a good melt pattern. To determine the proper time for any particular condition, make a melt pattern on a scrap piece of pipe, using the heating time as instructed by the pipe manufacturer. If the pattern is incomplete (be sure rounding rings are being used), try a 3 s longer cycle on a fresh (cold) end of pipe. If the melt pattern is still not completely around the pipe end, add an additional 3 s and repeat the procedure. Completeness of melt pattern is the key. Keep the heater dry at all times. Check the temperature of the heating tool regularly and keep the heating tool in an insulated container between fusions.

A1.4 *Butt Fusion*:

A1.4.1 *Joining*:

A1.4.1.1 The fusion operator shall be aware of ambient weather conditions during the butt fusion of polyethylene pipe and fittings and be ready and capable to make adjustments to the fusion procedure if ambient weather conditions change significantly.

A1.4.1.2 The qualified fusion procedure shall provide suitable measures for adjustment of fusion parameters, in particular the heating time, when the ambient temperature changes or during windy conditions. When the ambient temperature becomes colder, it will require a longer heating time to develop an indication of melt and the final bead size. The pipe wall thickness and pipe diameter are primary factors to consider when determining the necessary heating cycle time.

A1.4.1.3 The modifications to the fusion procedure require validation through the production of test fusions and their assessment by comparison to visual guidelines and bend testing.

A1.4.1.4 The specified heating plate temperature range shall not be exceeded to accommodate cold weather conditions.

A1.4.1.5 The fusion pressure must be maintained until a slight melt is observed around the circumference of the pipe or fitting before releasing pressure for the heat soak.

NOTE A1.1—Check for pipe slippage in the fusion machine in cold weather applications. The pipe is stiffer in cold temperatures and the OD of the pipe will shrink slightly, increasing the potential for slippage in the jaws.

A1.4.1.6 Do not apply additional pressure during the heat soak to accommodate cold weather conditions.

A1.4.1.7 Follow the minimum heat soak time for the wall thickness of pipe to be fused per 8.3.5.2. The melt beads formed against the heater surface during the heating soak shall be in accordance with Table 3. It is critical that the melt bead sizes specified in Table 3 be achieved.

A1.4.1.8 When the specified heat soak time and melt bead size has been achieved, the pipe and heater shall be separated in a rapid, snap-like motion. The melted surfaces shall then be joined as soon as possible, within the maximum times allowed in Table 4, so as to minimize cooling of the melted pipe ends. Cool the joint per 8.3.7.

A1.4.2 *Assessment* – Inspection assessment guidelines for fusion joints that are made under cold weather conditions are the same as for fusion joints made at warmer ambient temperatures. Key concerns affecting the quality of cold weather fusion joints are incorrect heating time and application of pressure during heating soak and moisture contamination that could generate a weak fusion joint. Therefore strict adherence to the butt fusion guidelines and adequate butt fusion process controls are the primary means to minimize this probability.

A1.4.2.1 Visual assessment of the finished bead is critical, since signs of incorrect heating , facing or joining force may be evident on the fusion bead. Correct shape of the finished bead, degree of bead rollover to the pipe surface and depth of the v-groove are key indicators (see Fig. 4 and Appendix X2.)

A1.4.3 *Joining in Adverse Weather*:

A1.4.3.1 *Cold Ambient Temperatures Below 32°F (0°C)*—Butt, Saddle or Socket, Fusion is generally not recommended below -4°F (-20°C) without special provisions such as a portable shelter or trailer or other suitable protective measures with auxiliary heating. When making a butt fusion joint with the ambient temperature is below 3°F(-16°C), the pipe ends shall be pre-heated using a heating blanket or warm air device to elevate the pipe temperature to improve the heating starting condition. With pipe mounted in the fusion machine, an alternate method of pre-heating is to stop the pipe ends within .25-.50 inches (6.4-12.7mm) of the heater plate face to allow the pipe ends to warm for 30 seconds to 2 minutes, depending on the pipe size and wall thickness. The use of direct application open flame devices, such as torches, for heating polyethylene pipe is prohibited due to the lack of adequate heating control and possibility of damage to the pipe ends. When fusing pipe under adverse cold weather or in windy field conditions with blowing dust is required, the provision of portable shelters or trailers with heating should be considered and are recommended to provide more consistent and acceptable working conditions. When fusing coiled pipe when the ambient temperature is below 32°F (0°C), it may be required to remove an end section of pipe from the coil and butt fuse on a straight section of pipe to enable correct pipe alignment. Completed joints shall be allowed to cool to ambient temperature before any stress is applied.

A1.4.3.2 *Wind—* Exposure of the fusion heater plate and pipe to wind can result in unacceptable temperature variations during butt fusions and possible joint contamination. When extreme wind conditions exist, the provision of a suitable shelter is required to protect the pipe and fusion heater plate to ensure a more consistent environment is provided. Wind conditions can develop through the pipe bore and cause unacceptable temperature variations during the heating process. Therefore, open pipe ends may require plugs or covers to prevent this condition. Note: Although wind conditions, during cold weather butt fusion, are the primary concern, wind conditions can affect butt fusion quality at all ambient temperatures by chilling the heated pipe surfaces during the heat soak. This increases the heat soak time to obtain the bead size against the heater surface.

A1.5 *Saddle Fusion*:

A1.5.1 *Surface Preparations*—Regular procedures for roughening the surfaces to be fused on the pipe and the fitting shall be emphasized. After the surfaces have been prepared, particular care shall be taken to protect against contamination.

A1.5.2 *Heating Time*—Make a trial melt pattern on a scrap piece of pipe. A clean, dry piece of wood is used to push the heating tool against the pipe. If the melt pattern is incomplete, add 3 s to the cycle time and make another trial melt pattern on another section of cold pipe. If the pattern is still incomplete, continue 3 s additions on a fresh section of cold pipe until a complete melt pattern is attained. Use this heating cycle for fusions during prevailing conditions. Regardless of the weather or the type of tools used, the important point to remember is that complete and even melt must occur on the fitting and the pipe in order to produce a good fusion joint. This requires pipe preparation to make it clean, straight, round, and well supported.

APPENDIXES

(Nonmandatory Information)

X1. JOINING

X1.1 *Parameters and Procedures*—These parameters and procedures in this practice are approved by the majority of pipe manufacturers for the majority of the solid wall polyethylene pipe materials on the market today. Consult with the pipe manufacturer to make sure they approve this procedure for the pipe to be joined. Other specific parameters and procedures, such as heater temperature variations, have been developed, tested and approved by some municipalities, utilities, and end users. They are not covered in this specification.

X1.2 *Quality Assurance Recommendations*—It is recommended that the following steps be followed to help insure quality fusion joints.

X1.2.1 Make sure the equipment or tooling used to make the fusion joints is in good working order and conforms to the equipment manufacturer's quality assurance guidelines.

X1.2.2 Make sure the operator of the equipment or tooling to be used has had the proper training in the operation of that equipment.

X1.2.3 If possible, use a datalogging device with hydraulic joining equipment to record the critical fusion parameters of pressure, temperature and time for each joint.

X1.2.4 Visually inspect each joint and. compare the datalogged records to this approved standard before burying the pipe. (See Appendix X2 for visual guidelines.)

X1.3 *Heating Polyethylene (PE) in a Hazardous Environment*—Electrically powered heat fusion tools and equipment are usually not explosion proof. When performing heat fusion in a potentially combustible atmosphere such as in an excavation where gas is present, all electrically powered tools and equipment that will be used in the combustible atmosphere shall be disconnected from the electrical power source and operated manually to prevent explosion and fire. For the heating tool, this requires bringing the heating tool up approximately 25°F (14°C) above the recommended maximum surface temperature in a safe area, then disconnecting it from electrical power immediately before use.

X1.4 *Butt Fusion of Unlike Wall Thicknesses*—The butt fusion procedure in this practice is based on joining piping components (pipes and fittings) made from compatible polyethylene compounds having the same outside diameter and wall thickness (PR) per ASTM or other industry product specifications. In some cases, butt fusion joining of pipes and fittings that have the same outside diameter but unlike wall thickness (different by one standard DR or more) is possible. The quality of butt fusion joints made between pipes of unlike wall thickness is highly dependent on the performance properties of the polyethylene compound used for the pipes or fittings being joined. Consult the pipe or fitting manufacturer for applicable butt fusion procedures for components with dissimilar wall thicknesses.

X1.5 *Butt Fusion of Coiled Pipe*—Coiled pipe is available in sizes up to 6 in. IPS. Coiling may leave a set in some pipe sizes that must be addressed in the preparation of the butt fusion process. There are several ways to address this situation:

X1.5.1 Straighten and re-round coiled pipe before the butt fusion process. (Specification D2513 requires field re-rounding of coiled pipe before joining pipe sizes larger than 3 in. IPS.)

X1.5.2 If there is still a curvature present, install the pipe ends in the machine in an "S" configuration with the print lines approximately 180° apart in order to help gain proper alignment and help produce a straight joint. See Fig. X2.15.

X1.5.3 If there is still a curvature present, another option would be to install a straight piece of pipe between the two coiled pipes.

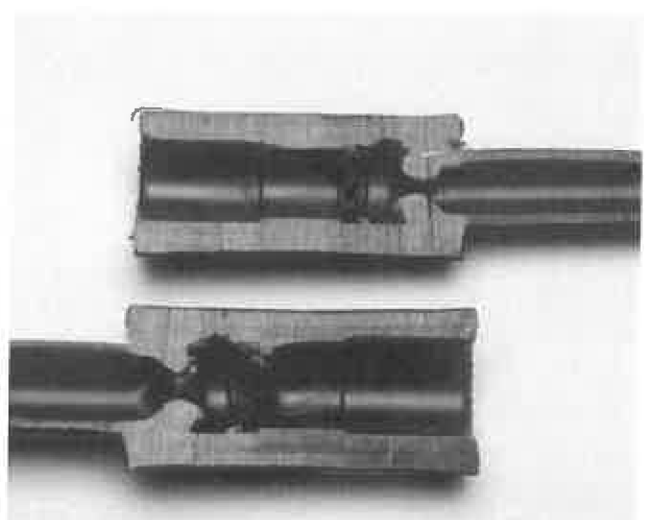
NOTE X1.1—Every effort should be made to make the joint perpendicular to the axis of the pipe. Visually mitered (angled, off-set) joints should be cut out and re-fused (see appearance guidelines in Appendix X2).

X2. HEAT FUSION VISUAL APPEARANCE GUIDELINE

Acceptable Visual Appearance

Melt bead flattened by cold ring.
No gaps or voids.
Good alignment between pipe and fitting.

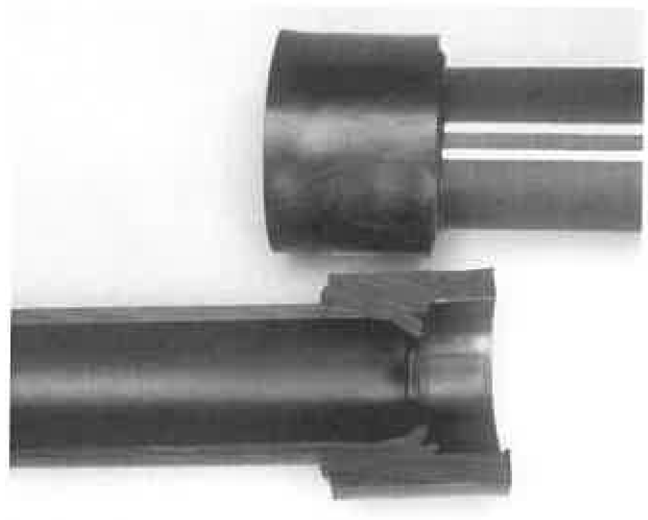
FIG. X2.1 Socket Fusion



Unacceptable Visual Appearance

Excessive heating.

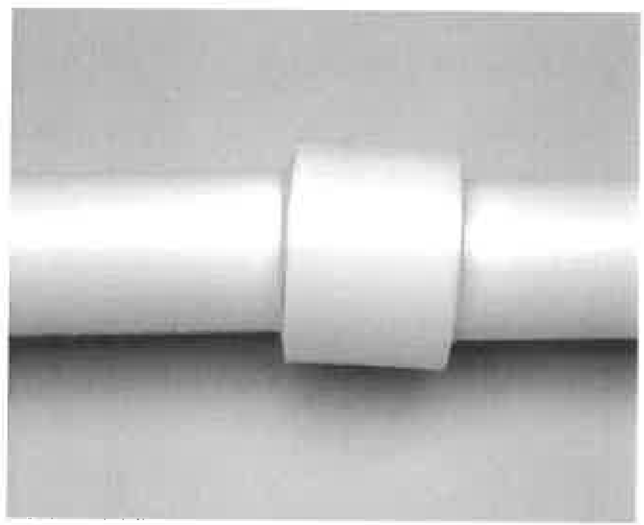
FIG. X2.2 Socket Fusion



Unacceptable Visual Appearance

Melt bead not flattened against the fitting/cold ring.
Improper insertion depth; no cold ring.
Excessive heating.

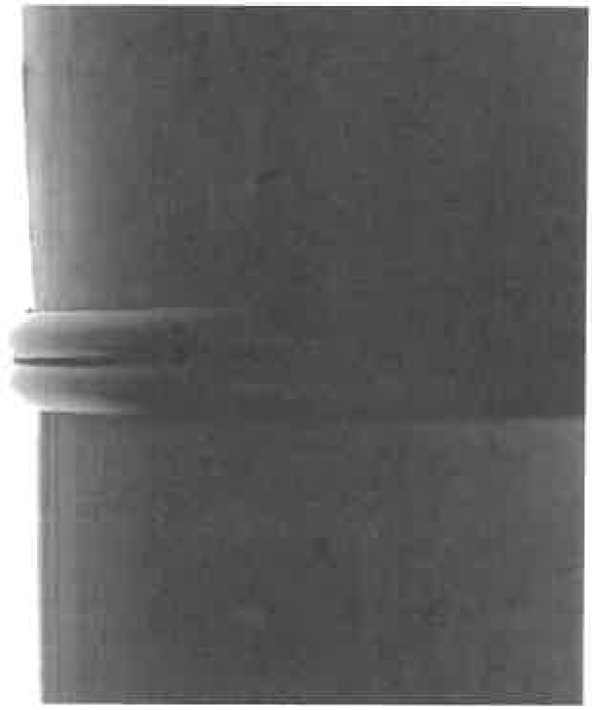
FIG. X2.3 Socket Fusion



Unacceptable Visual Appearance

Misalignment.

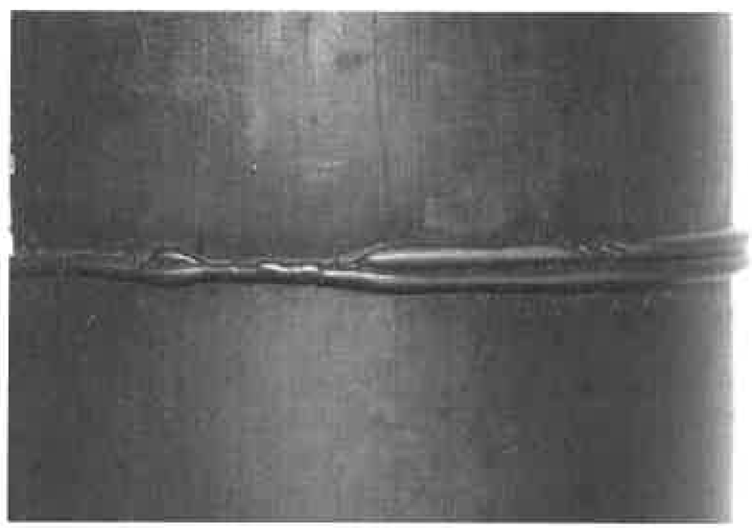
FIG. X2.4 Socket Fusion



Acceptable Visual Appearance

Proper double roll-back bead.
Proper alignment.

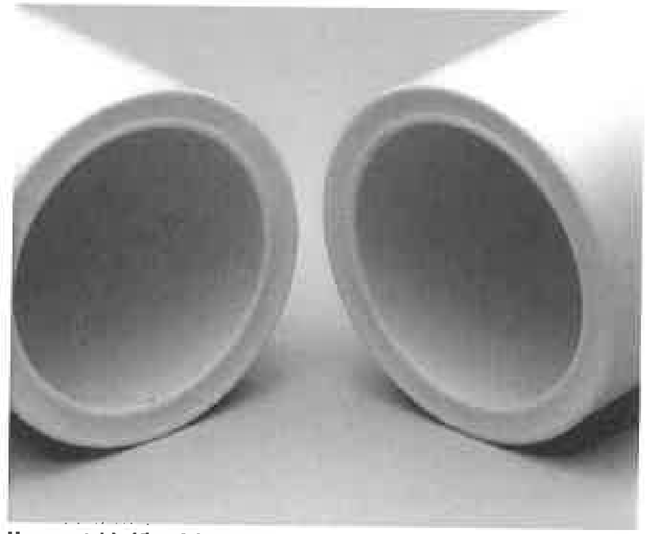
FIG. X2.5 Butt Fusion



Unacceptable Visual Appearance

Incomplete face-off.

FIG. X2.6 Butt Fusion



Unacceptable Visual Appearance

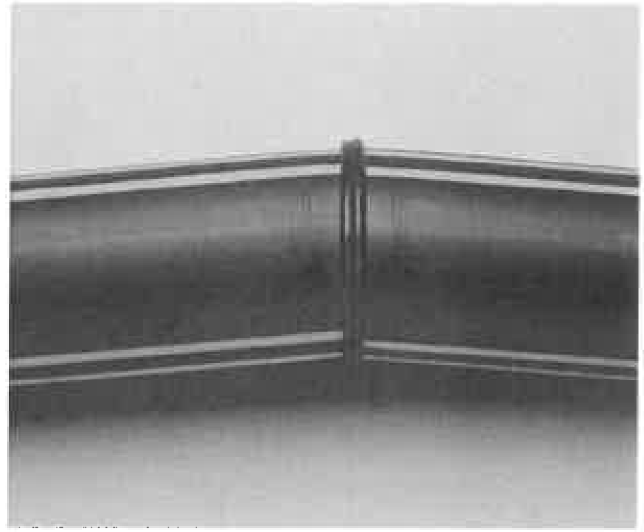
Unacceptable concave melt appearance after heating.
Possible over-pressurization during the heat cycle.

FIG. X2.7 Butt Fusion

Unacceptable Visual Appearance

Improper "high-low" pipe alignment.
Visually mitered joint.

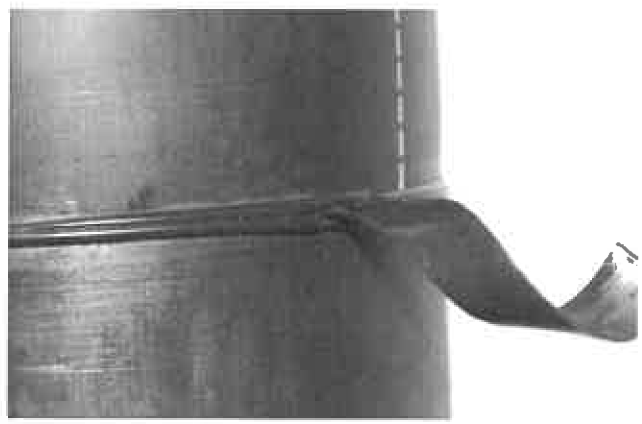
FIG. X2.8 Butt Fusion



Unacceptable Visual Appearance

Improper alignment in fusion machine–mitered joint.

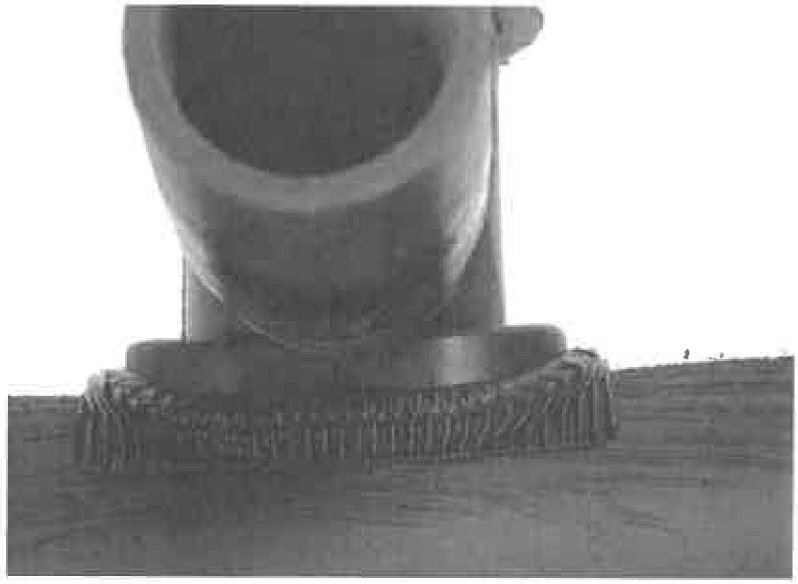
FIG. X2.9 Butt Fusion



Unacceptable Visual Appearance

Contamination in joint.

FIG. X2.10 Butt Fusion



Acceptable Visual Appearance

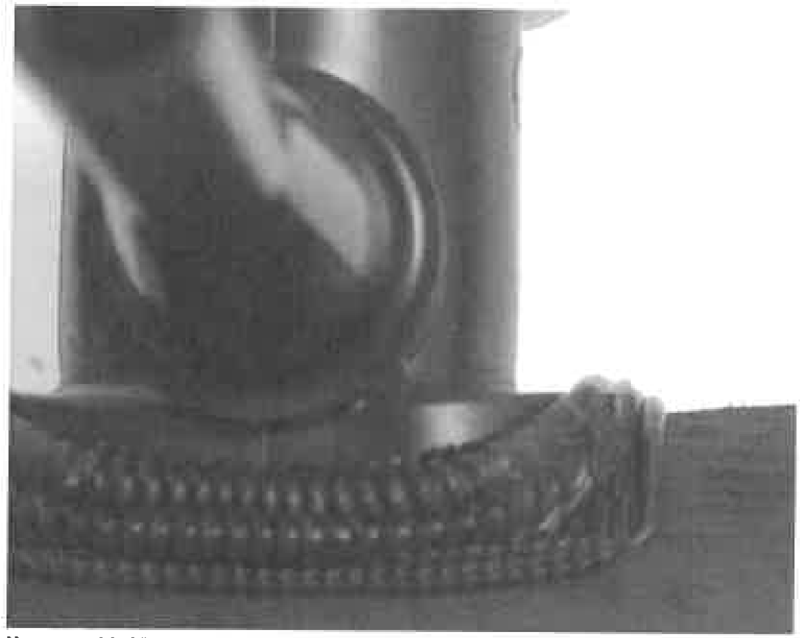
Proper alignment, force and melt.
Proper surface preparation.

FIG. X2.11 Saddle Fusion Joint

Unacceptable Visual Appearance

Improper alignment.
Fitting offset from melt pattern.

FIG. X2.12 Saddle Fusion Joint



Unacceptable Visual Appearance

Over-melt of fitting and main.
Possible over-pressurization of fitting on main.

FIG. X2.13 Saddle Fusion Joint

Unacceptable Visual Appearance

Under-melt of fitting and main.
Fitting offset from melt pattern.
Possible under-pressurization of fitting on main.

FIG. X2.14 Saddle Fusion Joint

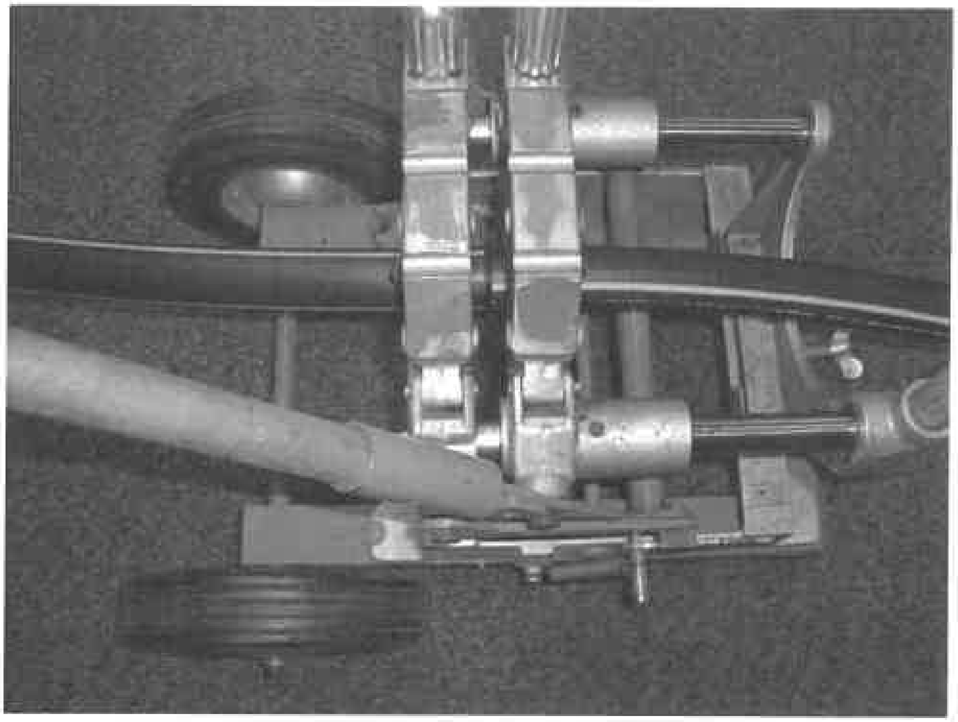


FIG. X2.15 Coiled Pipe Installation in Fusion Machine

X3. DETERMINING SADDLE FUSION FORCE IF LABEL IS NOT PRESENT

X3.1 When the saddle fusion fitting does not have a label to show the initial heat force (IHF) and the fusion force (FF), use the following formulas to determine the forces required.

X3.2 *Determining IHF and FF*:

X3.2.1 IHF is determined by multiplying the area of the saddle fitting base by 60 psi, the initial interface pressure. For rectangular base saddle fittings, the fusion area is the base length times the base width less the area of the outlet hole. Base curvature and corner radii are ignored. For round base saddle fittings, the fusion area is the area of the base outside diameter less the area of the outlet hole. Base curvature is ignored.

$$IHF = L \times W - (0.785 \times d^2) \times 60 \quad \text{(X3.1)}$$

$$IHF = 0.785 \times (D^2 - d^2) \times 60 \quad \text{(X3.2)}$$

where:

IHF = initial heat force, lb,
L = rectangular base length, in.,
W = rectangular base width, in.,
d = outlet hole inside diameter, in., and
D = round base outside diameter, in.

X3.2.2 *FF* is one-half of *IHF*:

$$FF = \frac{IHF}{2} \quad \text{(X3.3)}$$

X4. BEND BACK TESTING OF FUSED JOINTS

X4.1 It is possible to evaluate sample joints in order to verify the skill and knowledge of the fusion operator. Cut joints into straps, (see Fig. X4.1) and visually examine and test for bond continuity and strength. Bending, peeling, and elongation tests are useful for this purpose. These tests are generally conducted on smaller pipe sizes. For butt fusion test straps, limit the wall thickness of the pipe to 1in. (25mm) to prevent possible injury in conducting the test. Visually inspect the cut joint for any indications of voids, gaps, misalignment of surfaces that have not been properly bonded. Bend each sample at the fusion joint with the inside of the pipe facing out until the ends touch. The inside bend radius should be less than the minimum wall thickness of the pipe. In order to successfully complete the bend back, a vise may be needed. The sample must be free of cracks and separations within the fusion joint location. If failure does occur at the weld in any of the samples, then the fusion procedure should be reviewed and corrected. After correction, another sample fusion joint should be made per the new procedure and re-tested. Bend testing of pipes with a wall thickness greater than 1in. (25mm) could be danerous and should be done with an approved bending fixture that supports and contains the pipe during the test or with another approved procedure.

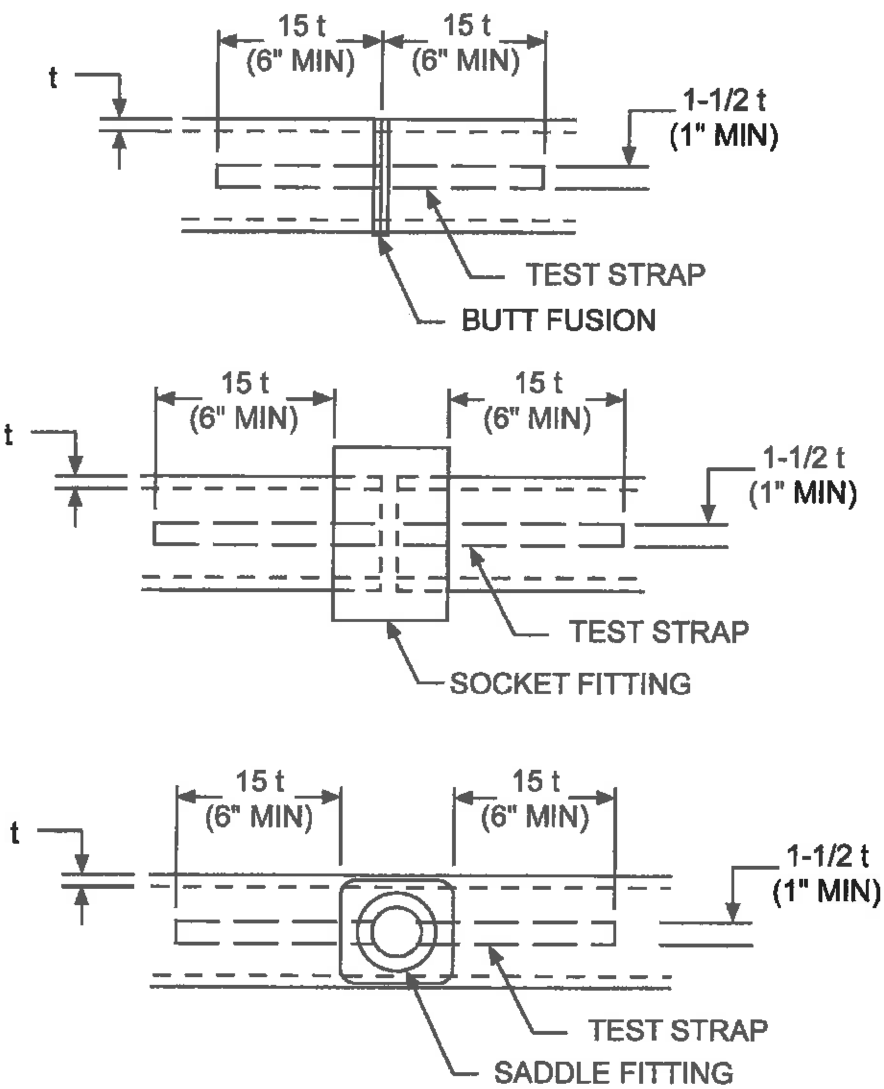


FIG. X4.1 Bent Strap Test Specimen

Designation: F2620 – 06

An American National Standard

Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings[1]

This standard is issued under the fixed designation F2620; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes procedures for making joints with polyethylene (PE) pipe and fittings by means of heat fusion joining in, but not limited to, a field environment. Other suitable heat fusion joining procedures are available from various sources including pipe and fitting manufacturers. This standard does not purport to address all possible heat fusion joining procedures, or to preclude the use of qualified procedures developed by other parties that have been proved to produce reliable heat fusion joints.

1.2 The parameters and procedures are applicable only to joining polyethylene pipe and fittings of related polymer chemistry. They are intended for PE fuel gas pipe per Specification D2513 and PE potable water, sewer and industrial pipe manufactured per Specification F714, Specification D3035, and AWWA C901 and C906. Consult with the pipe manufacturers to make sure they approve this procedure for the pipe to be joined (see Appendix X1).

NOTE 1—Information about polyethylene pipe and fittings that have related polymer chemistry is presented in Plastics Pipe Institute (PPI) TR-33 and TR-41.

1.3 Parts that are within the dimensional tolerances given in present ASTM specifications are required to produce sound joints between polyethylene pipe and fittings when using the joining techniques described in this practice.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 The text of this practice references notes, footnotes, and appendixes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the practice.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D2513 Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings

D2737 Specification for Polyethylene (PE) Plastic Tubing

D3035 Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

D3261 Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

F714 Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

F905 Practice for Qualification of Polyethylene Saddle-Fused Joints

F1056 Specification for Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings

2.2 *PPI Documents:*

TR-33 Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene[3]

TR-41 Generic Saddle Fusion Joining Procedure for Polyethylene Gas Piping[3]

2.3 *AWWA Documents:*

AWWA C901 Standard for Polyethylene (PE) Pressure Pipe and Tubing, ½ in. (13 mm) through 3 in. (76 mm), for Water Service[4]

AWWA C906 Standard for Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) through 63 in. (1575 mm), for Water Distribution and Transmission[4]

3. Summary of Practice

3.1 The principle of heat fusion joining of polyethylene (PE) pipe is to heat two prepared surfaces to a designated temperature, then fuse them together by application of a

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.20 on Joining.
Current edition approved Dec. 1, 2006. Published December 2006.. DOI: 10.1520/F2620-06.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Plastic Pipe Institute Inc., 1825 Connecticut Ave., NW Suite 680 Washington, DC 20009.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

sufficient force. This force causes the melted materials to flow and mix, thereby resulting in fusion.

3.2 The heat-fusion procedures covered in this practice are socket fusion, butt fusion, and saddle fusion.

3.2.1 *Procedure 1, Socket Fusion*—The socket-fusion procedure involves simultaneously heating the outside surface of a pipe end and the inside of a fitting socket, which is sized to be smaller than the smallest outside diameter of the pipe. After the proper melt has been generated at each face to be mated, the two components are joined by inserting one component into the other. See Fig. 1. The fusion bond is formed at the interface resulting from the interference fit. The melts from the two components flow together and fuse as the joint cools. Optional alignment devices are used to hold the pipe and socket fitting in longitudinal alignment during the joining process; especially with pipe sizes IPS 3 in. (89 mm) and larger. Automated socket fusion is not addressed in this procedure.

3.2.2 *Procedure 2, Butt Fusion*—The butt-fusion procedure in its simplest form consists of heating the squared ends of two pipes, a pipe and a fitting, or two fittings, by holding them against a heated plate, removing the heater plate when the proper melt is obtained, promptly bringing the ends together, and allowing the joint to cool while maintaining the appropriate applied force.

3.2.2.1 An appropriately sized butt fusion machine is used to clamp, align and face the pipe or fitting ends and to apply the specified fusion force. See Fig. 2.

3.2.3 *Procedure 3, Saddle Fusion*—The saddle-fusion procedure involves melting the concave surface of the base of a saddle fitting, while simultaneously melting a matching pattern on the surface of the pipe, bringing the two melted surfaces together and allowing the joint to cool while maintaining the appropriate applied force. See Fig. 3.

3.2.3.1 An appropriately sized saddle fusion machine is used to clamp the pipe main and the fitting, align the parts and apply the specified fusion force.

4. Significance and Use

4.1 The procedures described in Sections 7-9 are primarily intended for (but not limited to) field joining of polyethylene (PE) pipe and fittings, using suitable equipment and appropriate environmental control procedures. When properly implemented, strong pressure/leak-tight joints are produced. When these joints are destructively tested, the failure occurs outside the fusion joined area.

4.2 Melt characteristics, average molecular weight and molecular weight distribution are influential factors in establishing suitable fusion parameters; therefore, consider the manufacturer's instructions in the use or development of a specific fusion procedure. See Annex A1.

4.3 The socket fusion, butt fusion, and saddle fusion procedures in this practice are suitable for joining PE gas pipe and fittings, PE water pipe and fittings, and PE general purpose pipes and fittings made to PE product specifications from organizations such as ASTM, AWWA, API, and ISO that are used in pressure, low pressure and non-pressure applications. For gas applications, qualification of the procedure by testing joints made using the procedure in accordance with regulations from the authority having jurisdiction are required.

5. Operator Experience

5.1 Skill and knowledge on the part of the operator are required to obtain a good quality joint. This skill and knowledge is obtained by making joints in accordance with proven procedures under the guidance of skilled operators. Evaluate operator proficiency by testing sample joints.

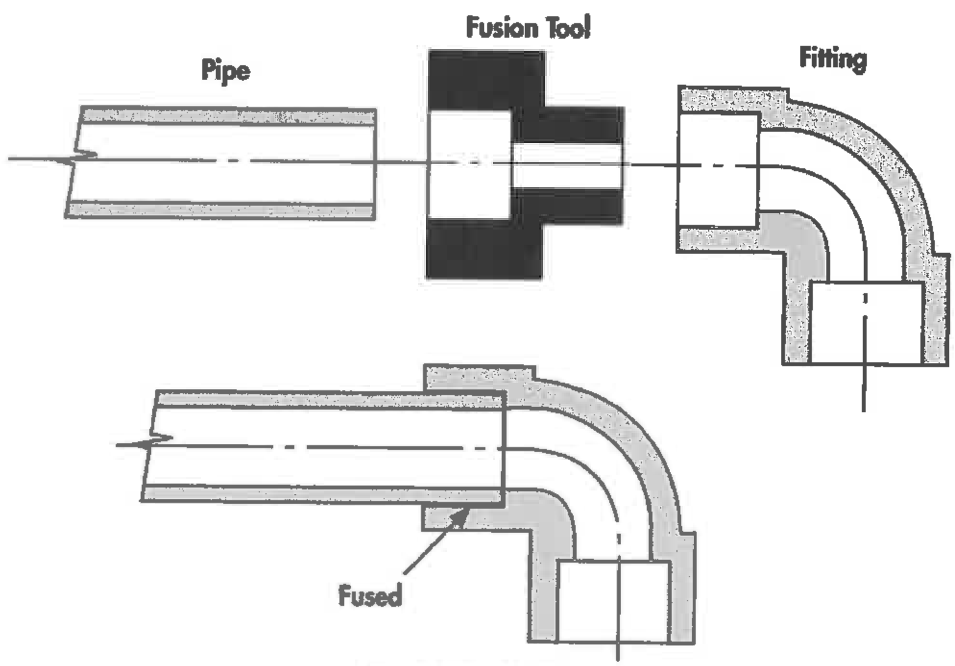


FIG. 1 Socket Fusion

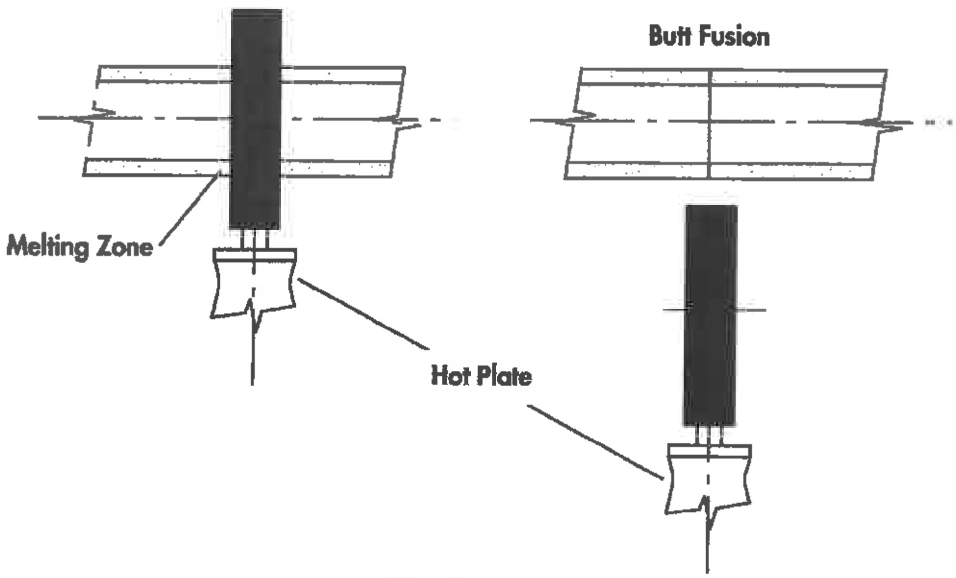


FIG. 2 Butt Fusion

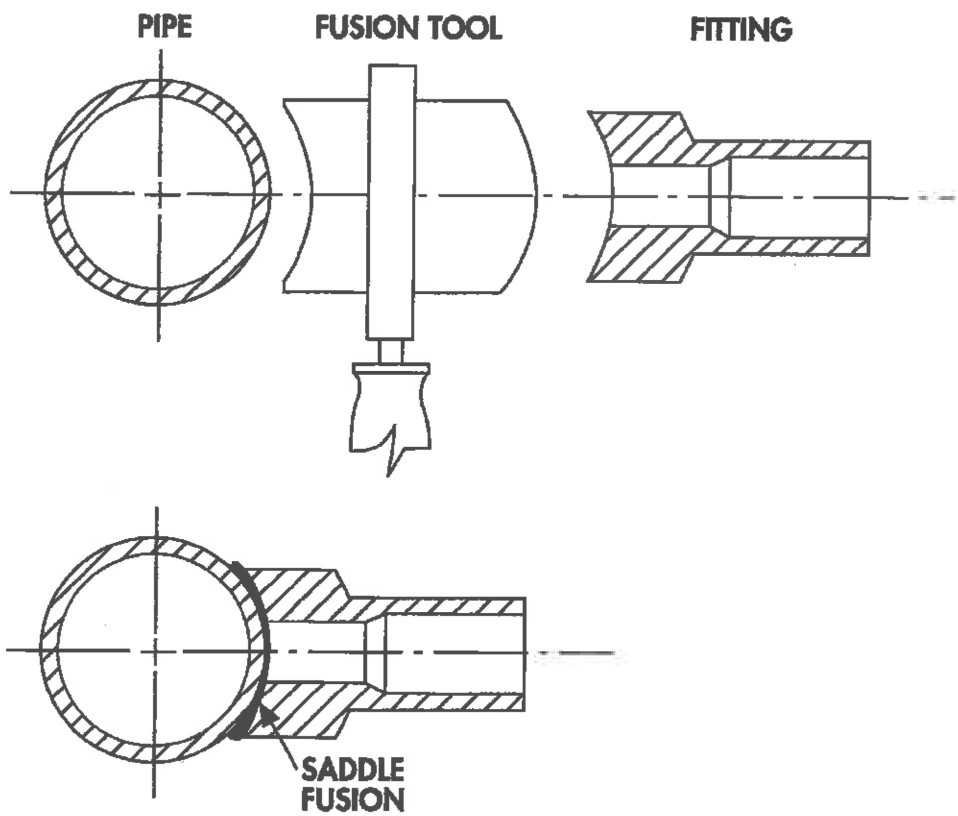


FIG. 3 Saddle Fusion

5.2 The party responsible for the joining of polyethylene pipe and fittings shall ensure that detailed procedures developed in conjunction with applicable codes and regulations and the manufacturers of the pipe, fittings, and joining equipment involved, including the safety precautions to be followed, are issued before actual joining operations begin.

6. Apparatus—General Recommendations

6.1 *Heating Tool*—Electric heating tools come in a variety of sizes that match the fusion machines capabilities. They are designed with enough wattage and electronic control to maintain the specified heater face temperature required in this procedure. The range of the heater control shall be larger than the heating temperature specification (the typical control range is 50°F (30°C) above and below the maximum and minimum required heating tool surface temperatures. Electric heating plates maintain consistent fusion temperatures when provided with an adequate power source.

6.2 *Heating Tool Faces*—Heating tools may be made from materials such as aluminum, stainless steel, copper, or copper alloys. Polyethylene material may stick to hot metal heating surfaces. This sticking may be minimized by applying a non-stick coating to the heating surfaces or by fitting a high-temperature, non-stick fabric over the heating surfaces. The heating plate surfaces, coated or uncoated, shall be kept clean and free of contaminants such as dirt, grease and plastic build-up, which may cause excessive sticking and create unsatisfactory joints. Most of these contaminants are removed from the hot tool surfaces using a clean, dry, oil-free lint-free cloth. Do not use synthetic fabrics which may char and stick to the fusion surface. Some pigments, such as carbon black, may stain a heating surface and probably cannot be removed; such stains will not contaminate the joint interface.

6.2.1 After a period of time in service, non-stick coatings or fabrics will deteriorate and become less effective. Deteriorated fabrics shall be replaced, and worn, scratched, or gouged non-stick coatings shall be re-coated when they lose effectiveness. Heat fusion quality may be adversely affected by deteriorated non-stick surfaces. Spray-on chemicals, such as non-stick lubricants or oils shall not be applied to heating iron surfaces as they will contaminate the joint.

6.3 *Temperature Indicator*—Heating tools shall be equipped with a thermometer or other built-in temperature indicating device. This device indicates the internal temperature of the heating iron, which is usually higher than temperature of the heating tool surfaces. Use a pyrometer, or other temperature measuring device, on the first joint of the day and periodically during the day to verify the temperature of the tool face surfaces within the pipe or fitting contact area. Select multiple checkpoints to ensure uniform surface temperature. An infrared pyrometer is calibrated by comparison to a calibrated surface pyrometer and adjusted to agree on each heating tool.

NOTE 2—A significant temperature variation, that is, cold spots, on the heating tool surfaces may indicate a faulty heating iron which may need to be serviced before it can be used.

7. Procedure 1—Socket Fusion

7.1 *Apparatus*:

7.1.1 *Socket Fusion Tools*—Socket fusion tools consist of a heating tool, heating tool faces, rounding clamps (cold rings), depth gage/chamfer tools, and pipe/fittings made to ASTM specifications.

7.1.2 *Heating Tool*—In order to obtain a proper melt, it is necessary for a uniform temperature to be maintained across the heating tool faces. An electrical tool shall have sufficient wattage and control to maintain the specified surface temperature of the tool faces.

7.1.3 *Heating Tool Faces*—Consisting of two parts, a male end for the interior socket surface and a female end for the exterior pipe surface. Both parts shall be made to such tolerances as to cause an interference fit. Heating tool faces are produced to Specification F1056 dimensions, and are coated with a non-stick material to keep melted pipe and fitting material from sticking to the face.

7.1.4 *Alignment Jig*—The alignment jig is an optional tool which consists of two sets of devices holding the components in alignment to each other. One set of holding devices is fixed, and the other allows longitudinal movement for making the joint.

7.1.5 *Rounding Clamps*, (cold ring) to maintain roundness of the pipe and control the depth of pipe insertion into the socket during the joining operation.

7.1.6 *Depth Gage*, for proper positioning of the rounding clamp on the pipe.

7.1.7 *Chamfering Tool*, to bevel the end of the pipe.

NOTE 3—The depth gage and chamfering tool may be combined into a single tool.

7.1.8 *Tubing Cutter*, to obtain a square end cut on the pipe.

7.1.9 *Fitting Puller*, an optional tool to assist in the removal of the fitting from the heating tool and to hold the fitting during assembly.

7.2 *Procedure*:

7.2.1 Attach the proper size heater faces to the heating tool, and bring the surface temperature of the tool faces to 490 to 510°F (254 to 266°C). Use a pyrometer, or other temperature measuring device, on the first joint of the day and periodically during the day to verify the temperature of the tool face surfaces within the pipe or fitting contact area. Select multiple checkpoints to ensure uniform surface temperature. Heating tool thermometers measure the internal temperature of the heating tool, which is typically higher than the surface temperature of the heating tool faces.

7.2.2 Cut the pipe end squarely, and clean the pipe end and fitting, both inside and outside, by wiping with a clean, dry, oil-free, lint-free cloth.

7.2.3 Chamfer the outside edge of the pipe end slightly and fix the rounding clamp about the pipe as determined from the depth gage. (See Note 4.)

7.2.4 Push the socket fitting onto the preheated fitting tool face first, and then push the pipe into the pipe-side tool face until the rounding clamps make contact with the heating faces.

7.2.5 Heat the pipe end and the fitting socket for the time required to obtain a proper melt. Proper melt is a function of material, time, tool temperature, and the size of the parts. Pipe and fittings of larger diameters require more time to reach the proper melt consistency than those of smaller diameters. Under-heated or overheated materials will not form a good bond. Contact the fitting manufacturer for the recommended heating times.

7.2.6 At the end of the heating time, simultaneously remove the pipe and fitting straight out from the tool, using a snap action. Immediately insert the pipe straight into the socket of the fitting so the rounding clamp is flush against the end of the fitting socket. Hold or block the joint in place until the melts of the mating surfaces have solidified. The exact cooling time depends on the size of the pipe and the material being fused.

7.2.7 Remove the rounding clamp, and inspect the melt pattern at the end of the socket for a complete impression of the rounding clamp in the melt surface. There shall be no gaps, voids, or unbonded areas. Visually inspect and compare the joint against recommended appearance guidelines (see Appendix X2).

7.2.8 Allow for extremes in weather when making field joints. Heating times, dimensional changes, etc., are affected by extreme weather conditions.

NOTE 4— Some recommend using a 50-60 grit emery or garnet cloth to roughen the outside of the pipe and inside of the fitting as a means of minimizing any possible skin interface when making the fusion. Sandpaper is not recommended for this purpose, as it might disintegrate and contaminate the joint interface. If roughening is performed, first clean the surfaces before roughening. Clean dust and particles from the roughened surfaces afterwards by wiping with a clean, dry, oil-free cloth.

8. Procedure 2—Butt Fusion

8.1 *Apparatus*:

8.1.1 *Heating Tool*—The heating tool shall have sufficient area to adequately cover the ends of the size of pipe to be joined. This electrical tool shall have sufficient wattage and control to maintain the specified surface temperature of the tool faces. It shall also be equipped with heater faces that are coated with a non-stick material to prevent sticking to the pipe surface.

8.1.2 *Butt Fusion Machine*—A Butt Fusion Machine has three basic parts: *(1)* a stationary clamping fixture and a movable clamping fixture for aligning and holding each of the two parts to be fused. This may or may not include the power supply to operate the machine; *(2)* a facer for simultaneously preparing the ends of the parts to be joined (Note 5); and *(3)* appropriate inserts for clamping different pipe sizes or fitting shapes. Butt Fusion Machines are operated manually or hydraulically. Some have their own power supply and some require a separate generator. They are available in a variety of sizes to fuse pipe and tubing produced to ASTM and other industry specifications.

NOTE 5—A facer is a rotating cutting device used to square-off the pipe or fitting ends to obtain properly mating fusion surfaces. If so equipped, facing should continue until a positive mechanical stop on the butt fusion machine is reached.

8.1.3 *Pipe Support Stands*—Optional pipe support stands are used to support the pipe on both ends of the butt fusion machine to help with linear pipe alignment in the machine.

8.2 *Setup*:

8.2.1 Butt fusion machine setup parameters are prescribed in Table 1.

8.2.2 An interfacial pressure of 60 to 90 psi (0.41 to 0.62 MPa) is used to determine the force required to butt fuse the pipe components. Multiply the interfacial pressure times the pipe area to calculate the fusion force required (lb). For manually operated fusion machines, enough force should be applied to roll the bead back to the pipe surface. A torque wrench may be used to apply the proper force. Manual fusion without a torque wrench has been used successfully by many gas utilities. For hydraulically operated fusion machines, the fusion force is divided by the total effective piston area of the movable carriage cylinders to give a hydraulic gauge reading in psi. This gauge reading is the theoretical fusion gauge pressure. The internal and external drag factors are added to this figure to obtain the actual fusion pressure required by the machine. (The hydraulic gauge reading and the interfacial pressure are *not* the same value.) This drag pressure is found by bringing the faced pipe ends within 2 in. (50 mm) of each other and increase the pressure on the carriage until it starts moving. Back off the pressure until the carriage is barely moving and record the drag pressure. Add this pressure to the theoretical fusion pressure to obtain the fusion machine gauge pressure required for fusion.

NOTE 6—Interfacial pressure is used to determine fusion joining pressure settings for hydraulic butt fusion machines when joining specific pipe diameters and DR's. Interfacial pressure is *not* the gauge pressure.

8.3 *Procedure*:

8.3.1 Clean the inside and outside of the components (pipe or pipe and fitting) to be joined. Remove all foreign matter from the piping component surfaces where they will be clamped in the butt fusion machine.

8.3.2 If applicable, place pipe support stands at both ends of the butt fusion machine and adjust the support stands to align the pipe with the fusion machine centerline. Install the pipes or fittings being joined in the stationary and movable clamps of the butt fusion machine. Leave enough pipe protruding through the clamps to allow for facing and clamp the pipe or fitting in the machine.

TABLE 1 Butt Fusion Machine Setup Parameters

Setup Parameter		Required Condition
Manual Butt Fusion Machine	Hydraulic Butt Fusion Machine	
Set heating tool temperature and heat to specified temperature		The surface temperature of heating tool faces must be 400 to 450°F (204 to 232°C). (See X1.1.) A pyrometer or other surface temperature measuring device should be used periodically to insure proper surface temperature of the heating tool faces.
Install inserts	Install inserts	Install inserts for the pipe OD or the fitting being fused.
Electric power supply	Electric power supply	Check field generator for adequate power supply.
Manual pressure	Set facing pressure	As required. Observe butt fusion machine manufacturer's instructions for setting facing pressure.
Manual pressure	Set heating pressure	Observe the pipe and butt fusion machine manufacturer's instructions for setting heating pressures.
Manual pressure (Drag a manual adjustment)	Set fusion joining pressure	Determine fusion joining pressure for the pipe OD and dimension ratio (DR) using 60 to 90 psi (414 to 621 kPa) interface pressure. Observe pipe and butt fusion machine manufacturer's instructions to determine the theoretical fusion joining pressure. Drag pressure is the amount of pressure required to get the carriage to move. Add this pressure to the theoretical fusion joining pressure to get the actual machine gage pressure to set.

8.3.2.1 Take care when placing pipe or fittings in the butt fusion machine. Pipes shall be aligned before the alignment clamp is closed. Do not force the pipe into alignment by pushing it against the side of an open butt fusion machine clamp. Pipes that are freshly cut and molded fittings generally do not have toe-in, and when mated to old-cut pipe or fabricated fittings, removing toe-in can ease adjustment for high-low alignment.

8.3.3 Face the piping component ends until the facer bottoms out on the stops and is locked between the jaws to establish clean, parallel mating surfaces between the pipe/fitting ends (Note 5). Open the jaws and remove the facer and all shavings and debris from the facing operation with a clean, lint-free cotton cloth. Bring the pipe/fitting ends together with minimal force. A visual inspection of this operation should verify a square face, perpendicular to the pipe centerline on each pipe end and with no detectable gap.

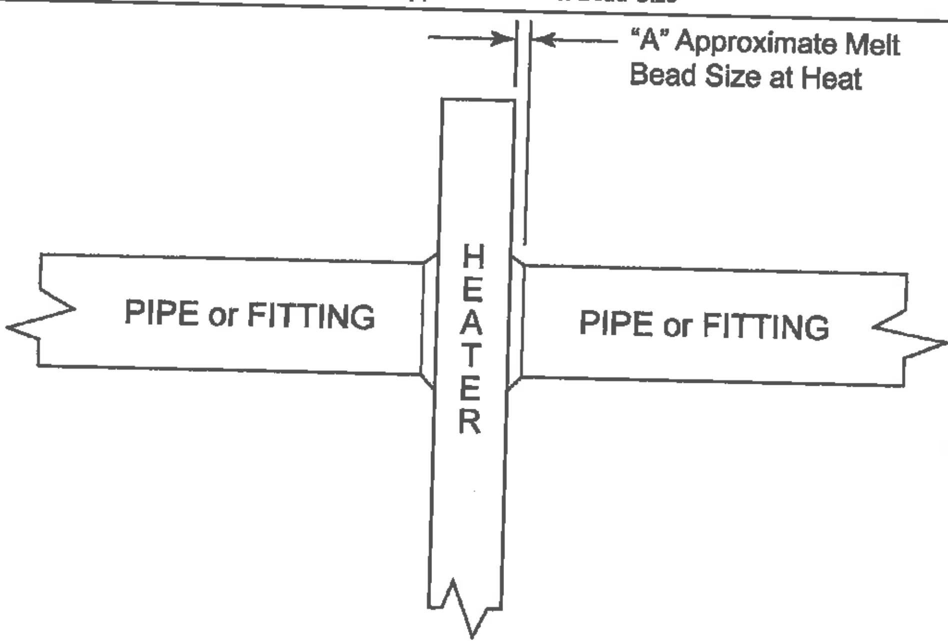
8.3.4 Check the pipe ends for high-low alignment and out-of-roundness. If adjustment is needed, adjust the high side down by tightening the high side clamp. Do not loosen the low side clamp or slippage may occur during fusion. Re-face the pipe or fitting ends if excessive adjustment is required (more than 180° rotation of the clamp knob)and remove any shavings from the re-facing operation with a clean, lint-free cotton cloth. The maximum high-low misalignment allowed in the butt fusion procedure is to be less than 10 % of the pipe minimum wall thickness.

8.3.5 Verify that the heater surface temperatures are in the specified temperature range 400 to 450°F (204 to 232°C). (See Appendix X1.) A pyrometer or other surface temperature measuring device should be used before the first joint of the day and periodically throughout the day to insure proper temperature of the heating tool face. Place the heating tool in the butt fusion machine between the piping component ends and bring the pipe or fitting ends into full contact with the heating tool at fusion pressure. Briefly ensure full contact between piping component ends and the heating tool and then reduce the pressure to drag pressure but without breaking contact between the piping component ends and the heating tool. (On larger pipe sizes, fusion pressure must be maintained until a slight melt is observed around the circumference of the pipe or fitting before releasing pressure.) Maintain contact, without force, while a bead of molten polyethylene develops between the heater and the pipe or fitting ends. Melt bead size is dependent on pipe size. See Table 2 for approximate melt bead sizes.

8.3.6 When the proper bead size is observed, move the piping component ends away from the heating tool. Remove the heating tool and quickly inspect the pipe ends (within 3 s). (See Appendix X1.)

8.3.6.1 Acceptable melt appears flat and smooth with no unmelted areas. If acceptable melt is observed, immediately bring the molten pipe ends together at the calculated fusion force determined by the pipe size and machine capability. With

TABLE 2 Approximate Melt Bead Size



Pipe Size	"A" Approximate Melt Bead Size
1¼ in. IPS and smaller (40 mm and smaller)	1/32 to 1/16 in. (1 to 2 mm)
Greater than IPS 1¼ in. (40mm) through IPS 3 in. (90 mm)	1/16 in. (2 mm)
Greater than IPS 3 in. (90 mm) through IPS 8 in. (225 mm)	1/8 to 3/16 in. (3 to 5 mm)
Greater than IPS 8 in. (225 mm) through IPS 12 in. (315 mm)	3/16 to 1/4 in. (5 to 6 mm)
Greater than IPS 12 in. (315 mm) through IPS 24 in. (630 mm)	1/4 to 7/16 in. (6 to 11 mm)
Greater than IPS 24 in. (630 mm) through IPS 36 in. (915 mm)	7/16 in. (11 mm)
Greater than IPS 36 in. (915 mm) through IPS 65 in. (1651 mm)	9/16 in. (14 mm)

a manual or hydraulic machine, this will be sufficient fusion force to form a double rollback bead against the pipe wall.

8.3.6.2 Unacceptable melt appearance is any combination of a concave surface, unmelted areas, a bubbly pock-marked sandpaper-like surface or melted material sticking to heating tool surfaces. Low strength joints result from unacceptable melt appearance. Discontinue the joining procedure. Allow the component ends to cool completely and restart from 8.3.1. (See Appendix X2.)

NOTE 7—For pipes with a wall thickness greater than 2 in. (50.80mm), consult the pipe manufacturer. Additional heat soak time may be required.

NOTE 8—A concave melt surface is caused by unacceptable high pressure during heating.

8.3.6.3 The correct fusion pressure rolls both melt beads over so that they touch the piping component OD surfaces. Do not use excessive or insufficient force (more than or less than the fusion interfacial pressure range). If the components are brought together with excessive force, molten material may be pushed out of the joint and cold material brought into contact forming a "cold" joint. If too little force is used, voids and weak bonded areas can develop in the joint as molten material cools and contracts.

8.3.7 Hold the molten joint immobile under fusion pressure until sufficiently cooled. Cooling under pressure before removal from the butt fusion machine is important in achieving joint integrity. Maintain fusion pressure against the piping component ends for approximately 30 to 90 s per inch of pipe diameter or until the surface of the bead is cool to the touch (approximately 110°F (54°C)). Avoid high stress such as pulling, installation or rough handling for an additional 30 min or more after removal from the fusion machine (only 10 minutes additional cooling time is required for IPS 1 in. and smaller pipe sizes). Do not apply internal pressure until the joint and surrounding material have reached ambient air temperature. (See Appendix X1.)

NOTE 9—Pouring water or applying wet cloths to the joint to reduce cooling time is not acceptable. Applying chilled air is acceptable only as part of a controlled cooling cycle procedure where testing demonstrates that acceptable joints are produced using the controlled cooling cycle procedure.

8.3.7.1 Visually inspect and compare the joint against appearance guidelines. Visually, the width of butt fusion beads should be approximately 2 to 2½ times the bead height above the pipe and the beads should be rounded and uniformly sized all around the pipe circumference. The v-groove between the beads should not be deeper than half the bead height above the pipe surface. When butt fusing to molded fittings, the fitting-side bead may display shape irregularities such as minor indentations, deflections and non-uniform bead rollover from molder part cooling and knit lines. In such cases, visual evaluation is based mainly on the size and shape of the pipe-side bead. (See Fig. 4 and Appendix X2.)

9. Procedure 3—Saddle Fusion

9.1 *Apparatus*:

9.1.1 *Heating Tool and Faces*—This electrical tool shall have sufficient wattage and control to maintain the specified surface temperature of the tool faces. The serrated or smooth faces are matched sets, by pipe size, of concave and convex blocks, which bolt or clamp onto a flat heating tool. The heating faces are coated with a non-stick material to prevent sticking to the pipe or fitting surfaces.

9.1.2 *Saddle Fusion Tool*—This tool clamps to the main, rounding and supporting the main for good alignment between the pipe and fitting. It holds the fitting. in correct alignment to the main. It also applies and indicates the proper force during the fusion process. A support or bolster is clamped to IPS 6 in. (168 mm) and smaller main pipe opposite the fitting installation area to support the main and assist in rounding the pipe.

9.1.3 *Optional Flexible Heat Shield*—A flexible heat resistant metal or insulated fabric pad used to help establish a melt pattern on larger mains before applying heat to the fitting.

9.2 *Saddle Fusion Terminology*:

9.2.1 *Initial Heat (Bead-up)*—The heating step used to develop an initial melt bead on the main pipe.

9.2.2 *Initial Heat Force (Bead-up Force)*—The force (lb) applied to establish an initial melt pattern on the main pipe. The Initial Heat Force is determined by multiplying the fitting base area (in.^{2}) by the initial interfacial pressure (lb/in.^{2}).

9.2.3 *Heat Soak Force*—The force (lb) applied after an initial melt pattern is established on the main pipe. The Heat Soak Force is the minimum force (essentially zero pounds) that ensures that the fitting, heater and main stay in contact with each other.

9.2.4 *Fusion Force*—The force (lb) applied to establish the fusion bond between the fitting and the pipe. The fusion Force

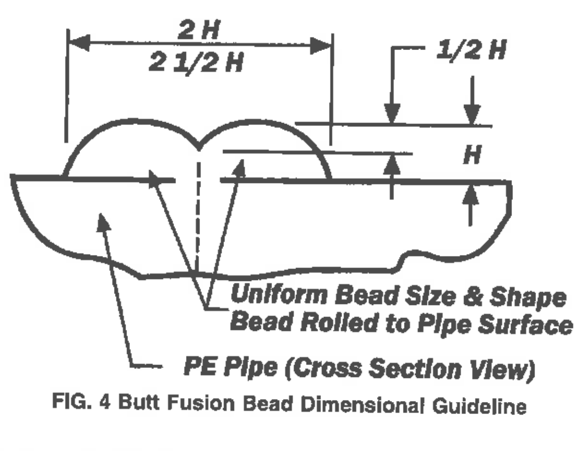


FIG. 4 Butt Fusion Bead Dimensional Guideline

is determined by multiplying the fitting base area (in.^{2}) by the fusion interfacial pressure (lb/in.^{2}).

9.2.5 *Total Heat Time*—A time that starts when the heater is placed on the main pipe and initial heat force is applied and ends when the heater is removed.

9.2.6 *Cool Time*—The time required to cool the joint to approximately 120°F (49°C). The fusion force must be maintained for 5 min on IPS 1¼ in. (42 mm) or 10 min for all other main sizes, after which the saddle fusion equipment can be removed. The joint must be allowed to cool undisturbed for an additional 30 min before tapping the main or joining to the branch saddle.

9.2.7 *Interfacial Area for Rectangular Base Fittings*—The major width times the major length of the saddle base, without taking into account the curvature of the base or sides, minus the area of the hole in the center of the base.

9.2.8 *Interfacial Area for Round Base Fittings*—The radius of the saddle base squared times π (3.1416) without taking into account the curvature of the base or sides, minus the area of the hole in the center of the base.

9.2.9 *Fitting Label*—The initial heat force, heat soak force and the fusion force will be listed on a fitting label in the lower right hand corner of the fitting for some manufacturer's saddle fusion fittings. This will eliminate the need to calculate the fusion forces in the field (for example, 180/0/90). The label is not mandatory, therefore the heat and fusion forces need to be calculated if the label is not present.

9.3 *Setup*:

9.3.1 Select and install the proper heating tool faces to the heating tool based on the main size and fitting base size. Consult the pipe, fitting or equipment manufacturer's recommendations.

9.3.2 Plug in the heating tool and bring the heating tool face surfaces to 490 to 510°F (254 to 266°C) (see Table 3). A pyrometer or other surface temperature measuring device is used to determine and periodically check the heating tool surface temperature. Heating tool thermometers measure the internal temperature of the heating tool which is typically higher than the surface temperature of the heating tool faces.

9.3.3 Install the proper clamps in the Saddle Fusion Tool for the main size to be fused. Install the proper fitting clamp for the fitting to be joined. Consult the pipe, fitting or equipment manufacturer's recommendations.

9.4 *Procedure*:

9.4.1 *Preparation*:

9.4.1.1 Install the Saddle Fusion Tool on the main according to the manufacturer's instructions. The tool should be centered over a clean, dry location where the fitting will be fused. Secure the tool to the main. A main bolster or support is recommended under the pipe on IPS 6 in. (168 mm) and smaller main pipe sizes.

9.4.1.2 Abrade the main, where the fitting will be joined, with a 50 to 60 grit utility cloth until a thin layer of the pipe surface is removed. This can be done before or after the Tool is attached to the main. The abraded area must be larger than the area covered by the fitting base. After abrading, brush residue away with a clean, dry cloth.

9.4.1.3 Abrade the fusion surface of the fitting with 50 to 60 grit utility cloth; remove all dust and residue. Insert the fitting in the Saddle Fusion Tool loosely. Using the Saddle Fusion Tool, move the fitting base against the main pipe and apply about 100 lbf to seat the fitting. Secure the fitting in the Saddle Fusion Tool.

9.4.2 *Heating Procedure for Small Fittings (<2 in. IPS)* (see Table 3):

9.4.2.1 Place the heating tool on the main centered beneath the fitting base. Immediately move the fitting against the heater faces, apply the Initial Heat Force (see fitting label), and start the heat time. Apply the Initial Heat Force until melt is first observed on the crown of the pipe main (Initial Heat is the term used to describe the initial heating (bead-up) step to develop a melt bead on the main pipe and usually is 3 to 5 s) and then reduce the force to the Heat Soak Force (Bead-up force) (see fitting label). Maintain the Heat Soak Force until the Total Heat Time is complete. Total Heat Time ends:

(1) When the Total Heating Time expires for a pressurized IPS 1¼ in. (42 mm) or IPS 2 in. (63 mm) main, or

(2) When a melt bead of about 1⁄16 in. (2 mm) is visible all around the fitting base for a IPS 1¼ in. (42 mm) or IPS 2 in. (63 mm) non-pressurized main, or a larger pressurized or non-pressurized main, (see Table 3).

9.4.2.2 At the end of the Total Heat Time, remove the fitting from the heater and the heater from the main with a quick snapping action. Quickly check for a complete and even melt pattern on the pipe main and fitting heated surfaces (no unheated areas).

9.4.3 *Heating Procedure for Large Fittings (>IPS 3 in.) and Large Mains (>IPS 6 in.)* (see Table 3):

9.4.3.1 Place the heating tool on the main centered beneath the fitting base, and then place the Flexible Heat Shield between the heating tool and the fitting base. (This step usually requires an assistant to handle the Flexible Heat Shield).

9.4.3.2 Move the fitting against the Flexible Heat Shield, apply Initial Heat Force, and observe melt bead formation on the main all around the heating tool faces. When a melt bead is first visible on the main all around the heating tool faces, in a quick continuous motion, release the Initial Heat Force, raise the fitting slightly, remove the Flexible Heat Shield, move the

TABLE 3 Generic Saddle Fusion Parameters

Heater Adapter Surface Temperature	500 ± 10°F (260 ± 6°C)
Initial Interfacial Pressure	60 ± 6 psi (4.14 ± 0.41 bar)
Heat Soak Interfacial Pressure	0 psi
Fusion Interfacial Pressure	30 ± 3 psi (2.07 ± 0.20 bar)
Total Heating Time on Main—1¼ in. IPS Pressure Main	15 s max
Total Heating Time on Main—2 in. IPS Pressure Main	25 to 35 s max
Total Heating Time on non-pressure 1¼ in. IPS, 2 in. IPS mains, and on pressure or non-pressure 3 in. IPS and larger mains.	Look for a 1⁄16 in. (1.6 mm) bead around the fitting base

fitting against the heating tool face, apply Initial Heat Force and start the heat time. When a melt bead is first visible all around the fitting base (usually about 3 to 5 s) immediately reduce applied force to the Heat Soak Force (usually zero). Maintain the Heat Soak Force until the Table 3 Total Heat Time ends.

NOTE 10—During heating, hold the heating tool in position by lightly supporting the heating tool handle. If not supported, the heating tool can slip out of position or displace the main or fitting melt and result in a poor joint.

9.4.3.3 At the end of the Total Heat Time, remove the fitting from the heater and the heater from the main with a quick snapping action. Quickly check for a complete and even melt pattern on the pipe main and fitting heated surfaces (no unheated areas). A mirror may be needed to check the bottom of the fitting.

9.4.4 *Fusion and Cooling* (see Table 3):

9.4.4.1 Whether or not the melt patterns are satisfactory, press the fitting onto the main pipe very quickly (within 3 s) after removing the heater and apply the Fusion Force (see the fitting label). Maintain the Fusion Force on the assembly for 5 min on IPS 1¼ in. (42 mm) and for 10 min on all larger sizes, after which the saddle fusion equipment may be removed. (Fusion Force adjustment may be required during Cool Time, but never reduce the Fusion Force during cooling.)

9.4.4.2 Cool the assembly for an additional 30 min before rough handling, branch joining or tapping the main. (If the melt patterns were not satisfactory or if the fusion bead is unacceptable, cut off the saddle fitting above the base to prevent use, relocate to a new section of main. and make a new saddle fusion using a new fitting.)

NOTE 11—These procedures are based on tests conducted under controlled ambient temperature conditions. Environmental conditions on a job site could affect heating and cooling times. Regardless of job site conditions or ambient temperature, the prescribed heating tool temperature is required. Do not increase or decrease the heating tool temperature. When saddle fittings are fused to pipes that are under pressure, it is important that the surface melt be obtained quickly without too much heat penetration with out exceeding the time guidelines in Table 3. Otherwise, too much heat penetration could result in pipe rupture from internal pressure.

9.5 *Visual Inspection*:

9.5.1 Visually inspect and compare the joint against visual inspection guidelines. There shall be three beads, a melt bead around the fitting base, a bead on the main from the edge of the heating tool, and a main pipe melt bead. The fitting and pipe melt beads should be rounded and about ⅛ in. (3 mm) wide all around the fitting base. The heating tool edge bead should be visible all around the fitting base, but may be separate from the main pipe melt bead.

9.5.2 The saddle fusion joint in unacceptable for use if visual bead appearance is unacceptable or if the melted surfaces were unacceptable. To prevent use, cut the fitting off at or just above the base. (See Appendix X2.)

NOTE 12—Look in the lower right hand corner of the fitting label for the forces required for that fitting in pounds force (Initial Heat Force/Heat Soak Force/Fusion Force) (for example, 180/0/90).

10. Keywords

10.1 butt fusion; fitting; heat fusion; joining; pipe; polyethylene; polyolefin; saddle fusion; socket fusion

ANNEX

(Mandatory Information)

A1. COLD WEATHER PROCEDURES

A1.1 *Cold Weather Handling*:

A1.1.1 Pipe shall be inspected for damage. Polyolefin Polyethylene pipes have reduced impact resistance in sub-freezing conditions. Avoid dropping pipe in sub-freezing conditions. When handling coiled pipe at temperatures below 40°F (4.44°C), it is helpful to uncoil the pipe prior to installation and let it straighten out. Gradually uncoil the pipe and cover it with dirt at intervals to keep it from recoiling. Always use caution when cutting the straps on coils of pipe because the outside end of a coil may spring out when the strapping is removed.

A1.2 *Preparation for Socket, Saddle, and Butt Fusion Joining*:

A1.2.1 *Wind and Precipitation*—The heating tool shall be shielded in an insulated container to prevent excessive heat loss. Shield the pipe fusion area and fusion tools from wind, snow, and rain by using a canopy or similar device.

A1.2.2 *Pipe and Fitting Surface Preparation*—The pipe and fitting surfaces to be "joined" or held in clamps shall be dry and clean and free of ice, frost, snow, dirt, and other contamination. Regular procedures for preparation of surfaces to be joined, such as facing for butt fusion and roughening for saddle fusion shall be emphasized. After preparation, the surfaces shall be protected from contamination until joined. Contamination of the area to be fused will likely cause incomplete fusion. Frost and ice on the surfaces of the pipe to be clamped in either a cold ring or alignment jigs may cause slippage during fusion. Inspect coiled pipe to see if it has flattened during storage, which could cause incomplete melt pattern or poor fusion. It may be necessary to remove several inches at the pipe ends to eliminate such distortion. Pipe may have a slight toe-in or reduced diameter for several inches at the end of the pipe. The toe-in may need to be removed before butt fusing to a freshly cut pipe end, or to a fitting.

A1.2.3 *Heating*—Work quickly once pipe and fitting have been separated from the heating tool, so that melt heat loss is minimized, but still take time (no more than 3 s) to inspect both melt patterns. Keep the heater dry at all times. Check the temperature of the heating tool regularly with a pyrometer or other surface temperature measuring device. Keep the heating tool in an insulated container between fusions. Do not increase heating tool temperature above the specified temperature setting. Gas-fired heating tools are used only in above freezing conditions.

A1.3 *Socket Fusion*:

A1.3.1 *Pipe Outside Diameter*—Pipe outside diameter contracts when cold. This results in loose or slipping cold rings. For best results, clamp one cold ring in its normal position adjacent to the depth gage. Place shim material (that is, piece of paper or rag, etc.) around the inside diameter of a second rounding ring and clamp this cold ring directly behind the first cold ring to prevent slippage. The first cold ring allows the pipe adjacent to the heated pipe to expand to its normal diameter during the heating cycle.

A1.3.2 *Fitting Condition*—If possible, store socket fittings at a warm temperature, such as in a truck cab, prior to use. This will make it easier to place the fitting on the heating tool because fittings contract when cold.

A1.3.3 *Heating*—At colder temperatures the pipe and fitting contract, thus the pipe slips more easily into the heating tool. At very cold outdoor temperatures (particularly with IPS 2, 3, and 4-in. pipe), the pipe may barely contact the heating surface. Longer heating cycles are used so that the pipe first expands (from tool heat) to properly contact the heating tool, then develops complete melt. The length of cycle necessary to obtain a complete melt pattern will depend not only on the outdoor (pipe) temperature but wind conditions and operator variation. Avoid cycles in excess of that required to achieve a good melt pattern. To determine the proper cycle time for any particular condition, make a melt pattern on a scrap piece of pipe, using the heating cycle as instructed by the pipe manufacturer. If the pattern is incomplete (be sure rounding rings are being used), try a 3 s longer cycle on a fresh (cold) end of pipe. If the melt pattern is still not completely around the pipe end, add an additional 3 s and repeat the procedure. Completeness of melt pattern is the key. Keep the heater dry at all times. Check the temperature of the heating tool regularly and keep the heating tool in an insulated container between fusions.

A1.4 *Butt Fusion*:

A1.4.1 *Joining*—It will take longer to develop the initial melt bead completely around the pipe ends on large diameter pipe. On larger pipe sizes, fusion pressure must be maintained until a slight melt is observed around the circumference of the pipe or fitting before releasing pressure to the heat soak cycle. Do not increase pressure during the heat soak cycle. When proper melt bead has been obtained, the pipe and heater shall be separated in a rapid, snap-like motion. The melted surfaces shall then be joined immediately in one smooth motion so as to minimize cooling of the melted pipe ends. (See Appendix X1.)

A1.5 *Saddle Fusion*:

A1.5.1 *Surface Preparations*—Regular procedures for roughening the surfaces to be fused on the pipe and the fitting shall be emphasized. After the surfaces have been prepared, particular care shall be taken to protect against contamination.

A1.5.2 *Heating Time*—Make a trial melt pattern on a scrap piece of pipe. A clean, dry piece of wood is used to push the heating tool against the pipe. If the melt pattern is incomplete, add 3 s to the cycle time and make another trial melt pattern on another section of cold pipe. If the pattern is still incomplete, continue 3 s additions on a fresh section of cold pipe until a complete melt pattern is attained. Use this heating cycle for fusions during prevailing conditions. Regardless of the weather or the type of tools used, the important point to remember is that complete and even melt must occur on the fitting and the pipe in order to produce a good fusion joint. This requires pipe preparation to make it clean, straight, round, and well supported.

APPENDIXES

(Nonmandatory Information)

X1. JOINING

X1.1 *Parameters and Procedures*—These parameters and procedures in this practice are approved by the majority of pipe manufacturers for the majority of the solid wall polyethylene pipe materials on the market today. Consult with the pipe manufacturer to make sure they approve this procedure for the pipe to be joined. Other specific parameters and procedures, such as heater temperature variations, have been developed, tested and approved by some municipalities, utilities, and end users. They are not covered in this specification.

X1.2 *Quality Assurance Recommendations*—It is recommended that the following steps be followed to help insure quality fusion joints.

X1.2.1 Make sure the equipment or tooling used to make the fusion joints is in good working order and conforms to the equipment manufacturer's quality assurance guidelines.

X1.2.2 Make sure the operator of the equipment or tooling to be used has had the proper training in the operation of that equipment.

X1.2.3 If possible, use a datalogging device with hydraulic joining equipment to record the critical fusion parameters of pressure, temperature and time for each joint.

X1.2.4 Visually inspect each joint and. compare the datalogged records to this approved standard before burying the pipe. (See Appendix X2 for visual guidelines.)

X1.3 *Heating Polyethylene (PE) in a Hazardous Environment*—Electrically powered heat fusion tools and equipment are usually not explosion proof. When performing heat fusion in a potentially combustible atmosphere such as in an excavation where gas is present, all electrically powered tools and equipment that will be used in the combustible atmosphere shall be disconnected from the electrical power source and operated manually to prevent explosion and fire. For the heating tool, this requires bringing the heating tool up approximately 25°F (14°C) above the recommended maximum surface temperature in a safe area, then disconnecting it from electrical power immediately before use.

X1.4 *Butt Fusion of Unlike Wall Thicknesses*—The butt fusion procedure in this practice is based on joining piping components (pipes and fittings) made from compatible polyethylene compounds having the same outside diameter and wall thickness (PR) per ASTM or other industry product specifications. In some cases, butt fusion joining of pipes and fittings that have the same outside diameter but unlike wall thickness (different by one standard DR or more) is possible. The quality of butt fusion joints made between pipes of unlike wall thickness is highly dependent on the performance properties of the polyethylene compound used for the pipes or fittings being joined. Consult the pipe or fitting manufacturer for applicable butt fusion procedures for components with dissimilar wall thicknesses.

X1.5 *Butt Fusion of Coiled Pipe*—Coiled pipe is available is sizes up to 6 in. IPS. Coiling may leave a set in some pipe sizes that must be addressed in the preparation of the butt fusion process. There are several ways to address this situation:

X1.5.1 Straighten and re-round coiled pipe before the butt fusion process. (Specification D2513 requires field re-rounding of coiled pipe before joining pipe sizes larger than 3 in. IPS.)

X1.5.2 If there is still a curvature present, install the pipe ends in the machine in an "S" configuration with the print lines approximately 180° apart in order to help gain proper alignment and help produce a straight joint. See Fig. X2.15.

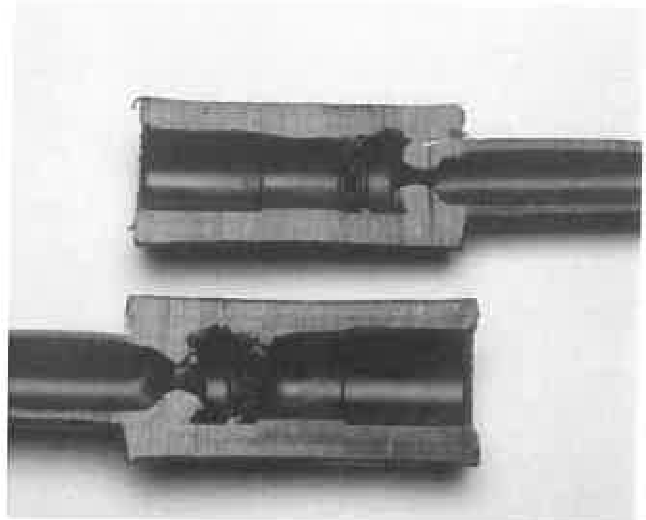
X1.5.3 If there is still a curvature present, another option would be to install a straight piece of pipe between the two coiled pipes.

NOTE X1.1—Every effort should be made to make the joint perpendicular to the axis of the pipe. Visually mitered (angled, off-set) joints should be cut out and re-fused (see appearance guidelines in Appendix X2).

X2. HEAT FUSION VISUAL APPEARANCE GUIDELINE

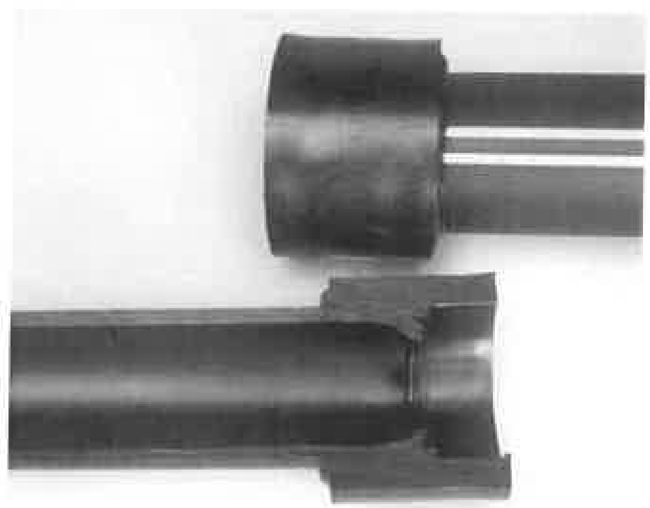
Melt bead flattened by cold ring.
No gaps or voids.
Good alignment between pipe and fitting.

FIG. X2.1 Acceptable Visual Appearance Socket Fusion



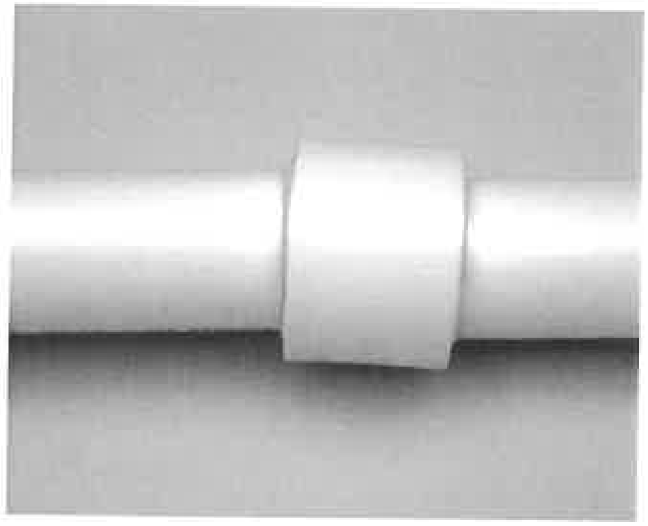
Excessive heating.

FIG. X2.2 Unacceptable Visual Appearance Socket Fusion



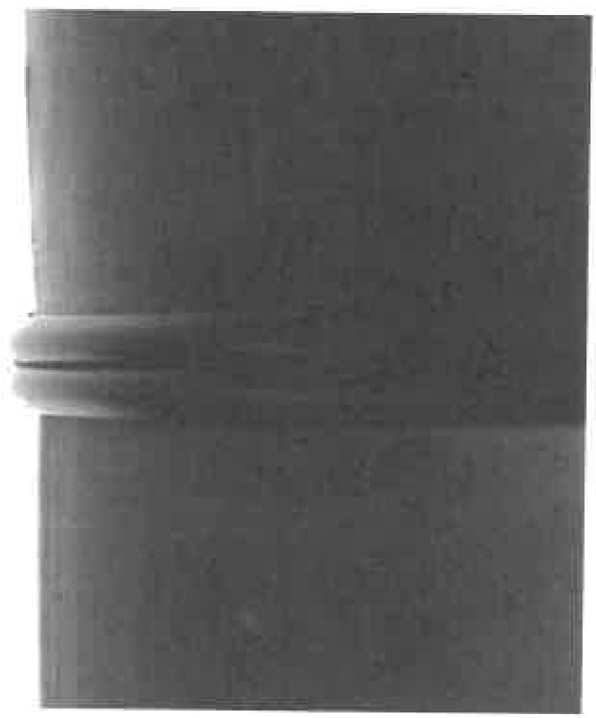
Melt bead not flattened against the fitting/cold ring.
Improper insertion depth; no cold ring.
Excessive heating.

FIG. X2.3 Unacceptable Visual Appearance Socket Fusion



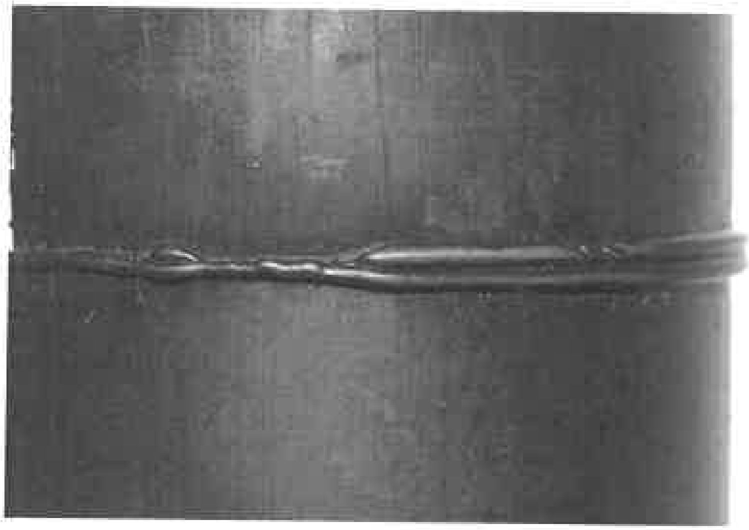
Misalignment.

FIG. X2.4 Unacceptable Visual Appearance Socket Fusion



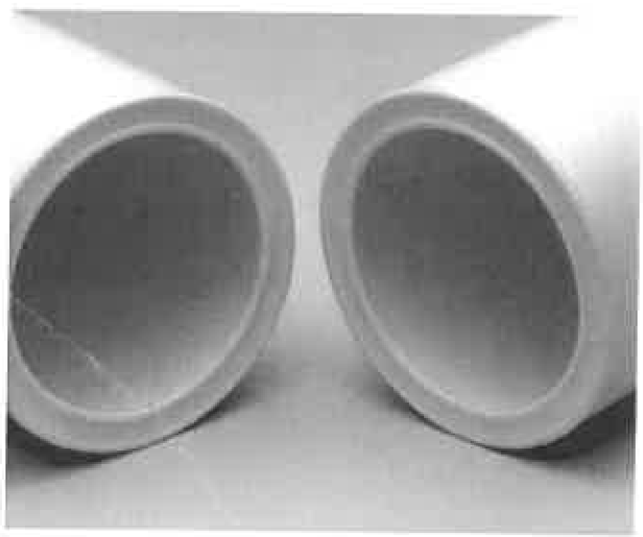
Proper double roll-back bead.
Proper alignment.

FIG. X2.5 Acceptable Visual Appearance Butt Fusion



Incomplete face-off.

FIG. X2.6 Unacceptable Visual Appearance Butt Fusion



Unacceptable concave melt appearance after heating.
Possible over-pressurization during the heat cycle.

FIG. X2.7 Unacceptable Visual Appearance Butt Fusion

Attachment DK-9

Ohio Rural Natural Gas, Co-Op

PUBLIC AWARENESS PROGRAM

May 5, 2015

OHIO RURAL NATURAL GAS CO-OP

PUBLIC AWARENESS RECORDS

DATE	DESCRIPTION OF PUBLICATION	NUMBER OF NOTIFICATIONS	SIGNATURE
1/6/2016	Public Awareness mailing		[illegible] Counter
8/5/2016	Mailing to customers, businesses, neighbors, and municiples.	284	[illegible]
8/11/2016	www.ORNGCO-OP.com Launch, Safety Section		[illegible]

Table of Contents

REVISIONS AND UPDATES

Date	Section Changed	Reason	What was changed	Expected Outcome
5/7/2015	Plan Implementation			

1. Program Overview

1.1. Program Objectives

The goal of the Ohio Rural Natural Gas Co-Op Public Awareness Program is to enhance public safety by educating the affected public, emergency officials, local public officials and excavators working and living near The Ohio Rural Natural Gas Co-Op pipelines. As a pipeline owner and operator, the Ohio Rural Natural Gas Co-Op will select the most appropriate mix of audiences, message types, delivery methods, and frequencies, depending on our system's respective needs. These stakeholders will receive safety information about pipeline routes, how to identify and react to potential pipeline emergencies and information on how to contact The Ohio Rural Natural Gas Co-Op to report problems. All stakeholders will also receive information on how to prevent potential pipeline problems by reducing third party damage through the use of the One Call System (811) before doing any excavating. The Ohio Rural Natural Gas Co-Op is committed to the safe operation of our pipelines and is dedicated to the protection of our employees and the public.

To achieve this goal, The Ohio Rural Natural Gas Co-Op works with One-Call Centers, pipeline awareness and educational organizations, informed employees and other pipeline companies to distribute information that is not only beneficial, but helpful to the overall success of this program increasing the stakeholders' awareness concerning pipeline operations and safety.

1.1.1 *Public Awareness of Pipelines*

The Ohio Rural Natural Gas Co-Op Public Awareness program educates by raising the awareness of the affected public and key stakeholders to the presence of pipelines in their community and increases their understanding of the role pipelines play in safely transporting energy.

A more informed public:

- Understands that while pipeline accidents are possible, pipelines are a safe mode of transportation.
- Understands that The Ohio Rural Natural Gas Co-Op undertakes a variety of measures to prevent pipeline accidents.
- Can contribute to the reduction or prevention of emergencies and/or releases by reporting unusual activity near pipeline routes.
- Should have the knowledge of how to identify a problem occurring on or near the Ohio Rural Natural Gas Co-Op pipeline and how to notify the Ohio Rural Natural Gas Co-Op.
- Understands that the public has a significant role in helping to prevent accidents that are caused by third-party damage and Right-of Way encroachment.

1.1.2 Prevention and Response

The Ohio Rural Natural Gas Co-Op Public Awareness program is designed to help the public understand steps that should be taken to prevent and respond to pipeline emergencies. "Prevention" refers to the objective of reducing the occurrences of pipeline damage and emergencies caused by third-parties through education about safe excavation practices and the use of the One-Call system.

The "Response" steps are intended to protect life, property and to promptly notify the Ohio Rural Natural Gas Co-Op and emergency response officials in the event of a release or pipeline emergency.

1.1.3 Regulatory Compliance

This program is intended to provide a framework for a public awareness program designed to help in compliance with federal regulatory requirements, as referenced in 49 *CFR* Parts 192. The three principal compliance elements include:

Public Awareness (49 CFR Parts 192.616)

The Ohio Rural Natural Gas Co-Op will establish continuing educational programs to enable the public, appropriate government organizations, and persons engaged in excavation-related activities to recognize a pipeline emergency and to report it to the operator and/or the fire, police, or other appropriate public officials. The program is provided in both English and in other languages commonly understood by a significant number and concentration of non-English speaking population in the operator's area.

Emergency Responder Liaison Activities (49 CFR Parts 192.615)

The Ohio Rural Natural Gas Co-Op will establish and maintain liaison with fire, police, and other appropriate public officials and coordinate with them on preplanned and actual responses during an emergency.

Damage Prevention (49 CFR Parts 192.614)

The Ohio Rural Natural Gas Co-Op will carry out a program to prevent damage to pipelines by excavation activities. The information provided in this program also provides a framework for public awareness programs that may be used for pipeline systems that are not governed by 49 *CFR* Parts 192.

2. Management Commitment and Support

The Ohio Rural Natural Gas Co-Op is committed to protecting the environment where we live and work. We promote environmental stewardship by designing, constructing, and operating facilities that serve the interests of our customers, communities, landowners and employees while meeting the challenge of protecting the environment. We are committed to:

- Protecting the environment and working with all applicable agencies (federal and state) to fully comply with laws and regulations designed to protect sensitive areas
- Conducting our operations in a manner that protects human health and the environment
- Enhancing the quality of the environment, in which we live and work
- Protecting the environment and our natural resources by operating in a safe and reliable manner
- Maintaining an open dialogue with neighboring communities throughout the planning, development, construction and operation stages to ensure the project reflects the communities' interests and needs
- Working with landowners to ensure minimal interruption of existing land use activities

Given these commitments, The Ohio Rural Natural Gas Co-Op's management supports the development and implementation of this public awareness plan through:

- Appropriate funding to support mailings, meetings, communications and reproduction of presentation materials as necessary for the success of this public awareness plan.
- Continued participation from the Ohio Rural Natural Gas Co-Op's personnel, in order to maintain proper communication, participation and common interest in the success of this public awareness plan.
- Accurate provision of necessary informational and supplemental resources such as contact information, product information, maps, response capabilities, emergency plans, evacuation routes, etc.
- Sustained attention to overall advancement of public response and improvement of public prevention endeavors in specific regard to tracking and documenting statistics, drills and tests (including mock emergency scenarios).
- Maintain and strengthen the public's trust and confidence in the Ohio Rural Natural Gas Co-Op as a capable, responsible long-term safe and reliable operator and a good neighbor.

In an effort to make public awareness a company priority, the Ohio Rural Natural Gas Co-Op further agrees to make reasonable necessary strategies and resources available to the public and appropriate government agencies to expand their public awareness and informational capacity.

Authorized Signature: Lauren A Tristano

Printed Name: Lauren A. Tristano

Title: Compliance Manager.

Date: 8/1/2016

3. PROGRAM ADMINISTRATION

The success of the Ohio Rural Natural Gas Co-Op's Public Awareness Program is a shared responsibility. Operations, GIS Support, and Program Administration have differing responsibilities of program administration. The frame work for managing the public awareness program is periodically reviewed and improved as needed to enhance the quality of the program.

3.1. ROLES and RESPONSIBILITIES

- **Program Administrator–** Responsible for executive support and securing funding for the Ohio Rural Natural Gas Co-Op Public Awareness Program. And will manage the development and implementation of the Ohio Rural Natural Gas Co-Op Public Awareness Program to be compliant with RP 1162 and DOT 192 requirements. When the program needs to be modified, the Program Administrator is responsible for making such modifications. The Administrator will form a Public Awareness Committee (PAC); to review, provide input and communicate identified changes. The committee will provide feedback on the public awareness program effectiveness and message content. If additional implementation measures are required, the Administrator will oversee the implementation. The Administrator reviews and approves vendors, trade associations, and non-profit organizations used in the Program.
- **Compliance Manager** – Will work with various intra-company personnel, vendors, trade associations, and nonprofit organizations to ensure the success of the Program. Coordinates the public awareness program and message content. Makes certain (PAC) findings are implemented. Participates as needed or assigns a designee to participate in public awareness associations, meetings, etc. Ensure that field personnel understand the importance of their role in public awareness and pipeline safety. Provide the necessary training so that field personnel understand the Program requirements and can effectively implement the program to comply with federal and state requirements. Carries out responsibilities of the program and to attend public awareness association meetings held for the purpose of providing specific information about the Ohio Rural Natural Gas Co-Op pipelines to affected public, government officials, emergency officials and excavators. Collect and maintain the necessary documentation of compliance to the Ohio Rural Natural Gas Co-Op Public Awareness Program.

- **Public Awareness Committee** - Monitor and receive guidance from the DOT Regulations on matters relating to Public Awareness. Track statutory and regulatory developments that could affect the Plan. Participate in industry initiatives and programs intended to facilitate Public Awareness Programs. Identify consultants and other outside resources that can assist in the continuing development, implementation and enhancement of the plan. Identify the target public, local officials, emergency officials and excavators who will be the target audience to be reached by the efforts of the program develop the "messages" to be delivered to the selected target audiences. Ensure methods to deliver the messages to the various target audiences are developed and implemented. Set targets for frequency with which messages will be delivered. Select the messages and methods of delivery to be used to reach the target audiences. Track Program implementation and document all activities related to the Program. Develop and implement training programs to educate employees on their roles in the process. Design methods to determine effectiveness of the Program and perform evaluations, and ensure the effectiveness evaluation is performed and reviewed for continuous improvement efforts. Review, maintain, update and enhance the Public Awareness Plan as needed, affirmatively re-adopting the Plan on an annual basis. Assign responsibilities to specific employees. Assist in the Annual Program Review Process. See appendix B for PAC members.

- **GIS Support** - Responsible for establishing pipeline locations. Will utilize the Ohio Rural Natural Gas Co-Op's procedures for damage prevention, public awareness and HCA requirements. Support providing pipeline centerline information to vendors, and nonprofit organizations when requested by the Operations Manager for the Ohio Rural Natural Gas Co-Op business purposes. GIS is responsible for contacting the Operations Manager to obtain buffer zones. The accuracy of the initial and final buffers submitted to One Call Center are determined by the Operations Manager or defaulted to the Ohio One Call requirements. Information regarding pipe changes, acquisitions or new construction must be submitted to the One Call Centers as they occur.

- **For Centerline Data for Mail Outs –** GIS Support is responsible for the dissemination of pipeline centerline data for mail outs. The Program Administrator specifies the buffers used in the mail outs to GIS Support, as detailed in the Ohio Rural Natural Gas Co-Op's Public Awareness Program. Any changes to centerline data are submitted to the designated vendor handling mail outs.

3.2. EMPLOYEE PARTICIPATION

Informed employees can play an important role in promoting pipeline awareness. Employees should be familiar with The Program objectives. Information and materials used should be available to employees where appropriate to promote pipeline awareness in their communities.

3.3 RECORD KEEPING AND DOCUMENTATION

Records and other documentation that reflect communication to stakeholder audiences; including copies of materials provided to each stakeholder audience, postal receipts or other proof of delivery, stakeholders lists, and stakeholder feedback (if applicable), shall be maintained for a minimum of five (5) years. Record retention location will be the Ohio Rural Natural Gas Co-Op Administrative office.

3.3.1 *DOCUMENT MANAGEMENT*

PAC COMMITTEE – Documentation shall be maintained for all baseline activities conducted from this level. Examples of baseline activities by the PAC are:

- Direct Mailings (may include any target audience)
- Group meetings
- Annual Evaluations (PAC coordination)
- Four-year Effectiveness Evaluations (PAC coordination)
- Company Website Content
- Supplemental Program Outreach

Designated person(s) serving on the PAC shall maintain a file, by calendar year, of all activities conducted within the region. The file should consist of date of activity, list of participants, and copy or written record of materials, resources, or message conveyed.

The following are some suggested file titles for documentation purposes:

- Baseline Compliance Communication
- Emergency Official Meetings/Notifications
- Public Official Meetings/Notifications
- Excavator/Contractor Meetings/Notifications
- Personal Contacts (written, telephone, or face to face)
- Regional/State Pipeline Association Activities
- Supplemental Activities

3.3.2. DOCUMENT MANAGEMENT PROCESS

Responsible members shall submit any and all information pertaining to the file titles listed above (or other) to a PAC member for public awareness documentation file. Transfer of records shall be done in a manner to ensure they are not lost.

4. ASSETS INCLUDED IN THE PROGRAM

At a minimum, pipelines owned and/or operated by the Ohio Rural Natural Gas Co-Op and regulated by 49 CFR 192 and the state of Ohio damage prevention requirements will be included in the Ohio Rural Natural Gas Co-Op Public Awareness Program. However, the Ohio Rural Natural Gas Co-Op makes an attempt to include other pipelines in the Public Awareness Program. This is done as an extended effort to protect public safety, employees and our pipelines regardless of regulated status. The Ohio Rural Natural Gas Co-Op operates natural gas distribution pipeline system in the state of Ohio. The Plan covers all assets regardless of product or operational status. The assets included in the Plan will be reviewed annually by the PAC during the annual review process.

See Appendix C for the most recent illustration of the Ohio Rural Natural Gas Co-Op's assets currently covered in this plan

5. STAKEHOLDER AUDIENCES

In general, the Ohio Rural Natural Gas Co-Op Public Awareness program shall communicate relevant information based on the following stakeholder audience table:

Stakeholder Audience Table

Audience Definitions, Examples and System Applicability

Audience	Definition	Examples
Affected Public		
Residents located along distribution system	People who live within the service territory to the land wherein the gas distribution pipeline is located.	• LDC Customers • Non-customers living within the service territory who do not receive gas.
LDC Customers	Those who are served by the gas distribution facility operated by Ohio Rural Natural Gas CO-OP.	• Customers
Emergency Officials		
Audience	**Definition**	**Examples**
Emergency Officials	Local, state, or regional officials, agencies and organizations with emergency response and/or public safety jurisdiction along the pipeline route. Those whom would reasonably respond to or be involved in a product release.	• Fire & police departments • Local Emergency Planning Commissions (LEPCs) • County and State Emergency Management Agencies • Other emergency response organizations • Public Safety Answering Points (PSAPs) • Other public safety organizations.
Public Officials		
Audience	**Definition**	**Examples**
Public Officials	Local, city, county or state officials and/or their staffs having land use and street/road jurisdiction along the pipeline route.	• Planning and zoning boards • Licensing and permitting departments • Building code enforcement • City and county managers • Public and government officials • Public utility boards

		• Includes local "Governing Councils" as defined by many communities • Public officials who manage franchise or license agreements.

Excavators

Audience	Definition	Examples
Excavators	Companies and local/state government agencies who are involved in any form of excavation activities.	• Construction companies • Excavation equipment rental companies • Public works officials • Public street, road and highway departments (maintenance and construction) • Timber companies • Fence building companies • Drain tiling companies • Landscapers • Well drillers
Land Developers	Companies and private entities involved in land development and planning	• Home builders • Land developers • Real estate sales
One-Call Centers	Excavation One-Call Centers relevant to the area.	• Each state, region, or other organization established to notify underground facility owner operator of proposed excavations.

6. MESSAGE CONTENT

6.1 *English and Other Languages*

English and other languages shall be considered for the purpose of communicating with the Affected Public and Excavator stakeholder audiences. Emergency Officials and Public Officials speak English in their day-to-day lives in order to interact with the public; therefore will be communicated in English only. Excavators will be provided written materials in English and Spanish based on the thought that excavation companies have significant staff that speak Spanish and may be prominent to damage pipelines.

6.1.1 *Affected Public "Other" Language Threshold*

- API RP 1162 Section 2.3.1 requires the program "to be provided in both English and in other languages commonly used by a significant concentration of non-English speaking population along the pipeline."
- Without a definition of "significant" the Ohio Rural Natural Gas Co-Op has determined it will provide the affected public materials to stakeholders along the pipeline where a threshold of 20% of non-English speaking stakeholders is exceeded.

6.1.2 *Process for Analyzing Languages Spoken*

- For each county intersecting the distribution service territory the most current and available Census Bureau demographics and American Consumer Survey (ACS) data will be tabulated in a spreadsheet.
- By reviewing the data, the Ohio Rural Natural Gas Co-Op will determine the need for any non-English communication provided to the affected public.
- Should Spanish exceed the threshold the Ohio Rural Natural Gas Co-Op will provide information in written form in Spanish, in the frequency determined by the appropriate stakeholder audience.
- Should other languages meet or exceed the threshold, the Ohio Rural Natural Gas Co-Op will assess the area and if needed provide public awareness messages in the determined language.

6.2 *Message Content Inclusion*

In order to reach a maximum number of readers and provide the most comprehensive distribution of information in a single effort, a brochure is used as the printed material for all stakeholder groups. The brochure is designed to be easy-to-read and easy-to-understand. The following items were taken into consideration during the brochure design process:

- English and other languages shall be considered for the purpose of communicating with the Affected Public and Excavator stakeholder audiences. Emergency Officials and Public Officials speak English in their day-to-day lives in order to interact with the public therefore will be communicated in English only. Excavators will be provided written materials in English and Spanish based on the thought that excavation companies have significant staff that speak Spanish and may be prominent to damage pipelines. Provide the Ohio Rural Natural Gas Co-Op emergency and the State One-Call Center excavation phone numbers.
- Educate the reader how to spot various pipeline markers and determine pipeline locations. Information shall include purpose of pipeline markers and the information on them. An example might be: "markers are used to delineate the approximate location of a pipeline and provide contact information"
- Educate the reader about how pipelines can be damaged, what can happen if they are damaged, and how to prevent damage to a pipeline.
- Emphasize the legal requirements of contacting the applicable State One-Call Center in advance of excavation.
- Educate the reader on the signs of a pipeline leak and what they should do in case they suspect a leak.
- Educate the reader on the purpose and reliability of pipelines.

The message content given in group meetings may be different from the printed brochure. The message content is tailored to the particular audience group and meeting purpose.

The following items may be included in discussion during group meetings:

The Affected Public – Relevant Information

- Proximity of homes and business places to a pipeline and the availability of the National Pipeline Mapping System (NPMS).

- Hazards associated with unintended pipeline releases.
- What the Ohio Rural Natural Gas Co-Op does to design, operate, maintain, inspect, and test pipelines as well as emergency preparedness to prevent accidents and mitigate the consequences of accidents when they occur.
- How to recognize and respond to a pipeline emergency.
- How to protect themselves and building occupants in the unlikely event of a pipeline release.
- How to notify the Ohio Rural Natural Gas Co-Op regarding questions, concerns, or emergencies.
- How to assist in preventing pipeline emergencies by following safe excavation and digging practices and reporting unauthorized digging or suspicious activity along the pipeline ROW.
- Education that individuals can create undesirable encroachments upon the Ohio Rural Natural Gas Co-Op pipeline ROW.
- What the Ohio Rural Natural Gas Co-Op does for pipeline security.

Local Public Officials – Relevant Information

- Awareness that a pipeline crosses their area of jurisdiction, its location and the availability of the National Pipeline Mapping System (NPMS).
- Hazards associated with unintended pipeline releases.
- What the Ohio Rural Natural Gas Co-Op does to design, maintain, inspect, and test pipelines as well as emergency preparedness to prevent accidents and mitigate the consequences of the accidents when they do occur.
- What the Ohio Rural Natural Gas Co-Op does to maintain ongoing relationships with local public officials.

Emergency Officials – Relevant Information

- The Ohio Rural Natural Gas Co-Op's top priorities are public safety and environmental protection in any pipeline emergency response.
- Location of pipelines in their jurisdiction, and location of detailed information regarding those pipelines.
- Who The Ohio Rural Natural Gas Co-Op is and the emergency contact information.
- Information about the potential hazards of the pipeline.
- Location of emergency response plans with respect to the pipelines.
- How to notify the Ohio Rural Natural Gas Co-Op regarding questions, concerns, or emergency.
- How to safely respond to a pipeline emergency.
- What the Ohio Rural Natural Gas Co-Op does to design, maintain, inspect, and test pipelines as well as emergency preparedness to prevent accidents and mitigate the consequences of the accidents when they occur.

- Awareness that a pipeline crosses their area of jurisdiction, its location and the availability of the National Pipeline Mapping System (NPMS). The NPMS provides a local and state government viewer which allows access to database for pipeline locations.

Excavators – Relevant Information

- Awareness that digging and excavating along the ROW may affect public safety, pipeline safety and/or pipeline operations.
- Information about damage prevention requirements in that jurisdiction.
- Information about the State One-Call requirements in that jurisdiction.
- Information about safe excavation practices in association with underground utilities.
- Information on digging related damage due to third parties.
- How to notify the Ohio Rural Natural Gas Co-Op regarding a pipeline emergency or damage to a pipeline.
- How to recognize a pipeline ROW and signs associated with the ROW.
- Hazards associated with unintended pipeline releases.
- Who the Ohio Rural Natural Gas Co-Op is and who to contact for emergency or non-emergency information.

Land Developers – Relevant Information

- Awareness that digging and excavating along the ROW may affect public safety, pipeline safety and/or pipeline operations.
- Information about damage prevention requirements in that jurisdiction.
- Information about the State One-Call requirements in that jurisdiction.
- Information about safe excavation practices in association with underground utilities.
- How to notify the Ohio Rural Natural Gas Co-Op regarding a pipeline emergency or damage to a pipeline.
- How to recognize a pipeline ROW and signs associated with the ROW and the availability of the National Pipeline Mapping System (NPMS).
- Hazards associated with unintended pipeline releases.
- Who the Ohio Rural Natural Gas Co-Op is and who to contact for emergency or non-emergency information.
- Education that individuals can create undesirable encroachments upon a pipeline ROW.

One Call Relevant Information

- Awareness that digging and excavating along ROW may affect personal and public safety, pipeline safety, and/or pipeline operations.
- Information about damage prevention requirements in that jurisdiction.
- Information about safe excavation practices in association with underground utilities.

- How to notify the Ohio Rural Natural Gas Co-Op regarding a pipeline emergency or damage to a pipeline.
- How to recognize a pipeline ROW and signs associated with the ROW.
- Hazards associated with unintended pipeline releases.
- Who the Ohio Rural Natural Gas Co-Op is and who to contact for emergency or non-emergency information.

7. DELIVERY FREQUENCIES

The Ohio Rural Natural Gas Co-Op operates a pipeline distribution system. The table below summarizes the minimum baseline delivery frequency for each audience. Information regarding message types is located in DELIVERY METHODS section of this plan.

Audience	Baseline Frequency
Affected Public	Biennial
Emergency Officials	Annually
Public Officials	Every 3 Years
Excavators and Contractors	Annually
One Call Centers	As Required

8. DELIVERY METHODS AND MEDIA

The Ohio Rural Natural Gas Co-Op uses various methods and tools to effectively communicate with stakeholder audiences. The Ohio Rural Natural Gas Co-Op recognizes that not all methods are effective in all situations. The Ohio Rural Natural Gas Co-Op has considered various delivery methods and media discussed in RP-1162. The following table outlines the BASELINE MESSAGE TYPE and possible DELIVERY METHODS of each message for the each stakeholder audience:

The Ohio Rural Natural Gas Co-Op will utilize alternate methods as outlined in Supplemental Programs section if the Baseline Message and targeted Delivery method are not effective.

Stakeholder Audience	Message Type	Delivery Frequency	Delivery Method(s)/Media
Residents located along distribution system and LDC Customers	**Baseline:** • Pipeline purpose and reliability • Awareness of hazards and prevention measures undertaken • Damage prevention awareness (including existence and purpose) • Leak recognition and response • How to get additional information	**Baseline Frequency:** • Non-Customers: Annual • Customers: twice annual **Supplemental Frequency**: Additional Frequency and supplemental efforts as determined by specifics of the pipelines segment or environment.	**Baseline Activity (Residents):** • Public service announcements, OR • Paid Advertising, OR • Bill Stuffers (for combination electric & gas companies) **Baseline Activity: (LDC Customers)** • Bill Stuffers **Supplemental Activity:** • Targeted distribution of print materials • Newspaper and magazines • Community events or • Community neighborhood newsletters **Supplemental Activity: (LDC Customers)** • Targeted distribution of print materials

Emergency Officials

Emergency Officials	**Baseline:** • Pipeline purpose and reliability • Awareness of hazards and prevention measures undertaken • Emergency preparedness communications • How to get additional information	**Baseline Frequency:** Annual	• Print materials, OR • Group Meetings
		Supplemental Frequency: Additional Frequency and supplemental efforts as determined by specifics of the pipelines segment or environment.	• Telephone calls • Personal contact • Videos and CD's • Group Meetings

Public Officials

Public Officials	**Baseline:** • Pipeline purpose and reliability • Awareness of hazards and prevention measures undertaken • Emergency preparedness communications • How to get additional information	**Baseline Frequency:** 3 years	• Targeted distribution of print materials
		Supplemental Frequency: Additional Frequency and supplemental efforts as determined by specifics of the pipelines segment or environment.	• Telephone calls • Personal contact • Group Meetings

Stakeholder Audience	Message Type	Delivery Frequency	Delivery Method(s)/Media
Excavators			
Excavators / Contractors	**Baseline:** • Pipeline purpose and reliability • Awareness of hazards and prevention measures undertaken • Leak recognition and response • How to get additional information	**Baseline Frequency:** Annual	• Targeted distribution of print materials • One-Call center outreach OR • Group meetings
		Supplemental Frequency: Additional Frequency and supplemental efforts as determined by specifics of the pipelines segment or environment.	• Personal contact • Videos and CDs • Open houses
One-Call Centers	**Baseline:** • Pipeline location or service territory information • Other requirements of the applicable One-Call Center	**Baseline Frequency:** Requirements of the applicable One-Call Center	• Membership in One-Call • Requirements of the One-Call Center • Maps (as required)
	Supplemental: • One-Call System Performance • Accurate line location information • One-Call system improvements	**Supplemental Frequency:** As changes in pipeline routes or contact information occur or as required by state.	• Targeted distribution of print materials • Personal contact • Telephone calls • Maps (as required)

8.1. Process for Management of Input/Feedback/Comments Received

The Ohio Rural Natural Gas Co-Op program effectiveness will consist of the following methods or combinations of methods:

The Program Administrator may utilize any of the following data sources

- A third party review of the program to collect, summarize, and report findings to The Ohio Rural Natural Gas Co-Op

- Review comments from Public Official and Emergency Responder who attend meetings or participate in drills.

The Program Administrator, after review of information, may incorporate the pertinent information received into The Ohio Rural Natural Gas Co-Op Public Awareness program on an annual basis.

9. SUPPLEMENTAL PROGRAMS

Supplemental Programs are implemented when the baseline programs have not been sufficient enough to express the public awareness information intended or the communications were deemed ineffective. Several factors are considered when initiating Supplemental Programs:

- The Ohio Rural Natural Gas Co-Op Public Awareness Committee will review the effectiveness of the Baseline Program. Should the review determine an ineffective Baseline Program, then Supplemental Programs should be used to improve the effectiveness.

- Inappropriate behavior by stakeholder audiences may drive the need to initiate Supplemental Programs beyond the baseline message. One of the primary purposes of public awareness is to change public behavior around pipelines.

- The presence of High Consequence Areas where public concentration is significant should prompt the operating asset to consider public awareness activity above the baseline level described in the Baseline Program. It is possible to consider an increase in the frequency of baseline communication as a supplemental communication practice, if it is warranted.

- Another consideration for enhanced program elements should be given where incidents of third party damage, high profile emergency, or areas of known public concern exist.

Supplemental activities may be added should information be provided regarding certain Relevant Factors along the route of the pipeline system. These certain Relevant Factors include:

- Population Density
- Land Development activity
- Land Farming activity
- Third-Party damage incidents
- Environmental considerations
- Pipeline history in an area
- Specific local situations
- Regulatory Requirements
- Results from previous Public Awareness Program evaluations
- Other relevant needs

If supplemental activities are accepted into the program, documentation as to when, what, and where supplemental program enhancements are used must be in the Log of Changes (Appendix A).

- The PAC will evaluate the pipelines in a Public Awareness Evaluation Area based on the factors listed above.
- The PAC shall conduct a review taking these factors into consideration annually. Additional reviews may be conducted if the PAC determines that an areas evaluation factors have changed significantly.
- The evaluation will determine if enhancements are needed for the public awareness program and/or materials, messages or frequency of distribution. If enhancement is necessary, the PAC will consider the three factors in §9.1 and an implementation plan will be developed.
- The Administrator shall be responsible for maintaining the documentation of the PAC's review and implementing improvements.

9.1. ***Supplemental Communication Methods-*** Three categories of supplemental enhancements for the Ohio Rural Natural Gas Co-Op are as follow:

9.1.1. ***Increased Frequency (Shorter Interval)*** – Increased frequency refers to providing communications to an audience on a more frequent basis than what the baseline frequency requirements of the program require. The time interval will be determined by the Public Awareness Committee.

9.1.2. ***Enhanced Message Content and Message Type*** – This method refers to providing additional or supplemental communications beyond those required in the Program's baseline requirements. It also refers to different or additional delivery methods to reach the specific audience.

9.1.3. ***Coverage Area*** – This method refers to broadening the audience coverage area beyond those required for baseline communications

- For each of the three supplemental enhancement methods, the Public Awareness administrator will make a determination as to which audience(s) the enhancements shall be directed.
- The Ohio Rural Natural Gas Co-Op supplemental enhancements by category are listed below and the Public Awareness administrator shall choose which enhancement(s) to apply for the area requiring supplemental enhancements.

10. PROGRAM IMPLEMENTATION AND PROGRESS

The Ohio Rural Natural Gas Co-Op program implementation includes funding of the program, employee participation, use of external resources, documentation, and program activities that involve the public, local public officials, emergency officials and excavators. It will also be important to measure implementation progress by collecting feedback from internal and external sources and update the program and activities as necessary. The Public Awareness Committee (PAC) shall implement and track the progress periodically during the calendar year. At a minimum, one PAC meeting will be held each calendar year, with additional meetings or telephonic conferences held as needed. Minutes with reference to The Program's status and ongoing implementation shall be used for tracking the progress.

10.1. Program Funding

Annual operating budgets cover the expenses associated with the Ohio Rural Natural Gas Co-Op required Public Awareness activities, training and materials.

10.2. Employee Participation

Field personnel are the primary liaison between The Ohio Rural Natural Gas Co-Op and the Public regarding pipeline activities. Field personnel will be required to participate in the public awareness program by involvement in various message delivery methods to communicate pipeline safety. It will be Operations responsibility to ensure employee understanding of program requirements, provide training, and develop an internal auditing process to measure effectiveness.

10.3. External Resources

The Program Administrator will utilize external resources and/or consultants for implementation of the Ohio Rural Natural Gas Co-Op program as needed. This may include, but not be limited to; mailings, printings, surveys, and audits.

10.4. Program Documentation

The Ohio Rural Natural Gas Co-Op will retain records the minimum five years required. A copy of this document is located at the Ohio Rural Natural Gas Co-Op in Mentor, Ohio.

10.5. Program Activities

Program activities that will support the implementation and continued management of the Ohio Rural Natural Gas Co-Op Public Awareness program include:

- Printed Materials – ROW Mailing, Limited Response Cards
- Liaison Programs – Public Awareness Associations, Companies Public Awareness Liaison
- Field Exercises- Tabletop drills and emergency scenarios.
- Face to Face personal contact – Local official meetings

Process for management of input/feedback/comments received

The Ohio Rural Natural Gas Co-Op program effectiveness will consist of the following methods or combinations of methods:

The Program Administrator may utilize any of the following data sources

- A third party review of the program to collect, summarize, and report findings to The Ohio Rural Natural Gas Co-Op