

METROPOLITAN UTILITIES DISTRICT	O & M Procedure	No:	E.225.3
	Welding Procedure – Gas Metal Arc Welding (GMAW)	Page:	1 of 6
Prepared by: Rich Baird	Test Nos. WPQ-5, WPQ-6, WPQ-7, WPQ-9, B 8429 A & WPQ-21	Supersedes:	8-1-06
Approved by: James Bartels		Effective:	9-4-25
The latest revisions can be found at the end of this document			

A. General

The welding shall be done by the semi-automatic CO₂ gas metal arc process for welding of butt-welded joints and fillet welded joints on steel pipe, valves, flanges and fittings.

**** B. Pipe Metals**

The pipe material shall conform to one of the following specifications: ASTM Specification A-53 or API Specification 5L Grade "A", Grade "B", or Grade X-42.

**** C. Diameter and Wall Thickness**

This procedure shall apply to pipe in the following groups:

Group I Under 2-3/8" outside diameter with wall thickness less than 0.188"

Group II 2-3/8" to 12-3/4" outside diameter with wall thickness less than 0.188"

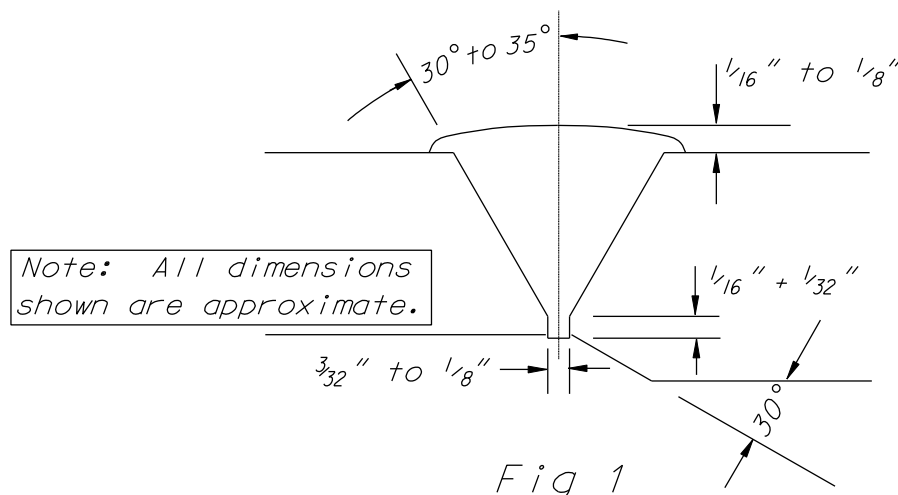
Group III 2-3/8" to 12-3/4" outside diameter with wall thickness 0.188" through 0.75"

Group IV Over 12-3/4" outside diameter with wall thickness 0.188" through 0.75"

**** D. Joint Design**

1. Butt Welds

The welding ends shall be beveled to an angle of approximately 30° to 35° with a root face of 1/16" + 1/32". The bevel shall form a "V" groove with an included angle of approximately 60° to 70°. The root opening shall be 3/32" to 1/8". Field bevels shall be made by machining or by gas cutting and grinding. Preparation of ends having unequal wall thickness shall comply with Fig 1.

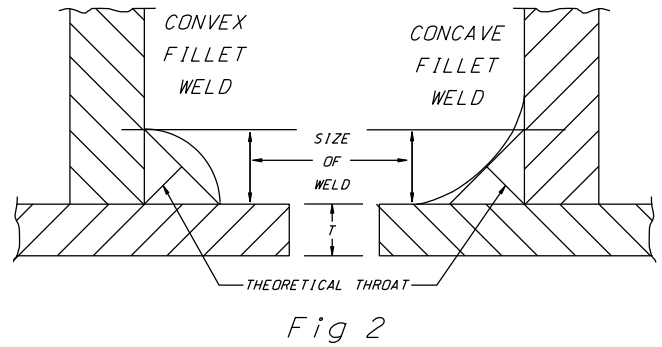


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2. Fillet Joints

Fillet welds may be concave to slightly convex. The size of a fillet weld is defined as the length of the shorter of the two perpendicular sides of the largest inscribed right triangle. See Fig 2.

The size of the fillet weld shall be not less than the thickness of the smaller nominal wall thickness (T) of the two pieces being joined.



** E. Filler Metal

The filler metal shall be Air Reduction Company Airco Type A608, National Standard 102 or equal.

The chemical composition of the filler metal shall be within the following limits:

Carbon (C)	0.10 - 0.15%
Manganese (Mn)	1.75 - 2.10%
Silicone (Si)	0.50 - 0.80%
Phosphorus (P)	0.025% Maximum
Sulphur (S)	0.025% Maximum
Nickel (Ni)	0.15% Maximum
Molybdenum (Mo)	0.40 - 0.60%

The mechanical properties of the filler metal shall be as follows:

Tensile strength	Minimum 85,000 psi
Yield strength	Minimum 65,000 psi
Elongation in 2"	Approximately 25%
Charpy V-notch impact	- minimum 20 ft-lbs @ 0°F
	- minimum 12 ft-lbs @ -40°F

** F. Wall Thickness and Number of Passes

The final covering bead of butt-welded joints shall completely fill the remaining groove with a slightly convex section rising 1/16" to 1/8" above the surface of the adjacent base metal. The final configuration of a fillet welded joint shall be concave to slightly convex as shown in Fig 2. Each bead shall be completed before the succeeding bead is deposited. When more than one pass is required to complete the weld, the deposited filler metal shall be maintained at a uniform level along the circumference of the joint. Two beads shall not be started at the same location.

** Essential Variable

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Note: Wall thickness is an “essential variable” – not the number of passes.

<u>Pipe Wall Thickness</u>	<u>Wire Size</u>	<u>Minimum Number of Passes</u>
.125" through .150"	.035"	One Pass
.151" through .250"	.035"	Two Passes
.251" through .312"	.035"	Three Passes
Greater than .312"	.035"	As required to produce a weld complying with API 1104* with individual pass thickness limited to 1/8" or less

* The edition of API 1104 referenced by Minimum Federal Safety Standards, 49 CFR, § [192.7](#)

**** G. Electrical Characteristic**

The welding current shall be direct current with reverse polarity (pipe negative and electrode positive), provided by a constant potential (voltage) power supply and accessory wire feed mechanism. Approximate welding current ranges are:

Wire Dia.	Volts	Amps	Shielding	Mode
.035"	18 min. 23 max.	80 min. 190 max.	CO ₂ "	Short Circuit "

The welding current and manner of depositing weld metal shall be such that the layers will show practically no undercut on the side walls of the joined parts, no overlap, no excessive spatter, evenly spaced ripple, adequate penetration and undercutting at the edges not to exceed 1/32" in depth or 12-1/2% of the pipe wall thickness whichever is smaller. There shall not be more than 2" of undercutting in any continuous 12" length of weld.

**** H. Position**

The welding shall be done with the axis of the pipe deviating not more than 30° from the horizontal position. The pipe shall remain in this fixed position until the weld is complete. Vertical welding is permissible but shall be kept to a minimum.

**** I. Direction of Welding**

Welding shall proceed downward from top center or any point on the side of the pipe to bottom center. The root bead shall start in the center of the tack weld located at the top center of the pipe and proceed downward and end, if possible, on a tack weld.

**** Essential Variable**

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J. Number of Welders

A minimum of two qualified welders working in opposite quadrants of the pipe, shall be required on 16" and larger pipe sizes.

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K. Time Lapse

There shall be minimum delay between completion and cleaning of the root bead and the start of welding on the second or "hot pass". Ordinarily a delay, while no welding is in progress, sufficient to allow welders and equipment to move along the pipeline, will not be objectionable between the second and third pass and between each successive pass. All welds shall be completed the same day they are started.

L. Lineup Clamp

An external line-up clamp shall be used on all butt joints. Before the clamp is loosened or removed, the joint shall be securely tack welded. The minimum number of tack welds shall be as follows:

Nominal Pipe Size	Minimum No. of Tack Welds
4" and smaller	2
6", 8" & 12"	4
16" and larger	6

Tack welds shall be not less than 1" in length, measured along the circumference of the pipe. The tack weld shall be "feathered" by grinding both ends to a long taper.

Internal line-up clamps may be used. The alignment of the abutting pipe ends shall be such as to minimize the offset between pipe surfaces. For pipe of the same nominal wall thickness, the offset shall not exceed 1/16". Any greater offset caused by dimensional variations shall be equally distributed around the circumference of the pipe. Hammering of pipe to obtain proper line-up should be held to a minimum.

M. Cleaning

All rust, dirt, and foreign matter shall be removed from the bevel surface or fillet joint welding surfaces before welding is started. Black "Glass" or residue shall be removed from the bead surface before the next bead is applied. Power tools may be used. The finished weld shall be cleaned.

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N. Preheat, Peening, Stress Relief

Preheat, peening, or stress relief shall not be required when the ambient temperature exceeds 40°F. At temperatures below 40°F, the joint shall be preheated to a temperature of 250°F before welding commences.

** Essential Variable

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**** O. Speed of Travel**

Speed of travel shall be 5” to 7” per minute.

**** P. Shielding Gas**

Welding grade carbon dioxide (CO₂) shall be used in conjunction with the process. The carbon dioxide shall have a dew point of 40° below 0° Fahrenheit or lower.

Depending on surrounding conditions, the flow rate for this gas shall range from 20 cubic feet/hour to 85 cubic feet/hour.

Q. Inspection and Repair of Defective Welds

Each new weld on distribution piping must be visually inspected by the welder prior to beginning the next weld. Defective welds must be repaired or removed from the pipeline. Injurious defects shall be removed by chipping, grinding or oxygen gouging to clean, sound metal. All slag and scale shall be removed by wire brushing. Before repair welds are started, the area of the weld shall be preheated. Repaired areas shall be carefully inspected and no further repairs shall be allowed in repaired areas. The following limits shall be used in determining the acceptability of welds.

1. Inadequate Penetration and Incomplete Fusion

Inadequate penetration is defined as the incomplete filling of the bottom of the weld groove with weld metal. Incomplete fusion is the lack of bond between beads or between the weld metal and the base metal. Any individual defect due to inadequate penetration or incomplete fusion shall not exceed 1” in length. The total length of such defects in any 12” length of weld shall not exceed one inch. Individual defects shall be separated by at least 6” of sound weld metal.

2. Burn-through Areas

A burn-through area is that portion in the root bead where excessive penetration has caused the weld puddle to be blown into the pipe. Any unrepaired burn-through shall not exceed 1/4” or the thickness of the pipe wall, whichever is smaller. The sum of the maximum dimensions of separate unrepaired burn-through in any continuous 12” length of weld on pipe 2-3/8" OD or larger, shall not exceed 1/2”. On pipe less than 2-3/8" OD, no more than one unrepaired burn-through is acceptable.

3. Gas Pockets

Gas pockets are voids occurring in the weld metal and are usually spherically shaped. The maximum dimension of any individual gas pocket shall not exceed 1/16”.

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4. Undercutting

Undercutting is the burning away of the side walls of the welding groove at the edge of a layer of weld metal, or the reduction in the thickness of the pipe wall adjacent to the weld where it is fused to the surface of the pipe.

Undercutting adjacent to the cover bead on the outside of the pipe shall not exceed 1/32" in depth or 12-1/2% of the pipe wall thickness whichever is smaller. There shall not be more than 2" of undercutting in any continuous 12" length of weld.

5. Cracks

Welds containing cracks, regardless of size or location, shall be considered defective and must be repaired or replaced. Minor cracks in the surface and filler beads may be repaired, but any crack which penetrates the root bead or the second bead shall be cut from the line and replaced. Minor crack are defined as cracks visible in the surface bead and not more than 8% of the weld length.

6. Combination of Defects

Any combination of defects having a total length of more than 2" in 12" of weld length is unacceptable. Any combination of defects which totals more than 10% of the weld length of a joint shall cause the weld to be rejected.

R. Equipment

Welding equipment shall be of a size and type suitable for the work and shall be maintained in such condition as to insure acceptable welds, continuity of operation and safety of personnel.

S. Welding During Inclement Weather

Welding shall not be done when the quality of the completed weld is likely to be impaired by the prevailing weather conditions including, but not limited to air-borne moisture, blowing sand or dirt, or high wind. Wind shields may be used when practical.

T. Arc Burns

All arc burns or strikes outside of the welded area shall be repaired by grinding the arc burn down to sound metal not deeper than 30% of the wall thickness.

Revision

The latest revision is detailed on the following page(s).

Pages affected: #3

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Prepared by: Bill TravnicekRich Baird		Effective: 8-1-06
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Yield strength - Minimum 65,000 psi
Elongation in 2" - Approximately 25%
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- minimum 12 ft-lbs @ -40°F

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