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|---------------------------------------------------|------------------------------------------------------------------|------------------------------------|
| <b>METROPOLITAN<br/>UTILITIES DISTRICT</b>        | <b>O &amp; M Procedure</b>                                       | No: <b>E.225.2</b>                 |
|                                                   | <b>Welding Procedure – Shielded Metal Arc<br/>Welding (SMAW)</b> | Page: 1 of 7                       |
|                                                   | Prepared by: Bill Travnicek                                      | <a href="#">Supersedes:</a> 8-1-06 |
|                                                   | Approved: Ron Reisner                                            | Effective: 11-30-09                |
| Test Nos. WPQ-03, WPQ-04, WPQ-08, WPQ-10, & B8429 |                                                                  |                                    |

## A. General

The welding shall be done by the manual shielded 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

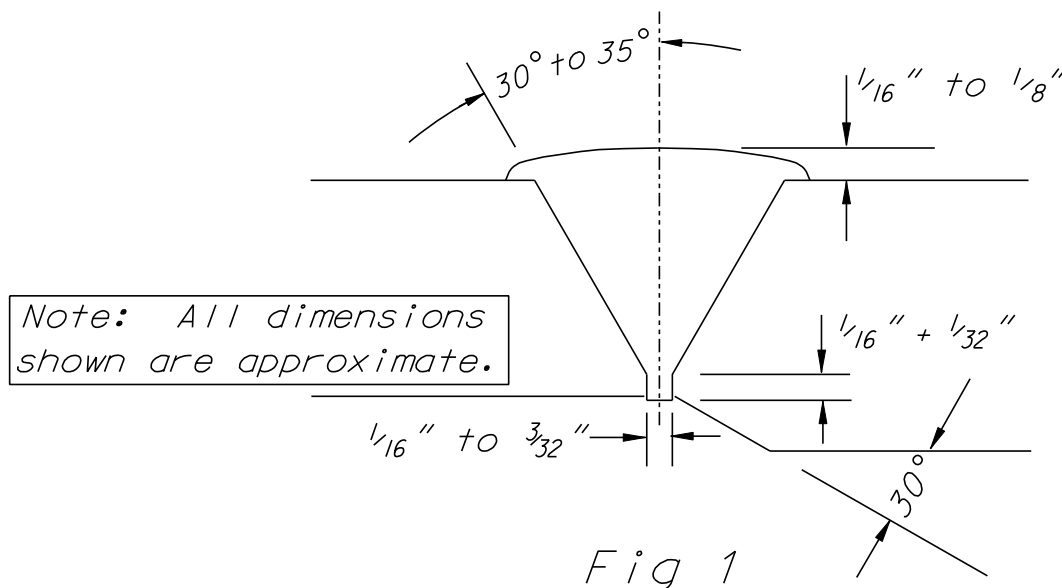
These procedures apply to pipe in the following groups:

Group 1 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"



\*\* Essential Variable

|                                                   |                                                                  |                                    |
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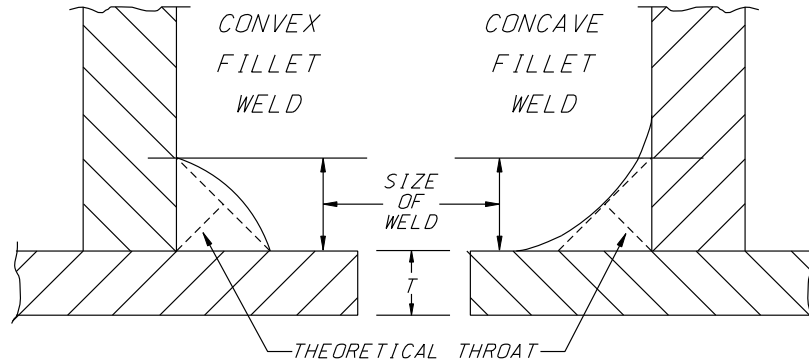
**\*\* D. Joint Design**

**1. Butt Welds**

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

**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 Figure 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.



*Fig 2*

**\*\* E. Filler Metal and Number of Beads**

All completed welds shall consist of a minimum of three beads. Each bead shall be completed before the succeeding bead is deposited. Two beads shall not be started at the same location.

The final covering bead of a butt welded joint shall completely fill the remaining groove with a slightly convex section rising 1/16 to 1/8 inch 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 Figure 2.

**\*\* Essential Variable**

|                                            |                                                                  |                                                   |                                    |
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| Pipe Wall<br>Thickness | Bead<br>Type | Electrodes (AWS No.) |                 | Size           | No. of<br>Beads |
|------------------------|--------------|----------------------|-----------------|----------------|-----------------|
|                        |              | Butt-weld            | Fillet Weld     |                |                 |
| .133-.188              | Root         | E-6010 or 7010       | E-6010 & E-7018 | 3/32"          | 3               |
|                        | Filler       | E-6010 or 7010       | E-6010 & E-7018 | 3/32" or 1/8"  |                 |
|                        | Cover        | E-6010 or 7010       | E-6010 & E-7018 | 1/8"           |                 |
| .189-.250              | Root         | E-6010 or 7010       | E-6010 & E-7018 | 1/8"           | 3               |
|                        | Filler       | E-6010 or 7010       | E-6010 & E-7018 | 1/8" or 5/32"  |                 |
|                        | Cover        | E-6010 or 7010       | E-6010 & E-7018 | 5/32" or 3/16" |                 |
| .251-.375              | Root         | E-6010 or 7010       | E-6010 & E-7018 | 1/8" or 5/32"  | 3 or 4          |
|                        | Filler       | E-6010 or 7010       | E-6010 & E-7018 | 5/32" or 3/16" |                 |
|                        | Cover        | E-6010 or 7010       | E-6010 & E-7018 | 3/16"          |                 |
| .376-.500              | Root         | E-6010 or 7010       | E-6010 & E-7018 | 1/8" or 5/32"  | 4 or 5          |
|                        | Filler       | E-6010 or 7010       | E-6010 & E-7018 | 5/32" or 3/16" |                 |
|                        | Cover        | E-6010 or 7010       | E-6010 & E-7018 | 3/16"          |                 |

**Note:** E-6010 or E-7010 electrodes shall be used for butt-welds. Also E-6010, E-7010, or E-7018 electrodes shall be used on fillet welds when welding fittings such as stoppers, no-blos, weld-o-lets, branch pipes, branch saddles, etc. Low hydrogen E-7018 electrodes shall be used on fillet welds when welding harness ears and strap restraints.

#### F. Storage of Electrodes

Electrodes shall be stored in unopened containers whenever possible to prevent moisture loss or moisture absorption and in such a manner as to avoid damage to the coating. Electrodes in opened containers shall be protected from excessive moisture changes. Electrodes which show signs of deterioration or damage shall not be used.

#### G. Electrical Characteristic

The welding current shall be direct current with reverse polarity (pipe negative and electrode positive). The voltage and amperage for each size electrode shall be as follows:

| <u>Electrode Size</u> | <u>Amperes</u> | <u>Minimum voltage</u> |
|-----------------------|----------------|------------------------|
| 3/32"                 | 60-100         | 21                     |
| 1/8"                  | 75-130         | 21                     |
| 5/32"                 | 90-180         | 21                     |
| 3/16"                 | 140-225        | 21                     |

\* Revised Text

\*\* Essential Variable

|                                            |                                                                  |                                    |
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| Approved: Ron Reisner                      |                                                                  |                                    |

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 shall not exceed 1/32 inch in depth or 12½ percent of the pipe wall thickness whichever is smaller. There shall not be more than 2 inches 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.

**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.

**\*\* K. Time Lapse**

There shall be a 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 pipe line, 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. Welding of the root bead shall be as fully completed as the members of the line-up clamp permit before the clamp is loosened or removed. 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 is not to exceed 1/16 inch. 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.

**\*\* Essential Variable**

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**M. Cleaning**

All rust , dirt, and foreign matter shall be removed from the bevel surface before welding is started. Tacks shall be feathered out before stringer bead is welded. Stringer bead shall be ground out to clean metal. Slag shall be removed from the bead surface before the next bead is applied. Power tools may be used. Holes must be cleaned with an ice pick or chisels. The finished weld must be cleaned and ground tack removed before wrapping.

**\*\* 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.

**\*\* O. Speed of Travel**

Speed of travel is to be 5 to 7 inches per minute.

**P. Inspection and Repair of Defective Welds**

Each 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 one inch in length. The total length of such defects in any 12 inch length of weld shall not exceed one inch. Individual defects shall be separated by at least 6 inches of sound weld metal.

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## 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 inch or the thickness of the pipewall, whichever is smaller. The sum of the maximum dimensions of separate unrepaired burn-through in any continuous 12 inch length of weld on pipe 2-3/8" O.D. or larger shall not exceed 1/2 inch. On pipe less than 2 3/8" O.D., no more than one unrepaired burn-through is acceptable.

## 3. Slag Inclusions

A slag inclusion is a nonmetallic solid entrapped in the weld metal or between the weld metal and the pipe metal.

Elongated slag inclusions (wagon tracks) shall not exceed 2 inches in length or 1/16 inch in width and in any 12 inch length of weld shall not exceed 2 inches.

Isolated slag inclusions shall not exceed 1/8 inch in width. The total length of isolated slag inclusions in any 12 inch length of weld shall not exceed 1/2 inch, nor shall there be more than 4 isolated slag inclusions in 12 inches of length. Adjacent isolated slag inclusions shall be separated by 2 inches of sound weld metal.

## 4. 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 inch.

## 5. 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.

## 6. 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 cracks are defined as cracks visible in the surface bead and not more than 8 percent of the weld length.

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## 7. **Combination of Defects**

Any combination of defects having a total length of more than 2 inches in 12 inches 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.

### Q. **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.

### R. **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.

### S. **Arc Burns**

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