

**ANSI/AWS B2.1-1-210-96**  
**An American National Standard**

**Standard  
Welding Procedure  
Specification (WPS) for**

**Gas Tungsten Arc Welding  
with Consumable Inserts of  
Carbon Steel (M-1/P-1/S-1, Group 1 or 2),  
1/8 through 1-1/2 inch Thick, INMs-1  
and ER70S-2, As-Welded  
or PWHT Condition,  
Primarily Pipe  
Applications**



**American Welding Society**

**Key Words** — Welding Procedure Specification,  
base metal, allowable joint designs,  
consumable insert, filler metal,  
carbon steel, manual welding,  
gas tungsten arc welding

**ANSI/AWS B2.1-1-210-96**  
**An American National Standard**

**Approved by**  
**American National Standards Institute**  
**June 7, 1996**

**Standard Welding Procedure  
Specification (WPS)  
Gas Tungsten Arc (Consumable Insert)  
Welding of Carbon Steel  
(M-1/P-1/S-1, Group 1 or 2)  
1/8 through 1-1/2 inch Thick,  
INMs-1 and ER70S-2  
As-Welded or PWHT Condition**

Prepared by  
AWS Committee on Welding Qualification

Under the Direction of the  
AWS Technical Activities Committee

Approved by  
AWS Board of Directors

**Abstract**

This standard contains the essential welding variables for carbon steel in the thickness range of 1/8 through 1-1/2 inch, using manual gas tungsten arc welding with consumable inserts. It cites the base metals and operating conditions necessary to make the weldment, the filler metal specifications, and the allowable joint designs for fillet and groove welds. This WPS was developed primarily for pipe applications.



**American Welding Society**

550 N.W. LeJeune Road, Miami, Florida 33126

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\*Advisor

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## Foreword

(This Foreword is not a part of the ANSI/AWS B2.1-1-210-96, *Standard Welding Procedure Specification (WPS)*, but is included for information purposes only.)

The American Welding Society and the Welding Research Council have joined in a cooperative effort to generate standard welding procedures for industry. The need for pretested welding procedures that are supported by adequate test data and that satisfy the technical requirements for the commonly used construction codes and specifications has been expressed by many individuals and organizations. The purpose of a welding procedure qualification is to provide test data for assessing the properties of a weld joint.

This Welding Procedure Specification is an outgrowth of the coordinated work of the Welding Procedures Committee of WRC and the Committee on Welding Qualification of the AWS. The summaries of Procedure Qualification Records are available from the Welding Research Council, Room 1301, 345 E. 47 St., New York, NY 10017.

The welding terms used in this specification shall be interpreted in accordance with the definitions given in the latest edition of ANSI/AWS A3.0, *Standard Welding Terms and Definitions*. Welding symbols shall be those shown in the latest edition of ANSI/AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*.

The AWS Committee on Welding Qualification was formed in 1979 to provide welding standards concerning the subject of qualification. The primary document developed by this committee is AWS B2.1, *Standard for Welding Procedure and Performance Qualification*. This document established the foundation and framework for Standard Welding Procedure Specifications.

Comments on this publication will be most welcome. They should be addressed to the Secretary, AWS Committee on Welding Qualification, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

# Standard Welding Procedure Specification (WPS)

## Gas Tungsten Arc Welding (Consumable Inserts) of Carbon Steel (M-1/P-1/S-1, Group 1 or 2), 1/8 through 1-1/2 inch Thick, INMs-1 and ER70S-2, As-Welded or PWHT Condition, Primarily Pipe Applications

**Welding Research Council<sup>1</sup>—Supporting PQR Numbers:**  
001002, 001007, 001013, 001014, 001015, 001017, 001024, 001038, 200270,  
200272, 200534, 200535, 200628, 200708, 200709, 200710, 200711, 200712,  
200713, 200834, 200835, 200850, 200851, 200852, 500108, 003B,  
004A, 029A, 030A, 107A, 108A, 109A, 113A, 114A, 115A

### Requirements for Application of Standard WPSs

**Scope.** The data to support this Standard Welding Procedure Specification (WPS) have been derived from the above listed Procedure Qualification Records (PQRs) which were reviewed and validated under the auspices of the Welding Research Council. This Standard WPS is not valid using conditions and variables outside the ranges listed. The American Welding Society considers that this Standard WPS presents information for producing an acceptable weld using the conditions and variables listed. The user needs a significant knowledge of welding and accepts full responsibility for the performance of the weld and for providing the engineering capability, qualified personnel, and proper equipment to implement this Standard WPS.

**Application.** This Standard WPS is to be used only as permitted by the applicable fabrication document(s) [such as code, specification, or contract document(s)]. The fabrication document(s) should specify the engineering requirements such as design, need for heat treatment, fabricating tolerances, quality control, and examination and tests applicable to the end product.

**User's Responsibility.** A Standard WPS does not replace or substitute for fabrication codes, specifica-

tions, contract requirements, or capability and judgment on the part of the user. A Standard WPS is to be used only as permitted by the applicable fabrication code, specification, or contract document.

The ability to produce production welds having properties suitable for the application depends upon supplementing the Standard WPS with appropriate performance qualification tests and sound engineering judgment. The user is responsible for the quality and performance of the final product in accordance with the provisions of the fabrication document(s).

**Supplementary Instructions.** To adapt this Standard WPS to a specific application, a user may issue supplementary instructions. Such instructions may consist of tighter fit-up tolerances, higher minimum preheat temperature or any other instructions necessary to produce a weldment that meets the requirements of the fabrication document(s). These instructions shall not be less restrictive than provided in the Standard WPS.

**Safety.** Safety precautions shall conform to the latest edition of ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, published by the American Welding Society.

This specification may involve hazardous materials, operations, and equipment. The specification does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to establish appropriate safety and health practices. The user should determine the applicability of any regulatory limitations prior to use.

1. Welding Research Council, 345 East 47th Street, New York, NY 10017.

## Standard Welding Procedure Specification (WPS)

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### LIMITATIONS

This procedure is not qualified for Notch Toughness applications. This WPS is not applicable for fillet welds.

### WELDING PROCESSES

**Welding Processes:** GTAW (Gas Tungsten Arc Welding) (Consumable Inserts)  
**Method of Application:** Manual

### BASE METALS

**Base Metal:**<sup>2</sup> Carbon Steel, M-1, P-1, or S-1, Group 1 or 2 to M-1, P-1, or S-1, Group 1 or 2  
**Thickness Range:** 1/8 in. through 1-1/2 in. for groove welds  
**Pipe Diameter:** All diameters

### FILLER METALS

**Filler Metal Specification:**<sup>2</sup> ANSI/AWS A5.30 or ASME SFA 5.30 for Consumable Inserts, ANSI/AWS A5.18 or ASME SFA 5.18 for Filler Rod  
 A Number 1, F Number 6  
**Classification:** INMs-1, Class 1 Insert through Class 5 Insert and ER70S-2  
**Deposit Thickness Range:** 1-1/2 in. maximum plus reinforcement  
**Consumable Inserts:** Required

### JOINT DESIGNS

**Joint Designs:** See Figure 1  
**Backing:** Consumable Insert only  
**Backing Material:**<sup>2</sup> Carbon Steel weld metal; nonmetallic or nonfusing metal retainers are not permitted

### POSITIONS

**Permitted Positions:** All  
**Vertical Progression:** Uphill

### PREHEAT AND INTERPASS TEMPERATURES

**Preheat Temperature:**<sup>3</sup> 50°F Minimum  
**Interpass Temperature:**<sup>3</sup> 50°F Minimum, 500°F Maximum  
**Preheat Maintenance:** Continuous or special heating is not required

### GAS

**Torch Shielding Gas:** Welding Grade Argon  
**Flow Rate:** 12 to 25 ft<sup>3</sup>/h  
**Root Shielding Gas:** Welding Grade Argon  
**Flow Rate:** A typical flow rate of 5 to 15 ft<sup>3</sup>/h may be varied depending on component configuration. When introducing root shielding gas to initiate the purge; it is necessary to have at least a 6 volume change of atmosphere within the purged zone prior to welding. Root shielding gas shall remain in place until the weld is completed or at least 3/16" weld metal has been deposited.

2. M, P, and S numbers for base metal and F and A numbers for filler metal and weld metal respectively, are as detailed in AWS B2.1 and ASME *Boiler and Pressure Vessel Code*, Section IX.

3. Preheat and interpass temperatures must be sufficient to prevent crack formation. Temperatures above the minimum shown may be required for highly restrained welds or by the fabrication document(s).

# Standard Welding Procedure Specification (WPS)

**Torch Gas Nozzle Size:** 1/4 to 3/4 in. inside diameter  
**Trailing Gas:** None

## TUNGSTEN ELECTRODES

**Type:** ANSI/AWS A5.12 or ASME SFA 5.12, EWTh-2, EWCe-2, or EWLa-1  
**Size:** 0.060 through 0.125 in. diameter sharpened to a blunt point

## ELECTRICAL CHARACTERISTICS

| GROOVE WELDS |                |                    |                      |                 |
|--------------|----------------|--------------------|----------------------|-----------------|
| Filler Metal |                |                    | Current              |                 |
| Layer        | Classification | Size (in.)         | Amperes <sup>1</sup> | Polarity        |
| Root         | INMs-1         | 1/16, 1/8, or 5/32 | 65-120               | DCEN (Straight) |
| Fill         | ER70S-2        | 1/16               | 60-100               | DCEN (Straight) |
| Fill         | ER70S-2        | 3/32               | 80-140               | DCEN (Straight) |
| Fill         | ER70S-2        | 1/8                | 100-160              | DCEN (Straight) |

1. Values not to exceed capacity of tungsten electrodes.

**Pulsing Current:** Not permitted

## POSTWELD HEAT TREATMENT (PWHT)

**Postweld Heat Treatment:** Welds may either be as-welded or postweld heat treated at 1100 to 1200°F or as required by the fabrication document(s). If heat treated, the heat treatment time shall be 1 hour per inch of thickness (15 minutes minimum) unless otherwise noted in the fabrication document(s).

## TECHNIQUE

**Weave or Stringer Bead:** Either  
**Peening:** Not permitted  
**Initial Cleaning:** Chemical or mechanical; joint shall be dry prior to welding  
**Interpass Cleaning:** Mechanical only  
**Backgouging:** Not applicable  
**Single or Multiple Passes:** Multiple  
**Maximum Bead Thickness:** 1/4 in.  
**Repair:** Defects in welds shall be removed by mechanical or thermal methods. The repair cavity may differ in contour and dimension from a normal joint preparation and may present different restraint conditions. Repair of base metal defects shall be in accordance with the requirements of the fabrication document(s)

COMPANY NAME \_\_\_\_\_

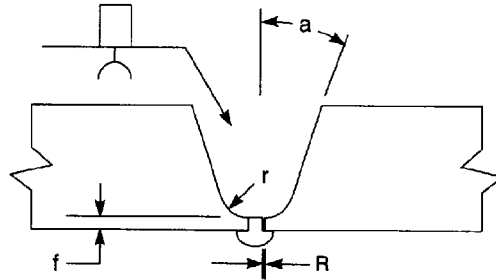
In the name of the Company stated above, I accept full responsibility for the application of this Standard WPS for use with:

\_\_\_\_\_  
 Fabrication Document(s): (such as Code, Specification, or Contract Document)

DATE \_\_\_\_\_ APPROVED BY \_\_\_\_\_ TITLED \_\_\_\_\_

## Standard Welding Procedure Specification (WPS)

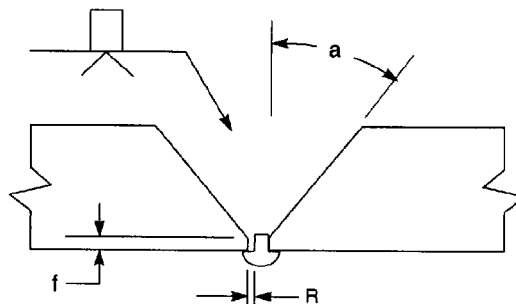
**GROOVE WELDS:** For pipe and tubular products, see Joints 1 through 13. In addition, joints having groove designs resulting from end preparations conforming with ASME/ANSI B16.25, *Buttwelding Ends*, are also allowable for application with this WPS.



CLASS 1 INSERT

$a = 22\text{-}1/2^\circ \pm 2\text{-}1/2^\circ$   
 $f = 1/16 \text{ in.} \pm 1/32 \text{ in.}$   
 $r = 1/8 \text{ in. TO } 3/16 \text{ in. RADIUS}$   
 $R = 1/32 \text{ in. MAX}$   
 I.D. MISMATCH =  $1/32 \text{ in. MAX.}$

JOINT 1



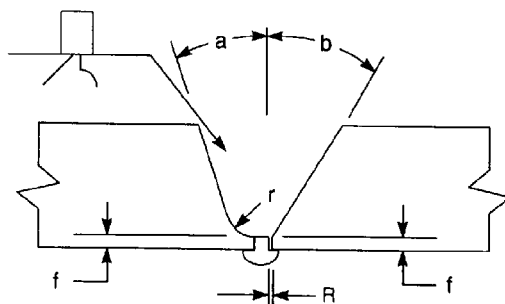
CLASS 1 INSERT

$a = 37\text{-}1/2^\circ \pm 2\text{-}1/2^\circ$   
 $f = 1/32 \text{ in.} \pm 1/32 \text{ in.}$   
 $R = 1/32 \text{ in. MAX.}$   
 I.D. MISMATCH =  $1/32 \text{ in. MAX.}$

JOINT 2

**Figure 1—Allowable Joint Designs**

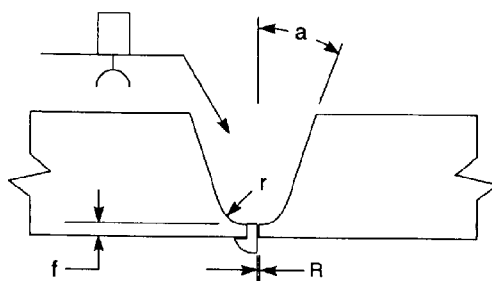
# Standard Welding Procedure Specification (WPS)



**CLASS 1 INSERT**

$a = 22-1/2^\circ \pm 2-1/2^\circ$   
 $b = 37-1/2^\circ \pm 2-1/2^\circ$   
 $f = 1/16 \text{ in.} \pm 1/32 \text{ in.}$   
 $r = 1/8 \text{ in. TO } 3/16 \text{ in. RADIUS}$   
 $R = 1/32 \text{ in. MAX.}$   
 I.D. MISMATCH =  $1/32 \text{ in. MAX.}$

**JOINT 3**



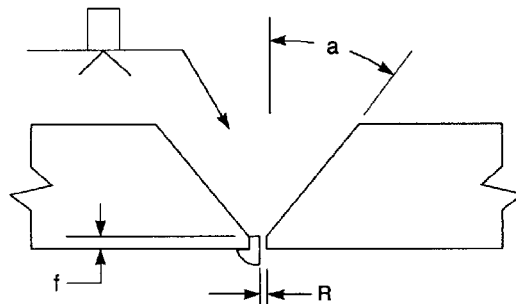
**CLASS 2 INSERT**

$a = 22-1/2^\circ \pm 2-1/2^\circ$   
 $f = 1/16 \text{ in.} \pm 1/32 \text{ in.}$   
 $r = 1/8 \text{ in. TO } 3/16 \text{ in. RADIUS}$   
 $R = 1/32 \text{ in. MAX}$   
 I.D. MISMATCH =  $1/16 \text{ in. MAX.}$

**JOINT 4**

**Figure 1 (continued) — Allowable Joint Designs**

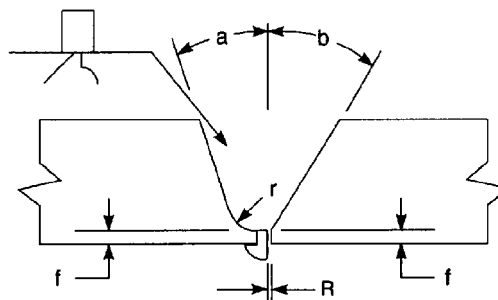
# Standard Welding Procedure Specification (WPS)



CLASS 2 INSERT

$a = 37-1/2^\circ, \pm 2-1/2^\circ$   
 $f = 1/32 \text{ in.} \pm 1/32 \text{ in.}$   
 $R = 1/32 \text{ in. MAX.}$   
 I.D. MISMATCH =  $1/16 \text{ in. MAX.}$

JOINT 5



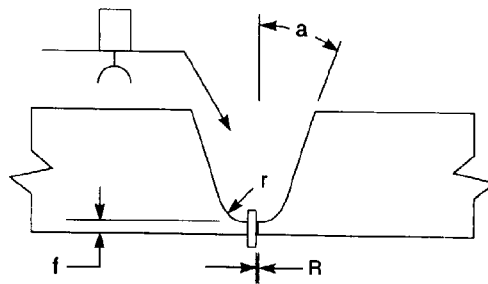
CLASS 2 INSERT

$a = 22-1/2^\circ \pm 2-1/2^\circ$   
 $b = 37-1/2^\circ \pm 2-1/2^\circ$   
 $f = 1/16 \text{ in.} \pm 1/32 \text{ in.}$   
 $r = 1/8 \text{ in. TO } 3/16 \text{ in. RADIUS}$   
 $R = 1/32 \text{ in. MAX.}$   
 I.D. MISMATCH =  $1/16 \text{ in. MAX.}$

JOINT 6

Figure 1 (continued) — Allowable Joint Designs

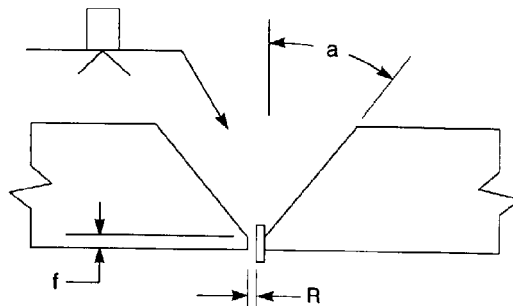
# Standard Welding Procedure Specification (WPS)



CLASS 3 INSERT

$a = 22-1/2^\circ \pm 2-1/2^\circ$   
 $f = 1/16 \text{ in.} \pm 1/32 \text{ in.}$   
 $r = 1/8 \text{ in. TO } 3/16 \text{ in. RADIUS}$   
 $R = 1/32 \text{ in. MAX}$   
 I.D. MISMATCH =  $1/16 \text{ in. MAX.}$

JOINT 7



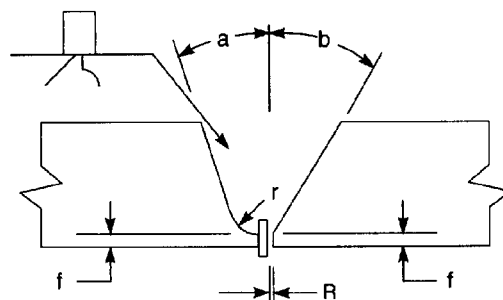
CLASS 3 INSERT

$a = 37-1/2^\circ, \pm 2-1/2^\circ$   
 $f = 1/32 \text{ in.} \pm 1/32 \text{ in.}$   
 $R = 1/32 \text{ in. MAX.}$   
 I.D. MISMATCH =  $1/16 \text{ in. MAX.}$

JOINT 8

**Figure 1 (continued) — Allowable Joint Designs**

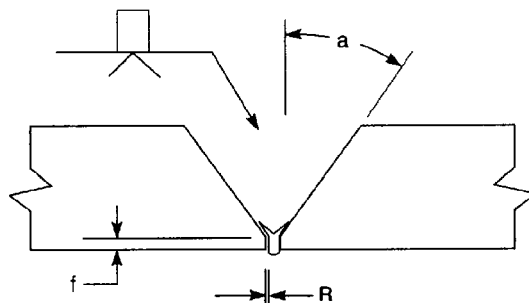
## Standard Welding Procedure Specification (WPS)



CLASS 3 INSERT

$a = 22\text{-}1/2^\circ \pm 2\text{-}1/2^\circ$   
 $b = 37\text{-}1/2^\circ \pm 2\text{-}1/2^\circ$   
 $f = 1/16 \text{ in. } \pm 1/32 \text{ in.}$   
 $r = 1/8 \text{ in. TO } 3/16 \text{ in. RADIUS}$   
 $R = 1/32 \text{ in. MAX.}$   
 I.D. MISMATCH = 1/16 in. MAX.

JOINT 9



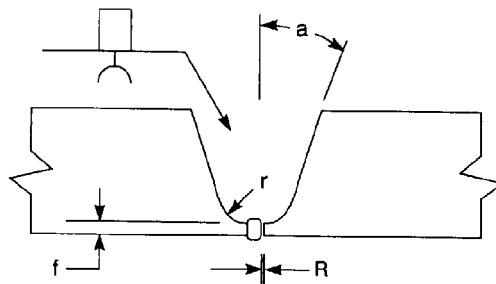
CLASS 4 INSERT

$a = 37\text{-}1/2^\circ, \pm 2\text{-}1/2^\circ$   
 $f = 1/16 \text{ in. } \pm 1/32 \text{ in.}$   
 $R = 1/32 \text{ in. MAX.}$   
 I.D. MISMATCH = 1/16 in. MAX.

JOINT 10

Figure 1 (continued) — Allowable Joint Designs

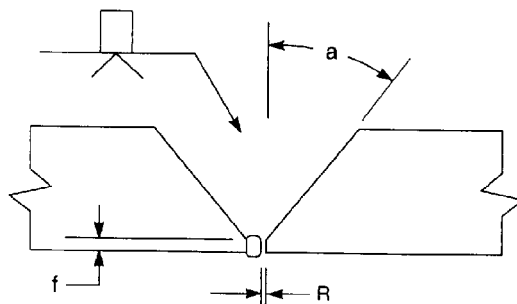
# Standard Welding Procedure Specification (WPS)



CLASS 5 INSERT

$a = 22-1/2^\circ \pm 2-1/2^\circ$   
 $f = 1/16 \text{ in.} \pm 1/32 \text{ in.}$   
 $r = 1/8 \text{ in. TO } 3/16 \text{ in. RADIUS}$   
 $R = 1/32 \text{ in. MAX}$   
 I.D. MISMATCH =  $1/32 \text{ in. MAX.}$

JOINT 11



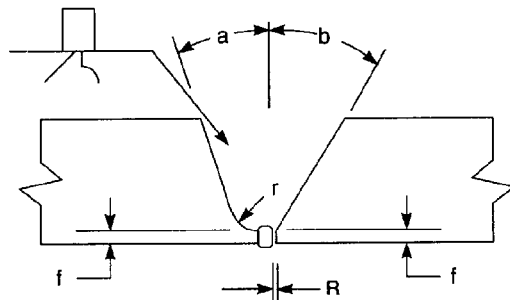
CLASS 5 INSERT

$a = 37-1/2^\circ \pm 2-1/2^\circ$   
 $f = 1/32 \text{ in.} \pm 1/32 \text{ in.}$   
 $R = 1/32 \text{ in. MAX.}$   
 I.D. MISMATCH =  $1/32 \text{ in. MAX.}$

JOINT 12

**Figure 1 (continued) — Allowable Joint Designs**

## Standard Welding Procedure Specification (WPS)



### CLASS 5 INSERT

$$a = 22\text{-}1/2^\circ \pm 2\text{-}1/2^\circ$$

$$b = 37\text{-}1/2^\circ \pm 2\text{-}1/2^\circ$$

$$f = 1/16 \text{ in. } \pm 1/32 \text{ in.}$$

$$r = 1/8 \text{ in. TO } 3/16 \text{ in. RADIUS}$$

$$R = 1/32 \text{ in. MAX.}$$

$$\text{I.D. MISMATCH} = 1/32 \text{ in. MAX.}$$

### JOINT 13

Figure 1 (continued) — Allowable Joint Designs

### Metric Conversions

| in.   | mm   | °F   | °C  | ft <sup>3</sup> /h | L/min |
|-------|------|------|-----|--------------------|-------|
| 1/32  | 0.8  | 50   | 10  | 5                  | 2.4   |
| 0.060 | 1.5  | 500  | 260 | 12                 | 5.7   |
| 1/16  | 1.6  | 1100 | 595 | 15                 | 7.1   |
| 3/32  | 2.4  | 1200 | 650 | 25                 | 11.8  |
| 0.125 | 3.2  |      |     |                    |       |
| 1/8   | 3.2  |      |     |                    |       |
| 3/16  | 4.8  |      |     |                    |       |
| 1/4   | 6.4  |      |     |                    |       |
| 3/4   | 19.0 |      |     |                    |       |
| 1     | 25.4 |      |     |                    |       |
| 1-1/2 | 38.0 |      |     |                    |       |