Field Welding Inspection Guide

Assistance in interpretation of any specification or questions concerning field welding issues can be obtained from the Office of Materials Management, Structural Welding and Metals Section.

Reference documents:

Construction and Material Specification (CMS)

AWS/AASHTO D1.5 Bridge Welding Code

ODOT Supplemental Specification 1011

- ODOT Revision to the AWS/AASHTO Bridge Welding Code

Construction Handbook of Procedures for Structures

- Section 800

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Welder Qualification

Welder qualifications are governed by the AWS/AASHTO D1.5 Bridge Welding Code and the Department's Supplemental Specification 1011. Part B of SS1011 explains the administrative procedures required to qualify as an approved welder for the Ohio Department of Transportation. It is the individual welders responsibility to make sure all required samples, test data, and employment records are on file with the Office of Materials Management.

Qualified welders are listed in the Department's Construction Management System. Each welder should be checked to make sure they are qualified to weld on ODOT projects.

To confirm a welder is qualified for ODOT projects enter the Construction Management System and use the Fastpath **WELD** or **LWELD** to check for the following information:

Test Date: A field welder qualification is in effect for a period of **5 years**. If the test date listed on the CMS screen exceeds the required 5 years the welder is no longer qualified and must retest.

Last Update: The welder's qualification is in effect for 5 years unless the welder is not engaged in a given process for a period exceeding **six months**. Employment records are the welder's responsibility to send to the Office of Materials Management. If the date listed on the CMS screen exceeds the **six month** period inform the welder they must update their work records. All welders are given a **six month** grace period if they have forgotten to send in their employment records. If the date listed on the CMS screen exceeds **1 year** (required six month update plus the six month grace period) then the welder is no longer qualified and must retest.

Process: Welder's must be qualified for the process for which they are welding in. Typical field welding processes are listed below:

SMAW (Shielded Metal Arc Welding) also known as stick welding

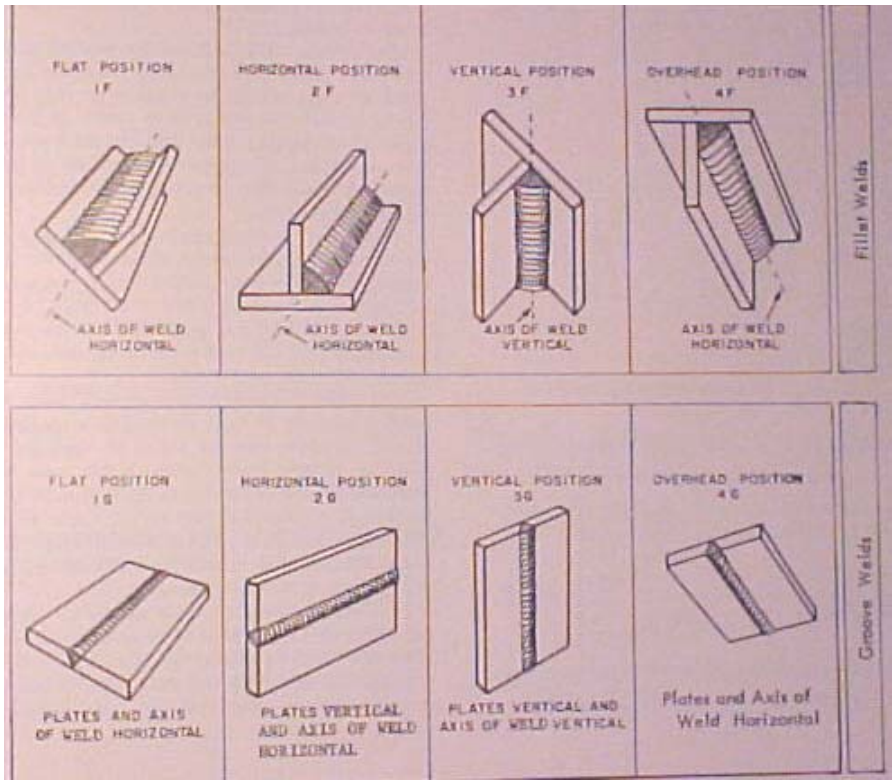
FCAW (Flux-cored arc welding) also know as wire welding

- Note: FCAW welding on main member structural steel requires Procedure Qualification testing by the Contractor per the AWS/AASHTO D1.5 Bridge Welding Code.

Weld Type: FI (Fillet welding) or GR (Groove welding)

Position: Welder's must be qualified for the position in which they are welding.

F - Flat position
H – Horizontal position
V – Vertical position
OH – Overhead position



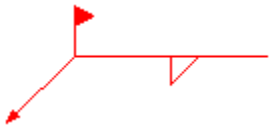
Any questions concerning welder qualifications can be directed to the Office of Materials Management, Structural Welding and Metals section.

Welding Symbols

BASIC WELD SYMBOLS

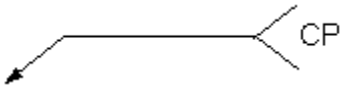
FIELD WELD SYMBOL

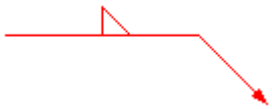
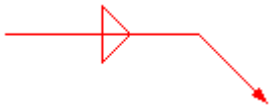
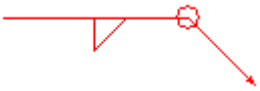
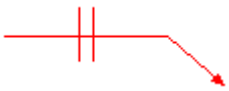
Field weld symbol indicates that weld is to be made at a place other than that of initial construction

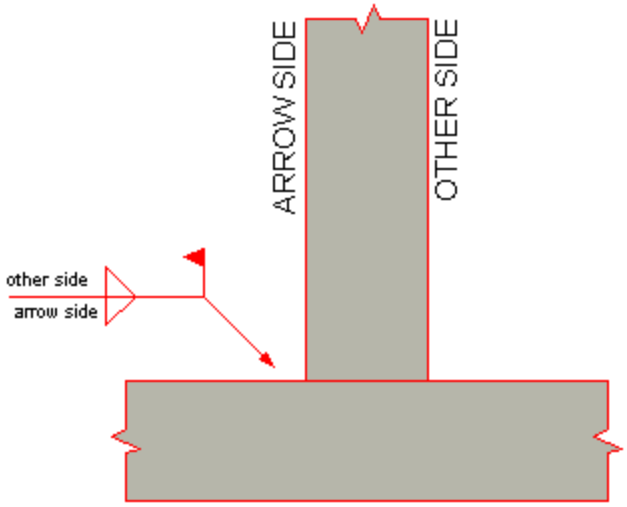


COMPLETE PENETRATION

Indicates complete joint preparation



LOCATION SIGNIFICANCE	FILLET
Arrow Side	
Other Side	
Both Sides	
Weld All Around	
	Groove & Butt Welds
Butt Weld	
Groove Weld Single V	



In the figure above a field welded fillet weld is required on both sides of the "T" joint. The welding symbol on the bottom of the reference line indicates a weld on the arrow side (the side of the joint that the arrow is pointing to). The welding symbol on the top of the reference line indicates a weld on the other side (the side of the joint opposite of where the arrow is pointing). The solid triangle (or flag) indicates the weld is to be made in the field.

These are a few of the basic weld symbols that you will encounter in the field. The AWS D1.5 Bridge Welding Code refers you to many more. Assistance in interpretation of any welding symbols may be obtained from the Office of Materials Management.

Electrodes

Only Ohio Department of Transportation approved electrodes may be used to join structural steel items. All electrodes must be of the low-hydrogen classification. Sources for information concerning electrodes may be found at the following:

- AWS/AASHTO D1.5 Bridge Welding Code
- Construction Handbook of Procedures for Structures
- Construction and Materials Specification (Section 711.08)
- ODOT Approved Electrode List
    - (www.dot.state.oh.us/testlab/applists/Approved.htm)

Shielded Metal Arc Welding (SMAW) is the only pre-approved process for welding on bridge members. All other welding processes and electrodes must have Procedure

Qualification testing performed by the Contractor. Contact the Office of Materials Management for further information.

The most common SMAW electrodes used are E7018 and E8018.

E7018 electrodes are used for bridge members that are coated (painted, galvanized, or metalized).

E8018 electrodes are used for bridge members that are un-coated.

E 70 1 8

The first two digits on a SMAW electrode stand for the minimum tensile strength of the welding electrode. The designation 70 correlates to the electrode having a tensile strength of 70 KSI.

The third digit on a SMAW electrode stands for the positions in which the electrode can be used.

- The number 1 means the electrode can be used in all positions
- The number 2 means the electrode can be used in the flat and horizontal position

The fourth digit on a SMAW electrode indicate the type of coating

- The numbers 6 or 8 classify the electrode as low-hydrogen

Hydrogen is one of the major causes for weld defects so care must be taken to ensure no moisture is picked up in the coating on the electrodes.

Electrodes shall be purchased in hermetically sealed containers or shall be dried for at least two hours between 450 and 500 degrees for E70XX electrodes or between 700 and 800 degrees for E80XX electrodes.

Immediately after opening of the hermetically sealed container electrodes not being used must be stored in a storage oven (also known as a hot box) and held at a temperature of at least 250 degrees.

One example of a storage oven (hot box)

After the electrodes have been removed from the hermetically sealed containers or from the storage oven the electrodes may be exposed to the atmosphere for a period not to exceed the following:

- E70XX 4 hours maximum
- E80XX 2 hours maximum

If the electrode has been exposed to the atmosphere for a period less than that shown above then the electrode may be placed back into the storage oven and dried for a period of no less than 4 hours.

In any case electrodes that have been wet shall not be used.

Weld Joint Preparation: Cleaning and Preheat

The first step in making a sound weld is to make sure the joint is correctly cleaned and then preheated prior to welding. Cleaning the joint can be accomplished by using a stiff wire brush.

All unpainted surfaces to be welded have to be free from all loose or thick scale, slag, rust, moisture, grease, or other foreign material by Code. Mill scale that can withstand a vigorous wire brushing, or anti-spatter compound may remain prior to welding.

The Construction and Material Specification (CMS) allows for inorganic zinc paint to remain in areas where cross-frames are welded in the field.

Preheat is an important step prior to welding. Preheating the joint helps remove any moisture from the joint and by heating the joint initially before welding commences will allow the joint to cool at a slower rate which will allow for more time for hydrogen to diffuse out of the molten weld metal.

Preheating is the required practice of providing localized heat to the weld zone. The preferred method of preheating is by the use of a manual torch.

Required preheat shall be applied for a distance of 3 inches in all directions from the weld joint.

Minimum Preheat required is found in Table 4.4 of the AWS/AASHTO D1.5 Bridge Welding Code and is listed below:

Minimum Preheat Temperature (degrees F)

Base Metal	Thickness of Thickest Part at Point of Welding			
	To ¾" Incl.	Over ¾" to 1-1/2"	Over 1-1/2" to 2-1/2"	Over 2-1/2" Incl.
A36, A572, A588 (A709-Grade 36, 50, 50W)	50	70	150	225

When the base metal temperature falls below 32 degrees F the base metal shall be heated to at least 70 degrees F.

No welding shall be done when the ambient temperature around the weld joint is below 0 degrees F.

Preheat can be checked by the use of a Tempstick.

If the weld joint has reached the required level of preheat the appropriate Tempstick will melt when rubbed across the base metal

Weld Inspection

The best set of tools a welding inspector will have is their eyes. In most cases, this is all the inspection that may be required. In a sense, everyone connected with the job, as well as yourself, participates in visual inspection (VT). Visual inspection is by far the most popular and the most widely used of the non-destructive inspection techniques.

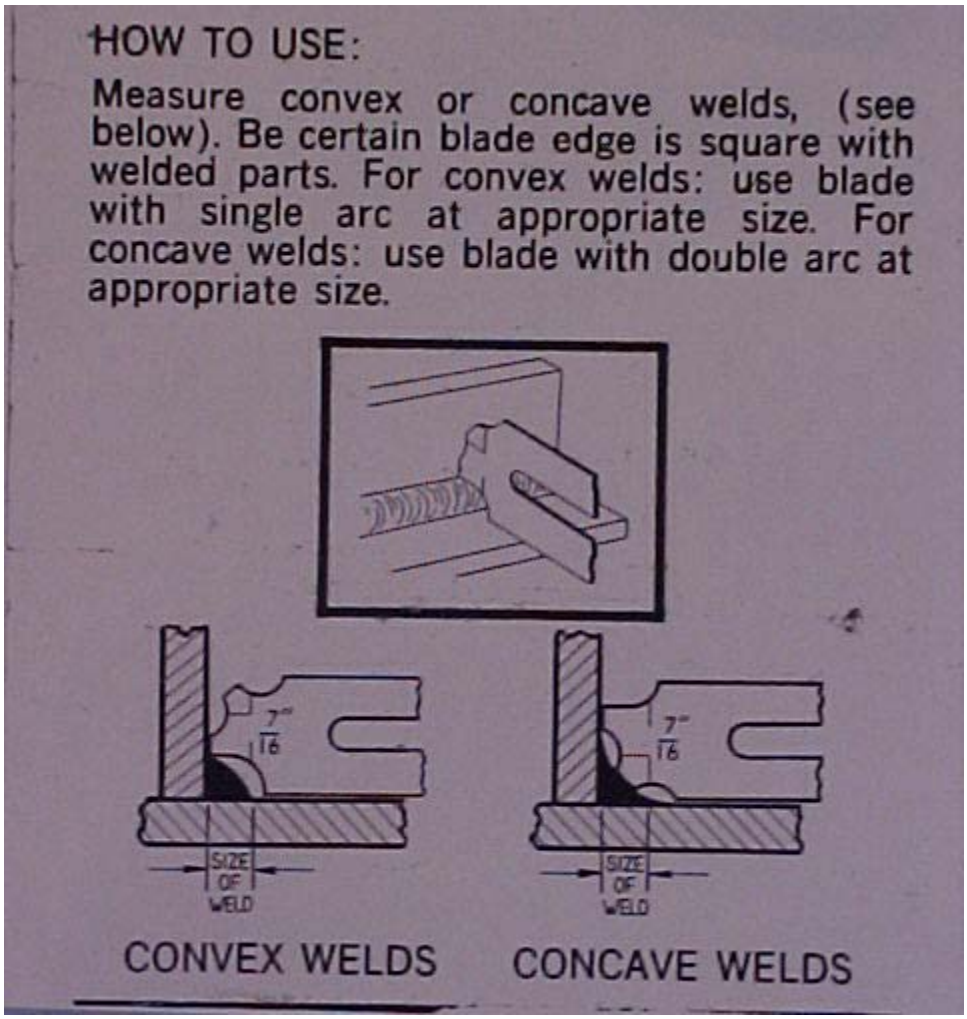
All completed welds should be checked for conformance to the plans and the specifications.

The most common welds that will need to be inspected in the field are fillet welds. Fillet welds are designed based on their leg sizes. If the plans show a fillet weld at 5/16 inches then each leg of the weld needs to measure to that dimension. If either leg is under the specified dimension then the strength required for that joint will be less than what the joint was designed for. The throat of the weld should be checked also.

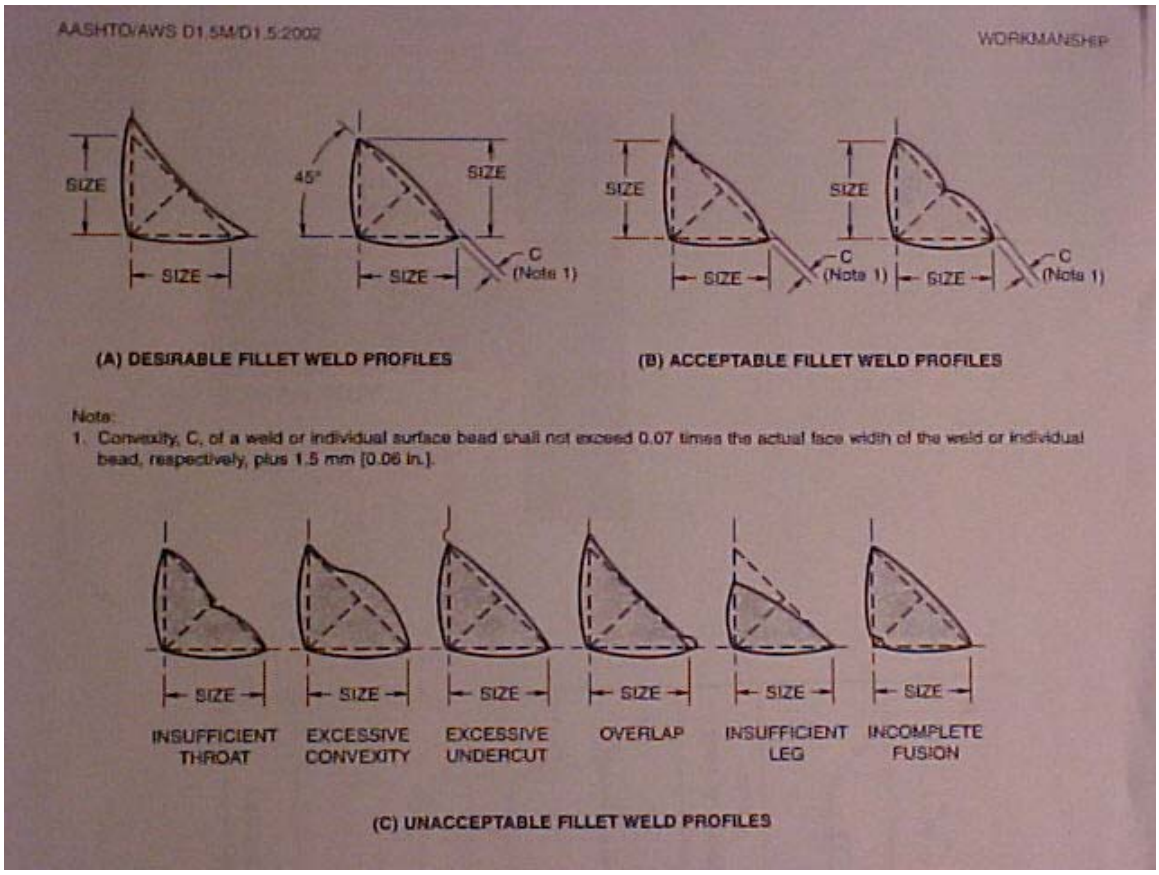
A fillet weld gauge is the standard tool to check weld sizes.

Standard fillet weld gauge

The fillet weld gauge has two corners for checking leg sizes and two corners for checking throats of the weld. An explanation of how to use the fillet weld gauge is shown below:



The profile of the welds should be checked. The AWS D1.5 Bridge Welding Code shows acceptable and unacceptable weld profiles. These are shown below:



Source: AWS D1.5-2002 Bridge Welding Code

All welds should be visually inspected for defects also. Defects to look for include the following:

Cracks: No cracks in the surface of the welds shall be allowed. If a crack is found the crack must be removed and magnetic-particle inspection performed to ensure all of the crack has been removed before re-welding

Porosity: Porosity is a cavity in the weld that is formed by gas escaping from the molten weld metal during solidification. The AWS D1.5 Code specification for porosity is

- Maximum diameter shall not exceed 3/32 inch
- Frequency of any sized porosity shall not exceed one in 4 inches or six in 4 ft. of weld length

Craters: Craters are the ends of welds where the weld is not filled to its full cross section. The stresses that are caused by the unfilled crater may cause cracks to form

because of tension on the weld in the affected area. All welds must have full cross section the entire length of the weld.

Undercut: Undercut occurs at the edge of the weld along the leg. Undercut actually refers more to the base metal adjacent to the weld. Undercut is normally caused by excessive current in the welding operation. Undercut will cause stress risers and should be avoided. The AWS D1.5 Code requirement for undercut is:

- Undercut shall be no more than .01 inches deep when the weld is transverse to tensile stress. (Example: If a cross-frame angle is welded into the web of a beam then the allowable undercut along the edge of the weld touching the beam is .01 inch)
- Undercut shall be no more than 1/32 inch deep for all other cases

Arc Strikes

Arc strikes are areas where the welding electrode comes into contact with the base metal outside of the final weld. Arc strikes result in heating and very rapid cooling. Arc strikes may result in hardening or fatigue cracking, and serve as potential sites for fracture initiation.

Example of an arc strike

All arc strikes are to be removed by grinding. Grinding to a depth of 1/8 inch below the original surface should remove all traces of arc strikes and their hardened heat-affected zones. However, in tension areas of the bridge, the locations where arc strikes were removed shall have magnetic-particle inspection and hardness testing performed per The AWS D1.5 Bridge Welding Code.