VTrans Field Welding Manual
February 1st 2016

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Introduction and Purpose

The purpose of this field manual is to provide introductory knowledge of welding processes, positions, types, and defects. It is also the intent to provide basic understanding of concepts, specifications, classifications, and selected code requirements. Quality field welds are of the upmost importance for the safety of construction personnel who are working on or around weldments, as well as for the longevity of the structure. There are many factors that can contribute to the quality of a weld and therefore it is critical that care and caution is always used in the field to minimize the negative effects of these.

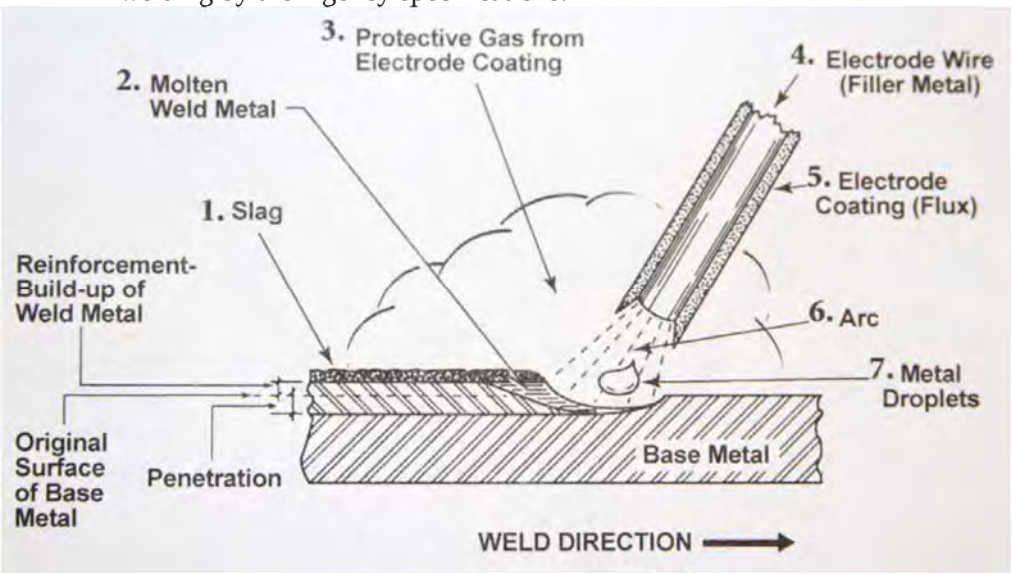
General information

Applicable codes:

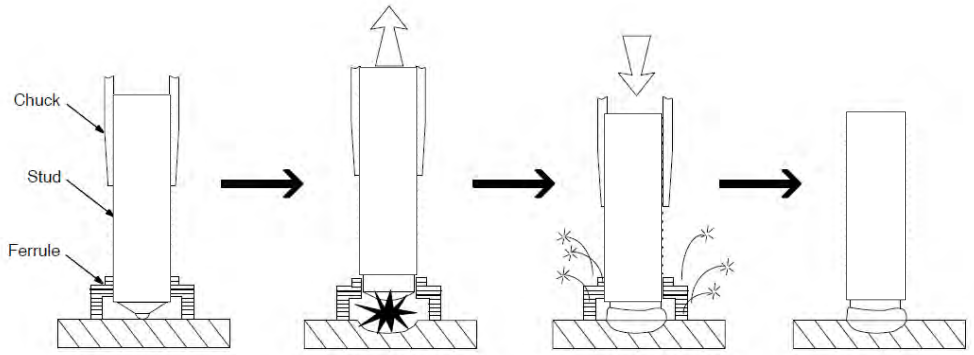
ANSI/AWS D1.1 Structural Welding Code – Steel
ANSI/AWS D1.2 Structural Welding Code – Aluminum
ANSI/AWS D1.3 Structural Welding Code – Sheet Steel
ANSI/AWS D1.4 Structural Welding Code – Reinforcing Steel
ANSI/AWS D1.5 Bridge Welding Code
ANSI/AWS D1.6 Structural Welding Code – Stainless Steel
ANSI/AWS D1.7 Guide for Strengthening and repairing Existing Structures

Welding Processes:

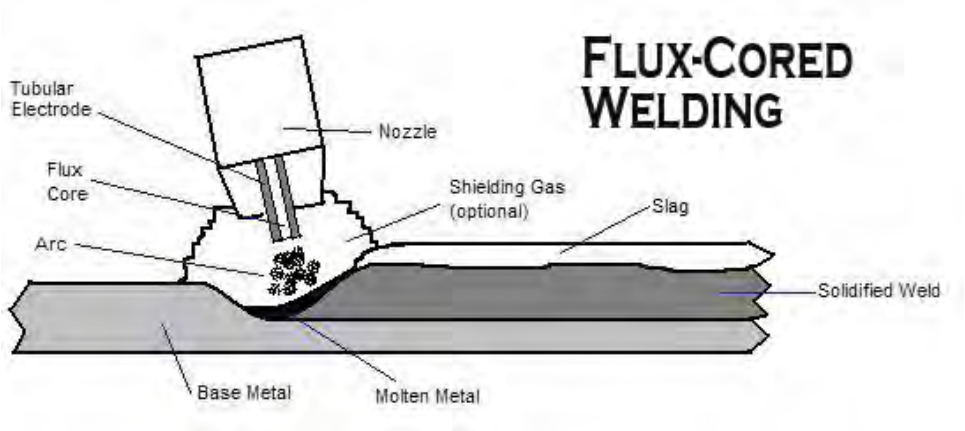
SMAW – Shielded Metal Arc Welding (also referred to as stick welding). SMAW electrodes have a core of filler metal that is surrounded with flux. As the electrode melts, the flux off gases to protect the weld puddle (molten metal) and leaves behind a layer on top of the weld called slag. The slag is a byproduct that protects the weld from contaminates while it cools and must be removed after each weld pass. This is the only process that is allowed for field welding by the Agency specifications.



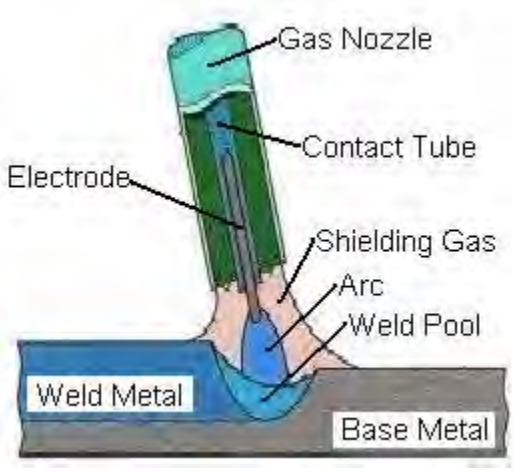
Stud Welding – This is an arc welding process which uses an automatically timed gun which controls the timing, lift and plunge. Each stud utilizes an arc shield (ferrule) which protects the weld from the atmosphere until it solidifies and cools. Once cooled, the ferrule is broken away from the stud.



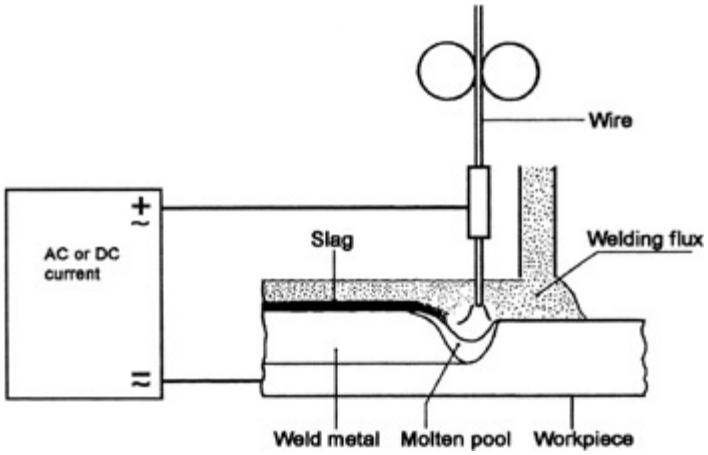
FCAW – Flux Core Arc Welding. FCAW is a wire fed process where the wire is tubular and the core is filled with flux in order to shield the weld. FCAW can be used with or without an additional shielding gas. This process is not currently allowed by specification to be used for field welding due to the effects that wind has on the shielding abilities of the flux cored electrodes. In some cases, with adequate atmospheric protection, FCAW has been allowed for certain applications only with the pre-approval of the Agency's shop inspector.



GMAW – Gas Metal Arc Welding. GMAW is similar to FCAW in that it is also a wire fed process, but it does not utilize any flux. This process relies completely on the shielding gas (which is not optional like FCAW) to protect the weld pool, which makes it not suitable for field welding because the gas can easily be blown away by wind. GMAW is sometimes used inside fabrication plants for welding bridge components but is not allowed in the field by the Agency specifications.



SAW – Submerged Arc Welding. SAW is an arc welding process that uses one or more arcs between a bare metal electrode (wire) and base metal. Both the arc and molten metal (weld pool) are completely covered by a layer of granular flux on the work pieces. Once the weld pool has solidified, the leftover flux can be swept off and re-used. There is a layer of slag under the loose flux that typically flakes off quite easily (unlike SMAW). It is highly unlikely to encounter this process in any field welding situation. This process is generally limited to only the flat and horizontal positions.



Material Cutting Processes:

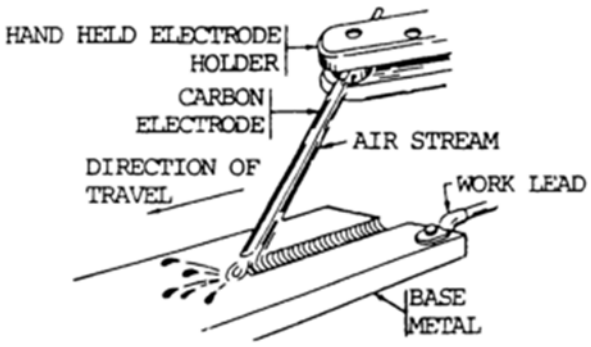
Oxy-Fuel Cutting – This process is also known as oxyacetylene cutting and is only used for carbon steel. This utilizes a combination of two gases, oxygen and some type of fuel; originally this was acetylene but this is being phased out due to the instability of the gas and being replaced with Chemtane (or others). In this process, the fuel gas is mixed with oxygen in the torch which then heats the metal to its kindling temperature (6000 ºF +/-). Then a stream of oxygen is forced through the torch tip which burns the metal into a metal oxide which flows out of the cut. Note that this is the same torch which is often used for preheating steel, except the tip is changed. The cutting tip is a very fine, concentrated flame whereas the rosebud heats a much bigger area.

Cutting Tip

Rosebud (Heating Tip)

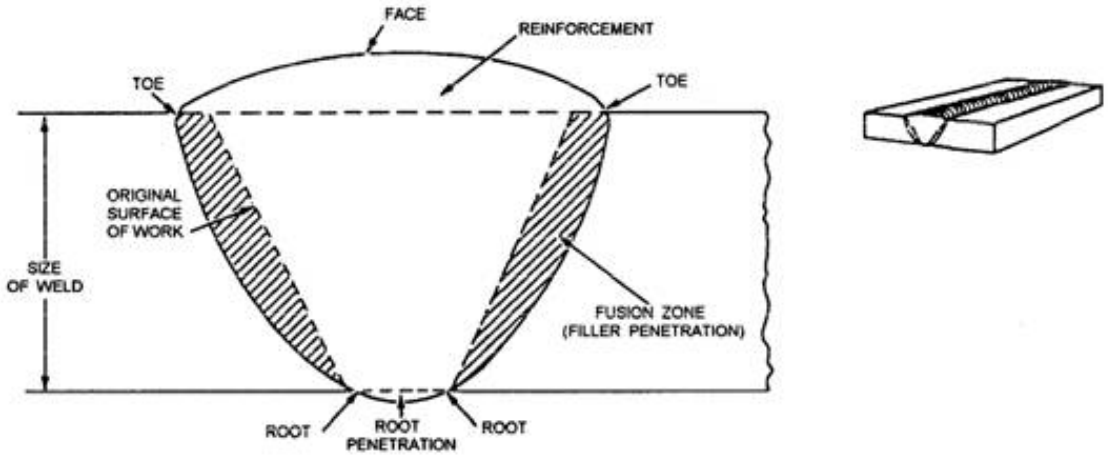
Plasma Cutting – This process uses compressed air and converts it to the 4th state of matter (plasma) to heat the metal to much greater temperatures than can be achieved with flame (30,000 ºF). Even though this is incredibly hot, it is also extremely concentrated and allows it to make very smooth and accurate cuts. Due to the extreme temperature and the relatively rapid cooling, plasma cutting often results in a cut edge which is very hard and can easily be above the C30 maximum reading with a Rockwell hardness tester.

Air Arc/Air Gouge – This process is not used often in the field however for weld repairs where weld metal needs to be removed or base metal needs to be removed this is sometimes used. This process requires a very experienced operator as it is quite easy to remove too much material at once. If this process is needed in the field, the Agency's Shop Inspector shall be closely involved with approved procedures and operators in place prior to commencing work.



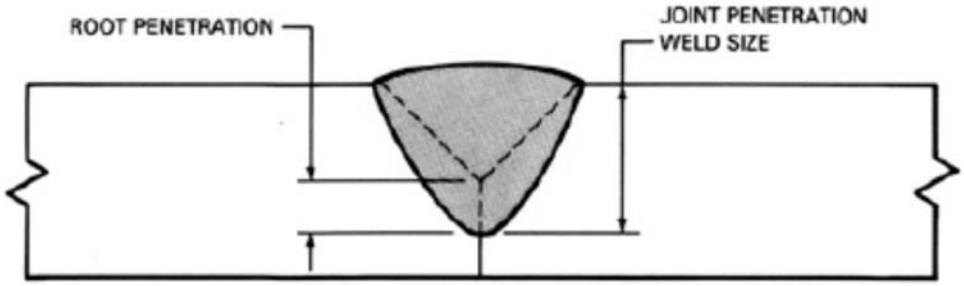
Weld Types:

Full penetration groove welds – also known as Complete Joint Penetration (CJP) welds. This type of weld utilizes either a backer bar or use of back gouging techniques to ensure that filler metal from the electrode is deposited throughout the entire cross section of the weld.



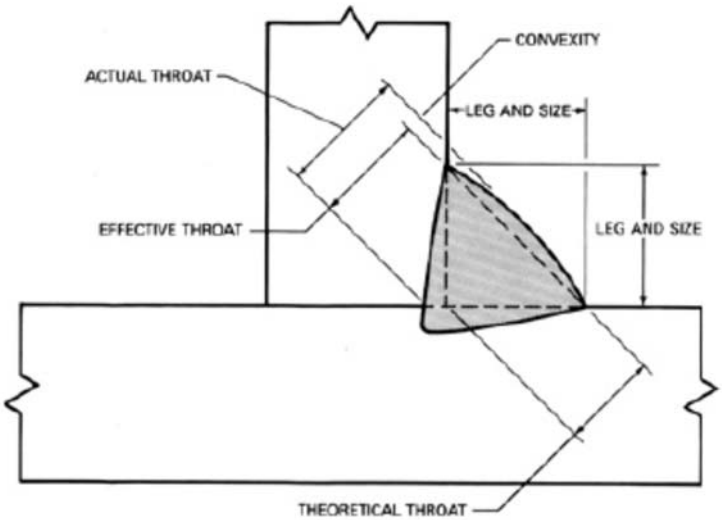
Full Penetration Groove Weld

Partial penetration groove welds – also known as partial joint penetration (PJP) welds. These welds are similar to CJP welds except that the weld metal does not fully penetrate the base metal in the sections that are being joined together. Since the weld metal is not designed to fill the entire cross-section, the use of a backer bar or back gouging is not required.

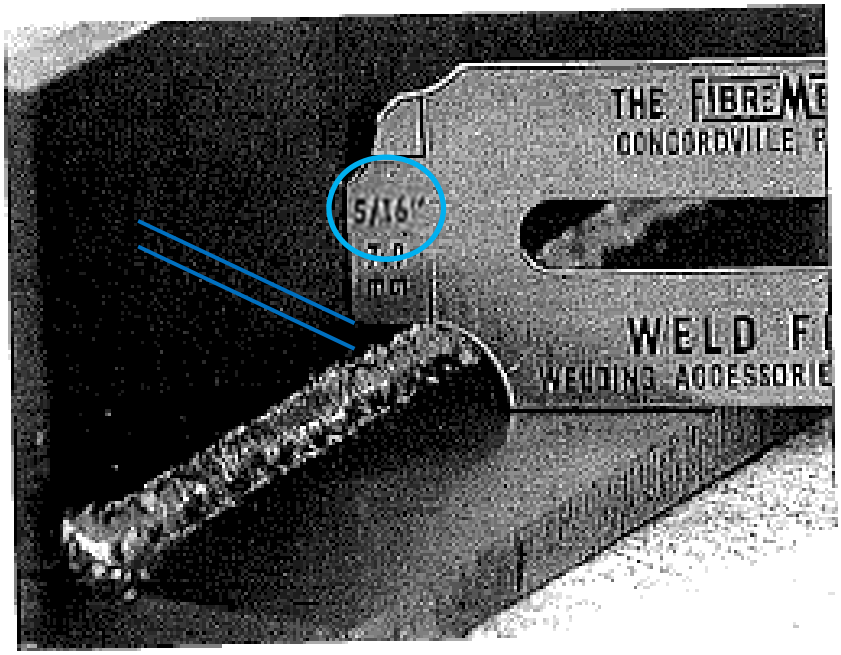


Partial Penetration Groove Weld

Fillet welds – Fillet welds are used to join sections of base metal lying in different planes from each other. The cross section of this weld is generally triangular and the face can have three types of finishes; convex, concave or flat.



Convex Fillet Weld

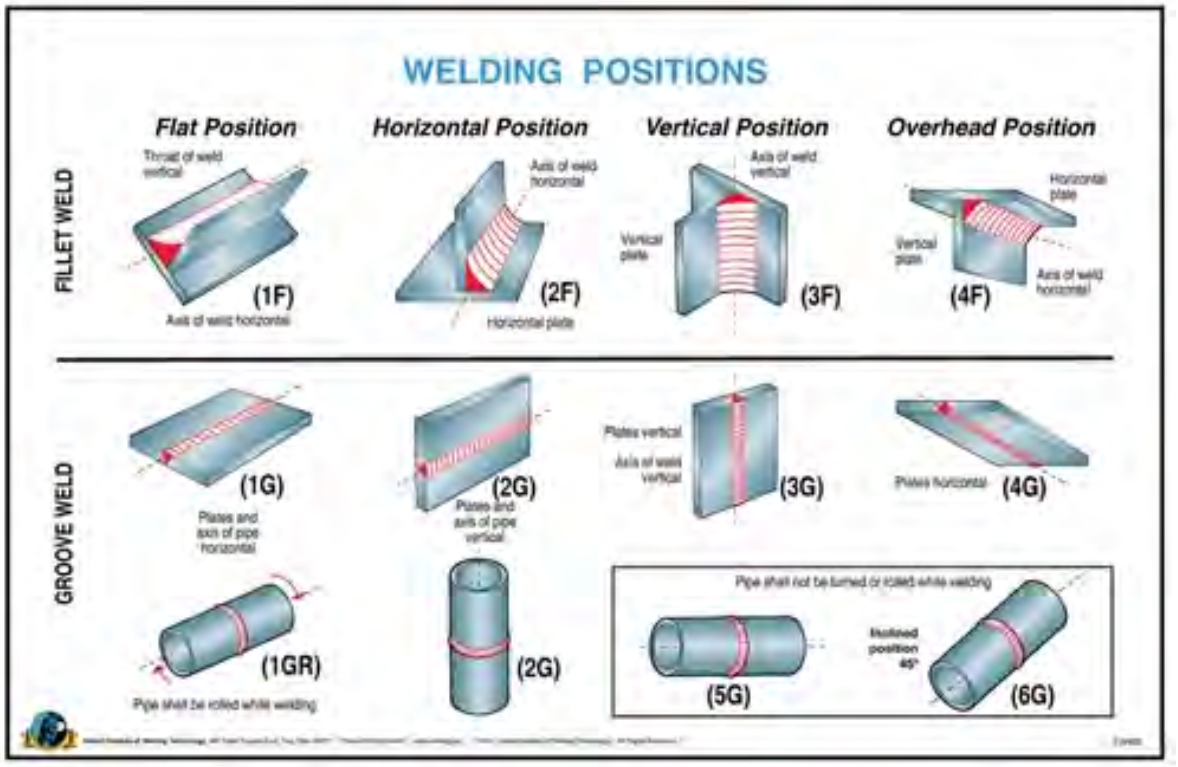


Measuring a Fillet Weld

In the Figure above, a fillet weld gauge is being used to check the size. This shows that the weld size is less than 5/16" due to the fact the gauge is not contacting the toe of the weld.

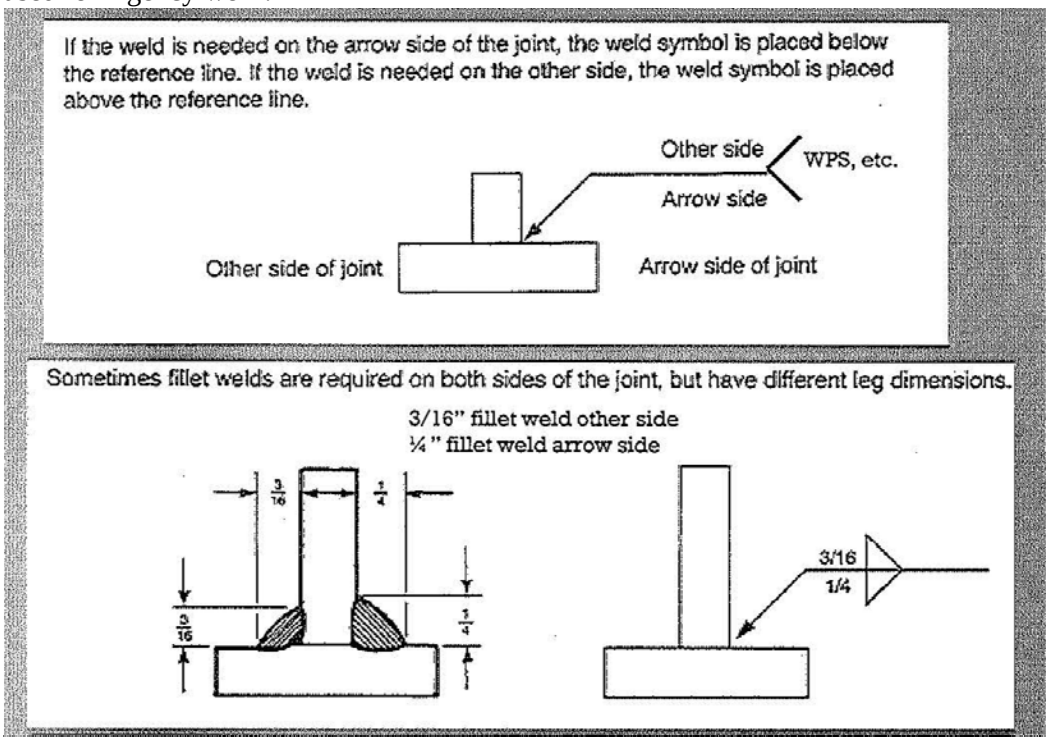
Weld Positions:

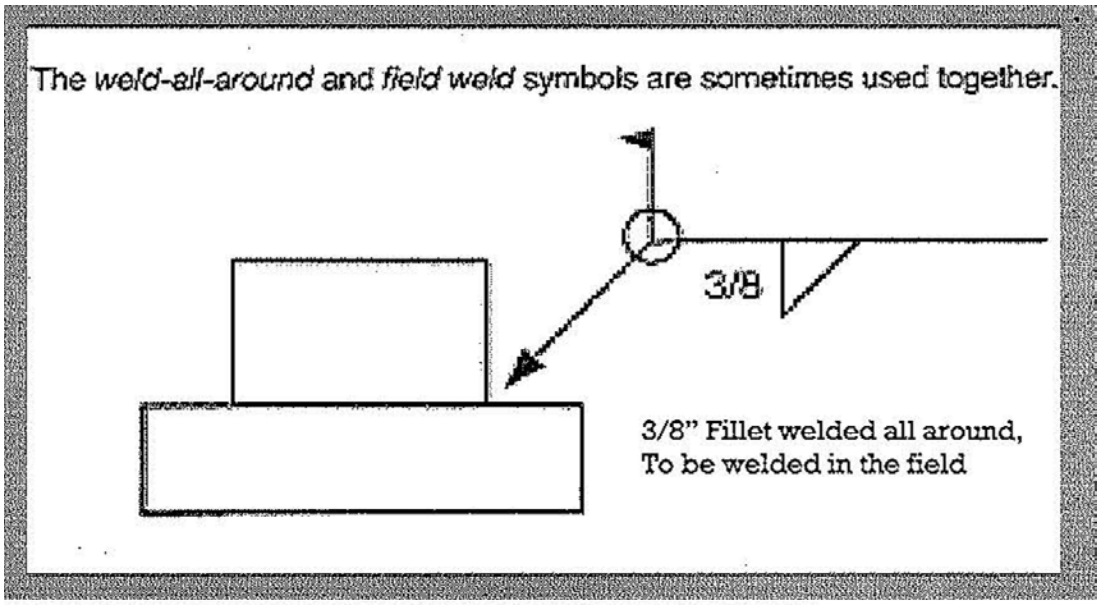
Refer to the figure below for descriptions of the different positions: flat, horizontal, vertical up, vertical down, overhead

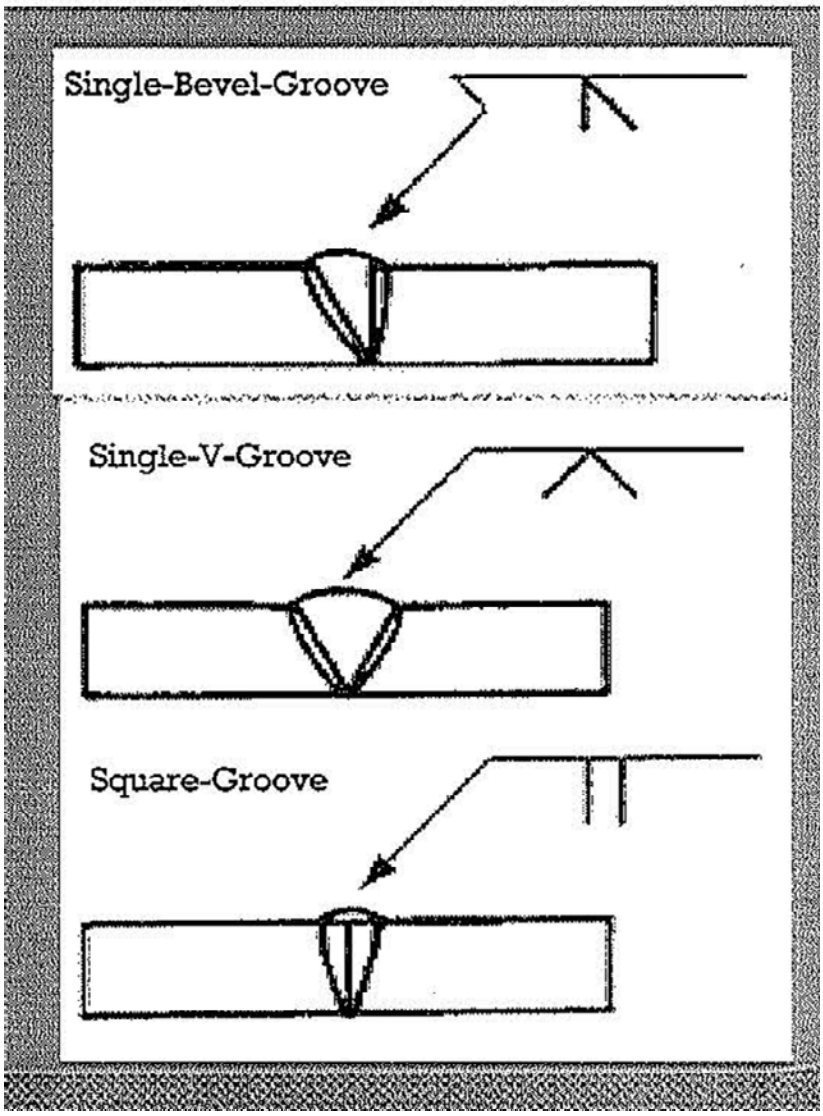


Weld Symbols:

Refer to the figures below for descriptions of a few of the most common weld symbols used for Agency work.




The weld-all-around and field weld symbols are sometimes used together.
3/8
3/8" Fillet welded all around,
To be welded in the field


Single-Bevel-Groove
Single-V-Groove
Square-Groove

Useful Definitions and Descriptions of Welding Terms

Back Gouging – The removal of weld metal and base metal from the weld root side of a welded joint to achieve full joint penetration upon subsequent welding from that side.

Backing – A material or device placed against the back side of a joint to support and retain molten weld metal. The material may be partially fused or remain unfused during welding and may be either metal or nonmetal, as approved by the Engineer.

CJP – Complete Joint Penetration.

Concavity – The under fill (or suck back) of metal in the weld causing the weld surface to be below flush with the parent metal surfaces. This condition may exist on either root or face surfaces.

Convexity – The solidified, overfilled weld metal causing the weld surface to be above flush with the parent metal surfaces. This condition may exist on root or face surfaces and, when measured, both should be added for an accumulated effect.

CWI – Certified Welding Inspector.

Electrode oven – Also known as a hotbox. These are used to keep electrodes dry for SMAW.

Field Welding – Any welding performed that is not done under the supervision of the fabricator's quality control management (who has an AISC Major Steel Bridge Certification per section 506.03 of the construction manual) shall be considered Field Welding.

Interpass Temperature – In a multi-pass weld, the temperature of the weld area between weld passes.

Joint Root – That portion of a joint to be welded where the members approach closest to each other. In cross section, the joint root may either be a point, a line, or an area.

MT – Magnetic Particle Testing.

NDE – Non-Destructive Evaluation (see page 19 for more info).

Preheat Temperature – The temperature of the base metal in the area surrounding the point of welding immediately before welding is started. In a multiple-pass weld, it is also the temperature immediately before the second and subsequent passes are started. This is a minimum temperature.

PQR (procedure qualification record) – A record of welding variables used to produce an acceptable weld and the results of the tests conducted to qualify a weld procedure.

PT – Liquid Penetrant Testing (also known as dye penetrant testing).

Root Face – The portion of the groove face within the joint root.

Shop Welding – Any welding that takes place under the supervision of the fabricator's Quality Control Management, who has an AISC Major Steel Bridge Certification per section 506.03 of the construction manual, shall be considered Shop Welding.

Tempilstik® – A temperature indicating crayon. Each crayon is for a specific temperature where if the crayon melts when drawn on the steel, the base metal temperature is greater than that specified crayon. These are commonly used when heating a beam/girder to adjust the camber or sweep.

Tack weld – A weld made to hold parts of a weldment in proper alignment until the final welds are made.

UT – Ultrasonic Testing.

Weld Face – The exposed surface of a weld on the side from which welding was done.

Weld Pass – A single progression of welding along a joint. The result of a pass is a weld bead or layer.

Weld Reinforcement – Weld metal in excess of the quantity required to fill a joint.

Weld Root – The points, as shown in cross section, at which the root surface intersects the base metal surfaces.

Weld size (fillet weld) – For equal leg fillet welds, the leg lengths of the largest isosceles right triangle that can be inscribed within the fillet weld cross section. For unequal leg fillet welds, the leg lengths of the largest right triangle that can be inscribed within the fillet weld cross section.

Weld Toe – The junction of the weld face and the base metal.

Weldment – An assembly whose component parts are joined by welding.

Welder Certification Requirements

1) Field welds for the Vermont Agency of Transportation work: Welding performed under the supervision of a Contractor, or Subcontractor, on material that will become an integral part of the finished work, or on any material used in a temporary status that will affect public safety shall be subject to the requirements herein.

Field welding shall be done by the Shielded Metal Arc Welding (SMAW) process and must be performed by welders who:

a) Have been approved to perform field welding by the Agency's Shop Inspector and are currently on the pre-qualified welder list (See Page 24).

b) Have met the requirements for the period of effectiveness in accordance with the AWS D1.5 (5.21.4) AND has kept a documented log to support and show that these requirements are met. All welders shall have their welding log available for review upon request on site while welding is performed. Welders shall be prepared to show government photo identification upon request by the Agency.

Welds used to attach miscellaneous construction fixtures referred to in Subsection 506.10 of the VTrans Standard Specifications are considered "Temporary Welds" by the AWS D1.5 code, section 9.20, and must comply with the requirements herein.

2) The integrity of any welding performed by, or for a Contractor on material that is for his/her use in performing project work, will not be attached to, or become an integral part of the final work, will not adversely affect public safety, and is otherwise covered by contract requirements, will be the full responsibility of the Contractor. However, welding of this nature still must be done with the SMAW process and by certified welders.

3) Application of shear connectors by an approved automatically timed process does not require welder certification. Operator qualification and application procedure approval are accepted in accordance with the requirements of AWS D1.5, Section 7.8.

Attachment, or repair of shear connectors by the SMAW process will require AWS D1.5 Certification (as outlined in #1 above).

4) Questions concerning the responsibility or requirements for field welding should be addressed to the Agency's Shop Inspector. See Contacts on Page 23.

Welding Procedure Specification (WPS) Requirements

Welding procedures outline all of the information about the intended weld, including but not limited to material specification, welding process/position, filler metal, joint type/prep., preheat requirements, and limits of variables such as amps, volts, electrode size, travel speed, etc.

WPS's shall be prepared by either the contractor or the welder, but need to be signed by both prior to submitting to the Agency for approval. Blank WPS forms can be found on page 26 of this Manual.

WPS's (and welders) must be approved in advance for all field welding by the Agency's Shop Inspector. Any variations in the field that are out outside the limits specified on the WPS shall require additional procedures with approval prior to starting the welding.

Steel Classification

AASHTO	ASTM	Description
M270 Gr. 36	A709 Gr. 36	36 KSI Standard Carbon Steel
M270 Gr. 50	A709 Gr. 50	50 KSI Standard Carbon Steel
M270 Gr. 50W	A709 Gr. 50W	50 KSI Carbon Steel with weathering characteristics
M270 Gr. 70W	A709 HPS 70W	High Performance 70 KSI Carbon Steel w/weathering characteristics

E7018-1H$_4$R

<table>
<tr><td>E</td><td>Electrode</td></tr>
<tr><td>70</td><td>The first two digits indicate the minimum required tensile strength in ksi.
<table>
<tr><th>Metal No.</th><th>Minimum Tensile Strength (psi)</th><th>Minimum Yield Strength (ksi)</th><th>Minimum Elongation</th></tr>
<tr><td>60</td><td>60,000</td><td>48</td><td>22%</td></tr>
<tr><td>70</td><td>70,000</td><td>58</td><td>22%</td></tr>
</table></td></tr>
<tr><td>1</td><td>The third digit = Welding Positions
<table>
<tr><td>4</td><td>Especially good Vertical-Down</td></tr>
<tr><td>2</td><td>Flat & H/V Fillets</td></tr>
<tr><td>1</td><td>All Positional</td></tr>
</table></td></tr>
<tr><td>8</td><td>The fourth digit indicates the Flux type and Welding Current / Polarity to be used.
8 = Hydrogen controlled Low Iron Powder A.C. & D.C.+, medium penetration.</td></tr>
<tr><td>-</td><td></td></tr>
<tr><td>1</td><td>This number indicates that the electrode meets the requirements for improved impact toughness.
<table>
<tr><th colspan="2">Average Minimum Results</th></tr>
<tr><td>Grade</td><td>CVN Impact Requirements</td></tr>
<tr><td>E7016-1</td><td>20Ft Lb @ -50°F (27J @ -46°C)</td></tr>
<tr><td>E7018-1</td><td>20Ft Lb @ -50°F (27J @ -46°C)</td></tr>
<tr><td>E7024-1</td><td>20Ft Lb @ 0°F (27J @ -18°C)</td></tr>
</table></td></tr>
<tr><td>H$_4$</td><td>Optional Designator
The 2nd letter and 6th number indicate the diffusible hydrogen content of the deposited weld metal (DWM).
<table>
<tr><td>H$_4$</td><td>≤4 mls H$_2$ / 100g of DWM</td></tr>
<tr><td>H$_8$</td><td>≤8 mls H$_2$ / 100g of DWM</td></tr>
<tr><td>H$_{16}$</td><td>≤16 mls H$_2$ / 100g of DWM</td></tr>
</table></td></tr>
<tr><td>R</td><td>Optional Designator
The last letter indicates the coating is Moisture Resistant.</td></tr>
</table>

Electrode Selection

- Electrode classification and specification shall be listed on all WPS's which must be approved by the Agency's Shop Inspector prior to welding. The selection of all electrodes shall be per the requirements of the AWS D1.5 Bridge Welding Code (Table 4.1 and Table 4.2). This table provides the matching requirements of filler metals to base metals. Some of the most common electrodes/base metal combinations are listed below.

- Welding that is performed by, or for a Contractor on material that is for his/her use in performing project work, will not be attached to, or become an integral part of the final work, will not adversely affect public safety, and is otherwise cover by contract requirements, will be the full responsibility of the Contractor, and therefore pre-approved WPS's are not required. However, for all field welding of this nature, electrodes that are used shall meet the matching requirements of Table 4.1 and Table 4.2 in the AWS D1.5 Bridge Welding Code.

- Common filler metal (electrode) and base metal combinations (from Table 4.1 & Table 4.2):

ASTM	**Electrodes for SMAW**
A709 Gr. 36	E6018, E7018, E7018-1
A709 Gr. 50	E7018, E7018-1
A709 Gr. 50W, HPS 50W	E8018-C1, 8018-C3
A709 HPS 70W	E9018M

Electrode Requirements

- Electrodes that have been wet may not be dried or re-dried.
- Electrodes that have been dropped on the ground, exposed to rain, or not stored properly must be discarded, and cannot be used.
- Electrodes to be used within the allowable exposure limit should be removed from a hermetically sealed container or a hot box kept at a minimum of 250º F.
- Electrodes not to be used within the allowable atmospheric exposure limit shall be stored in a hot box at a minimum of 250º F.
- Any electrodes exposed to the atmosphere for more than the allowable limit, must be re-dried according to 12.6.5.4 of the AWS D1.5.
- Any electrodes that are exposed to temperatures in a hot box below 250º F, (for longer than the allowable atmospheric exposure limit), shall also follow the requirements of 12.6.5.4 of the AWS D1.5.
- Electrodes may only be re-dried one time. If the maximum allowable exposure time is then reached, they shall not be used for Vermont Agency of Transportation work.

Allowable atmospheric Exposure of Low-Hydrogen SMAW Electrodes (AWS D1.5 Table 4.6)

Electrode	**Maximum Time**
E70XX-X	4 Hour
E80XX-X	2 Hour
E90XX-X	1 Hour
E100XX-X	30 Minute

From AASHTO/AWS D1.5 Bridge Welding Code:

12.6.5.1 – All SMAW electrodes shall be manufactured, packaged in hermetically sealed containers, stored, transported, and delivered so that when removed from the container, the electrodes are undamaged and meet the diffusible hydrogen limits specified in 12.6.2.

12.6.5.2 – Manufacturers' containers shall remain sealed until the electrodes are dispensed for work or are placed in heated storage as specified in 12.6.3. Containers shall be examined and if the hermetic seal was lost before opening, electrodes shall not be used for FCM welding. Electrodes shall be examined to ensure there is no damage that may adversely affect weld quality, including previously wet, contaminated or broken coatings. Any electrode with such defects in their usable length shall be discarded.

12.6.5.3 – After removal from the manufacturer's sealed container, electrodes not immediately dispensed for use shall be continuously stored in an electrically heated, thermostatically controlled ovens at a minimum temperature of 250º Fahrenheit until dispensed for use in the work. If the temperature falls below the 250º F, electrodes shall be dried or re-dried per 12.6.5.4.

12.6.5.4 – As used here, the terms **dried** and **drying** are defined as holding electrodes at a specified temperature for a minimum period of time (below) or according to the manufacturer's requirements. Unless the manufacturer stipulates otherwise based on testing, electrodes for base metal with specified minimum yield strength of 50 KSI or less shall be dried at 450ºF - 550ºF for a minimum of four hours, and electrodes for matching higher strength base metal shall be dried at 800ºF - 1000ºF for two hours. The terms **re-dried** and **re-drying** are defined as drying a second time, whether the initial drying followed exposure or was based on manufacturer's requirements. If the temperature inside the storage oven falls to between 125ºF and 225ºF for a period of up to eight hours, or below 125ºF for up to four hours, electrodes which were not previously re-dried shall be dried or re-dried or shall not be used to weld FCMs. Electrodes in storage ovens exposed to temperatures below 250ºF and times beyond the limits described above, or that were previously re-dried, shall not be used.

12.6.5.5 – Electrode ovens shall be designed for the storage, segregation, and drying of electrodes and shall be capable of maintaining a specified temperature between 250ºF - 550ºF. Each oven shall have a thermally sealed, latching door that is closed when not charging or discharging electrodes. To regularly verify the inside temperature without opening the door, each oven shall have either instrumentation allowing direct reading or a small port through which a thermometer can be inserted. Such ports shall be closed when not in use. Regardless of type, all oven temperature sensors shall be verified at least once per year.

Joint & surface preparation, preheat, climate restrictions

Joint & Surface Preparation – The joint fit up and preparation shall be in accordance with the approved WPS, including (but not limited to) bevel angles, bevel depth, root opening, and backing requirements. All surfaces to be welded shall be properly cleaned and free of containments, rust, slag, mill scale, etc. Most common surface preparation methods are grinding, chipping and brushing, however for some situations use of a needle scalar is needed. Surface preparation between weld passes is also necessary to remove slag left behind during previous welds with the SMAW process

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Preheat Temperatures – If the ambient air temperature or the base metal temperature is less than the specified minimums (see table below), the base metal temperature of the materials to be joined shall be pre heated to the minimum preheat temperature specified. Preheat requirements are applicable to all field welding, including tack welds, and miscellaneous construction fixtures.

Ambient Air Temperature – No welding will be permitted if the ambient air temperature is below 0º F (AASHTO/AWS D1.5 Bridge Welding Code, section 3.1.3).

Climate Restrictions – No welding will be permitted when the surfaces are wet or exposed to rain, snow or high wind velocities. (AASHTO/AWS D1.5 Bridge Welding Code, section 3.1.3).

Minimum Preheat and Interpass Temperature, ºF

	Thickness of Thickest Part at Point of Welding in inches			
Base Metal	Up to ¾" incl.	Over ¾" to 1 ½" incl.	Over 1 ½" to 2 ½" incl.	Over 2 ½"
Grade 36, 50, 50W, HPS 50W	50º F*	70º F	150º F	225º F
Grade HPS 70W, 100, 100W	50º F*	125º F	175º F	225º F

* When the base-metal temperature is below 32º F, the minimum preheat temperature shall be increased to 70º F and maintained during welding (AASHTO/AWS D1.5 Bridge Welding Code, section 4.2.8).

Common Weld Defects and Testing

Cracks – All cracks are unacceptable and must be completely removed and re-welded.

Porosity – Porosity is a cavity in the weld that is formed by gas escaping from the molten weld metal during solidification. It is commonly caused by contamination of the base metal or electrode, but can also be caused by improper weld technique, or too fast of a travel speed.

Craters – Craters are the ends of weld passes where the weld is not filled to its full cross section, typically caused by pulling the electrode away too soon. The stress concentrations that are caused by the unfilled crater may cause crater 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 – A notch in the base metal along a leg characterizes a weld undercut. Excessive current or improper technique can cause undercut.

Overlap – Overlap is a sharp surface connected discontinuity that forms a severe mechanical notch because the weld metal protrudes or flows beyond the toe of face of the weld without fusion. Overlap can occur as a result of improper preparation of the base metal or failure to control the welding process.

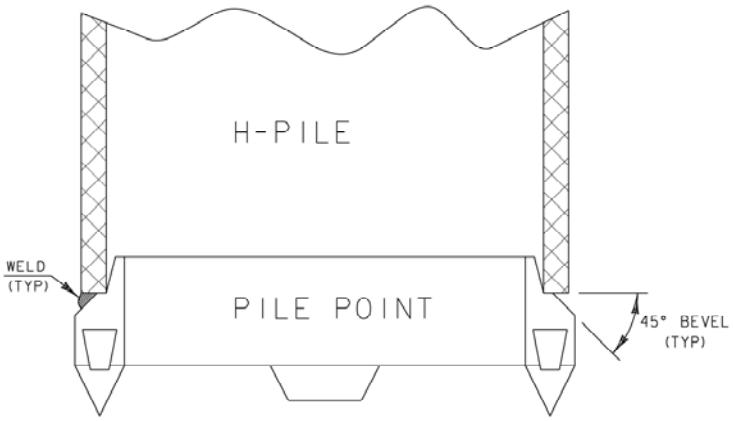
Arc Strike – Arc strikes are areas where the welding electrode comes into contact with the base metal outside of the final weld. Arc strikes result in heating and very rapid cooling. Arc strikes may result in hardening or fatigue cracking, and serve as potential sites for fracture initiation.

Non-destructive Evaluation – There are 5 main types: Visual, Liquid Penetrate, Magnetic Particle, Ultra Sonic, and X-Ray. On typical field welding situations, visual inspection is often the only NDE that is done. However, on weld repairs or crack repairs, it is highly likely to see at least one other type of NDE besides visual.

Weld Repairs – If any defects or discontinuities are noticed, the Agency's Shop Inspector shall be contacted. When an unacceptable defect or discontinuity exists, some type of a weld repair is required (this will require an approved WPS and welder to perform the repair).

Pile tip detail

- Pile Tips shall be welded onto piles per the specifications of the Manufacturer. These can be welded in the field or in a fabrication plant, however in either case, pre-approval is required for procedures and welder/fabricator by the Agency's Shop Inspector. Piles that arrive to the construction site with tips welded to them without pre-approved procedures/welders are rejectable.



NOTES:

H-PILE SHALL HAVE A SQUARE CUT END FOR THE PILE POINT TO FIT ON TO.

PILE POINT SHALL BE WELDED IN EITHER THE FLAT OF VERTICAL POSITION USING 70XX OR 60XX ELECTRODES.

WELD ACROSS THE FULL WIDTH OF BOTH FLANGES WHILE MAINTAINING THE MINIMUM WELD SIZE ACCORDING TO THE CHART BELOW.

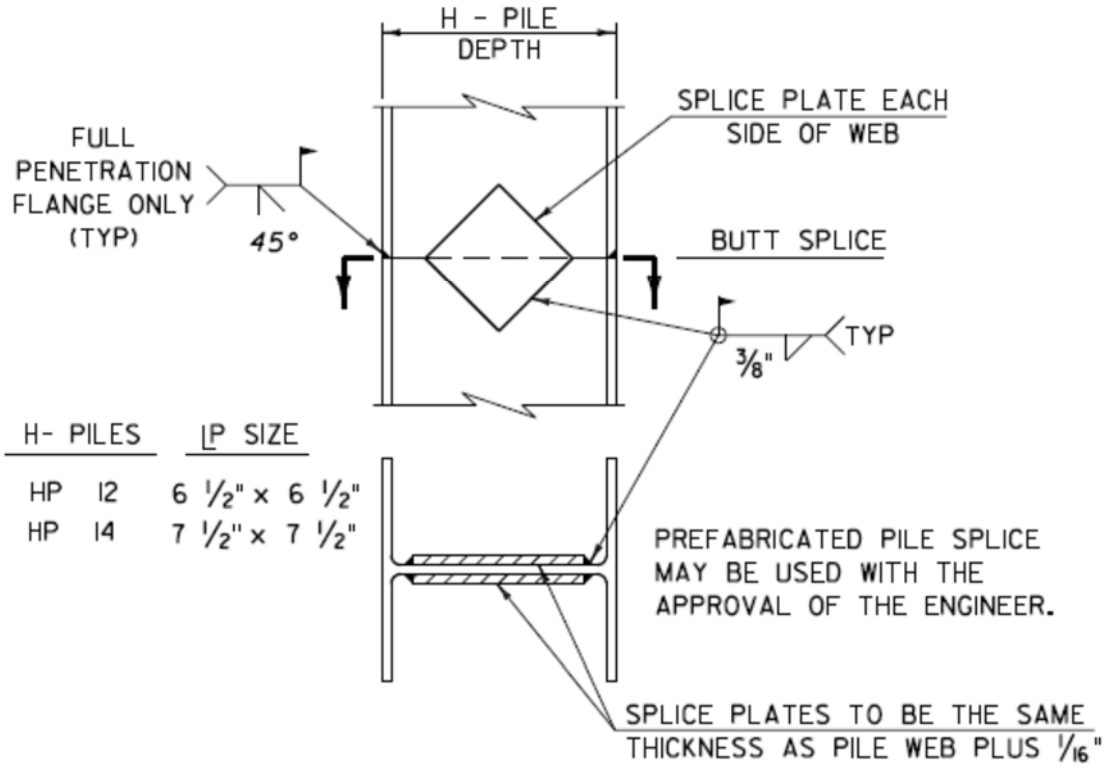
Pile Size	Flange Thickness	Min. Size Groove Weld*
HP 14 x 117	0.805	7/16
HP 14 x 102	0.705	3/8
HP 14 x 89	0.615	3/8
HP 14 x 73	0.505	5/16
HP 12 x 84	0.685	3/8
HP 12 x 74	0.610	3/8
HP 12 x 63	0.515	5/16
HP 12 x 53	0.435	5/16
HP 10 x 57	0.565	5/16
HP 10 x 42	0.420	5/16
HP 8 x 36	0.445	5/16

* UNLESS OTHERWISE SPECIFIED BY THE MANUFACTURER.

Pile Point

Pile Splice detail

- Even though the splice detail can be seen here, approved WPS's and approved welders are required for all pile splices.



DETAIL OF PILE SPLICE

Galvanizing Repair

- Per Agency Specifications:
  - Galvanizing that has been damaged shall be repaired in accordance with ASTM A 780 "Standard Practice for Repair of Hot Dipped Galvanized Coatings, Annex A2". The paint used in the repair shall be organic-rich, containing 92 percent (min.) zinc by mass (weight) in the dry film. The paint shall be applied per manufacturer's recommendations to a thickness equivalent to the surrounding galvanizing.

- Per ASTM A 780 Annex 2 (in part):

A2.1 - Preparation of the damaged surface will be influenced by the type of paint selected and the anticipated service conditions. The following general guidelines shall apply:

A2.1.1 - Surfaces to be reconditioned shall be clean, dry, and free of oil, grease, preexisting paint, and corrosion by-products

A2.1.2 - Clean the surface to bare metal, in accordance with SSPC-SP11 as a minimum. Where circumstances do not allow blast or power tool cleaning, it is permissible to hand tool areas clean in accordance with SSPC-SP2. To ensure that a smooth reconditioned coating can be affected, surface preparation shall extend into the undamaged galvanized coating.

SSPC-SP11 – Power Tool Cleaning to Bare Metal (refer to specifications for full description). This level of surface preparation removes loose mill scale, loose rust, loose or otherwise defective paint, weld flux, slag, spatter, etc., from metal surfaces by power wire-brushes, power impact tools, power grinders, power sanders or by combination of these methods. Power tool cleaning requires that all oil, grease, weld flux, etc., be first removed by solvent cleaning (SSPC SP1).

SSPC-SP2 – Hand Tool Cleaning (refer to specifications for full description). Hand tool cleaning removes all loose mill scale, loose rust, loose paint, and other loose detrimental foreign matter. It is not intended that adherent mill scale, rust, and paint be removed by this process. Mill scale, rust and paint are considered adherent if they cannot be removed by lifting with a dull putty knife.

A2.1.3 - If the area to be reconditioned includes welds, first remove all weld flux residue and weld spatter (of a size that cannot be removed by wire brushing or blast cleaning) be mechanical means, such as chipping, grinding, or power scaling, etc.

A2.1.4 - Spray or brush-apply the paints containing zinc dust to the prepared area. Apply the paint as in accordance with the manufacturer's printed instructions in a single application employing multiple passes. Allow adequate curing time before subjecting the repaired items to service conditions in accordance with the manufacturer's printed instructions.

VTrans Contacts

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Construction Structures Engineer –	Bob Klinefelter ----------	802-595-4403 (cell)

Pre-Qualification Process for field welding

Notes:

- **Any welder who was on the 2015 pre-qualified** list and wants to be on the 2016 list, he/she must submit to the agency (prior to March 1st) their 2015 welding log to show that they have met the 6-month requirement (refer to the requirements section below for more details).

- **Any welder who was NOT on the 2015 pre-qualified list** and wants to/intends to perform field welding for the state of Vermont in 2016 shall submit to the agency **ALL** of the required documentation and records (see below) prior to March 1st, 2016.

    1. Welder's Qualification test results and/or a copy of the welder's AWS photo certification card.
    2. The welder's welding log showing that they meet the period of effectiveness in accordance with the AWS D1.5 Bridge Welding Code. (There cannot be a period of more than 6 months pass where the welder did not engage in a given process that he/she is qualified for)

- By March 15th, 2016 the Agency will post a list of pre-qualified welders for field welding on agency work for a one-year period (through March 15th, 2017). Even though pre-qualified welders are said to be approved for a 12-month period, all welders shall continue to maintain a welding log to show that they meet the AWS D1.5 requirements of not letting more than 6 months pass without welding in a given process in which they are qualified for. All welders shall have their welding log available for review upon request on site while welding is performed.

- Any welders, who are not on the 2016 pre-qualified list, still have the possibility to be approved by submitting all of the required documentation and records to the Agency's Shop inspector. However, it shall be noted that this may take up to two weeks (14 days) to review and either approve or reject the welder. Upon approval, that welder will be added to the pre-qualified list for the remainder of the qualified period (March 15th 2016 through March 14th 2017).

- If a welder is not approved due to in-adequate documentation or test results, the welder has the option to re-test in order to meet those requirements.

- Even though a welder may be pre-qualified or certified by testing in accordance with the AWS D1.5 Bridge Welding Code, the Agency Shop Inspector can still revoke the approval if there is reason to question the welder's ability.

Requirements:

- Welders must successfully pass the qualification tests for given process and position in accordance with the AWS D1.5 Bridge Welding Code.
    - To qualify for SMAW (stick welding) unlimited thickness and all positions (typically done by most welders who do Agency work), there are 2 tests performed. Both tests are full penetration groove welds on 1" thick plate. One is done in the vertical up position, and the second is done in the overhead position. Successful completion of both of these tests, qualifies that welder for both fillet welds and groove welds in all positions.

- Welders who successfully complete and pass the qualifications tests, shall continue to be qualified unless the welder allows 6 months to pass without welding in a given process, or until there is reason to question the welder's ability.

- Welders shall keep a welding log of work they have performed to document and show that they have not let 6 months lapse without welding in each process in which they are qualified for. If a welder cannot produce a log showing this, they have the option to do the requalification test in accordance to the AWS D1.5 Bridge Welding Code.

Future years:

- Welders on the 2016 pre-qualified list shall submit their welding log for 2016 work, prior to March 1st, 2017 in order to stay on the pre-qualified list. Welding logs will be verified by the Agency Shop inspector to ensure that the requirements for period of effectiveness have been met.

Welding Procedure Specification

Material specification _____
Welding process _____
Manual or machine _____
Position of welding _____
Filler metal specification _____
Filler metal classification _____
Flux _____
Shielding gas _____ Flow rate _____
Single or multiple pass _____
Single or multiple arc _____
Welding current _____
Polarity _____
Welding progression _____
Root treatment _____
Preheat and interpass temperature _____
Postheat treatment _____

WELDING PROCEDURE

Pass no.	Electrode size	Welding current		Travel speed	Joint detail
		Amperes	Volts		

This procedure may vary due to fabrication sequence, fit-up, pass size, etc., within the limitation of variables given in Section 5. **(of the AASHTO/AWS D1.5 Bridge Welding Code and latest revision)**

Procedure no. _____ Contractor _____

Revision no. _____ Authorized by _____

Welder _____ Date _____

Photo Examples - Acceptable

Root pass of a full penetration groove weld free of slag and ready for additional passes.

Additional passes being added to the root pass.

Back gouging to sound metal before welding the back side

Completed full penetration groove weld. Note that all slag and arc strikes have been removed. Grinding and additional weld metal was added on the flange edges to correct minor misalignment.

Photo Examples - Unacceptable

Insufficient back gouging and incomplete penetration.

Porosity.

Misalignment, arc-strikes, unacceptable profile, contaminated surfaces, slag, undercut, porosity.

Misalignment, unacceptable profile, slag.

Slag, undercut, under fill, arc strikes.

Under fill, use of an unapproved wire fed process (GMAW) - note wire protruding from weld.