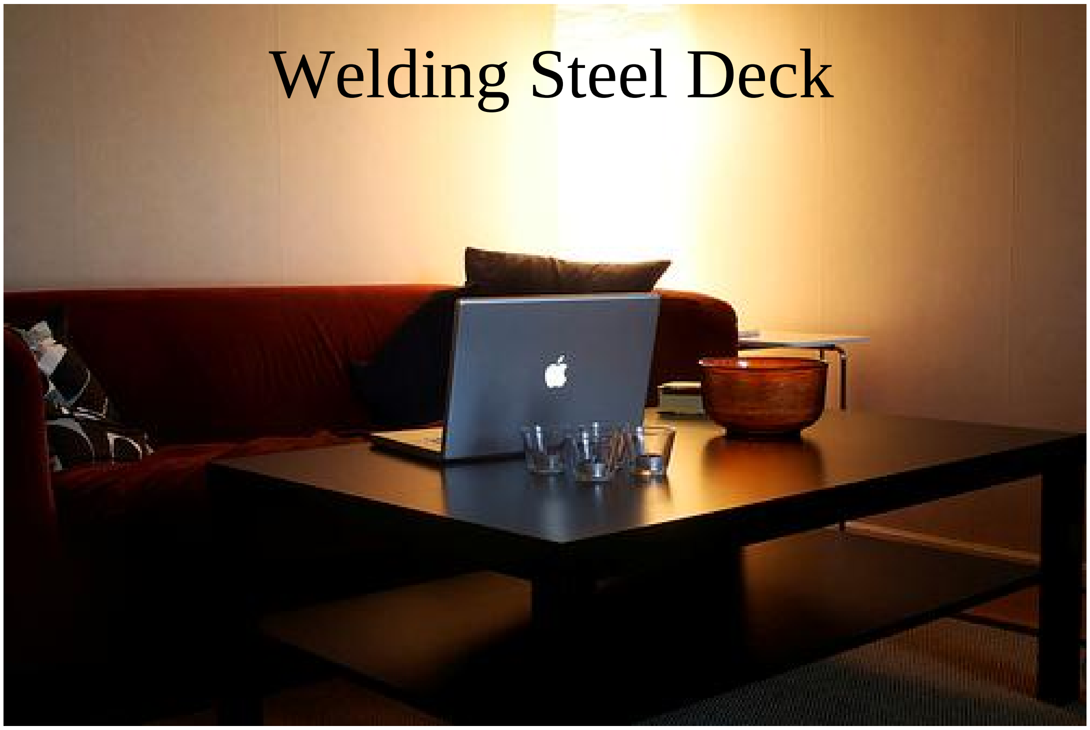

Welding Steel Deck

By

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WELDING STEEL DECK

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Arc Spot Welding Steel Deck – A Primer

Thomas Sputo, Ph.D., P.E., S.E.

Introduction

Steel deck is often installed using arc spot welds, either with or without weld washers. Arc spot welds (Figure 1.), often referred to as "puddle welds", are similar to plug welds except that the thin top sheet does not require a hole to be pre-punched prior to welding. This article will focus on what an arc spot weld is, how the weld is made, and how to ensure quality welds are produced.

How Are Arc Spot Welds Made?

The arc spot or "puddle" weld is started by striking an arc on the deck surface causing a hole to form in the deck. The weld operation then continues by depositing electrode material on the beam or joist and allowing the molten "puddle" to engage the penetrated deck. It is essential that the finished weld penetrate into the supporting beam or joist and that the puddle engage the deck on the weld perimeter. The complete welding process usually requires 8 to 13 seconds, or perhaps more on multiple deck thicknesses or thicker deck. Research has shown that arc spot weld times and weld quality can vary substantially depending on the welding equipment and technique used to produce the welds. This process requires a welder who is qualified to make these specific welds. Arc spot welds can be made through multiple thicknesses of steel deck, as long as the total base metal (bare steel) thickness of the deck does not exceed 0.15 in.

Arc-puddle welding methods and operator qualifications are described in the American Welding Society *Structural Welding Code for Sheet Steel*, AWS D1.3. The essential issue in forming a good weld rests in bringing the deck and the supporting beam or joist to fusion temperature at the same time, avoiding "burn-out" in the sheet, with adequate penetration into the beam or joist, and with proper puddle engagement on the weld perimeter.

Quality welded connections require that the elements to be joined be in intimate contact for proper heat transfer; seldom can a gap between the deck and the beam or joist be bridged with electrode material. The operator must select weld machine power settings sufficient to provide energy levels to raise the deck and beam or joist to fusion temperature while preserving the integrity of the hole formed in the steel deck.

What are Weld Washers?

Weld washers are small elements of sheet steel with a punched hole at their center and may be curved to fit into the valleys of deck panels (Figure 2). Washers may be of differing thickness and have different hole diameters or hole shapes. The most common type is approximately 0.06" thick with holes of 3/8" in diameter and a minimum ultimate strength of 45 ksi, and may be designated as 3/8" x 16 gage washers. Weld washers are laid in position on the deck units, an arc is struck on the sheet inside the hole, and the operation continues usually until the hole is filled (Figure 3). The weld washer acts as a heat sink and retards burn-away of the sheet. The washer permits welds in thin deck that might otherwise burn away from the welding operation faster than weld material can be deposited.

Should Weld Washers Be Used for All Deck Welding?

Not necessarily.

It is essential to understand the heat issue in welding. The weld washer acts as a heat sink, drawing some of the heat and therefore reducing the energy delivered to the substrate, compared to that delivered in arc-spot welding without washers. For a particular application, an 8 second welding time may be adequate to form a high-quality weld through a weld washer into steel deck thicknesses between 0.015 and 0.028 inch thicknesses. However, using the same washer type and the same welding rates with a thicker steel deck panel, may severely limit heat available for penetration into the substrate. Without sufficient heat, a weld washer used with thicker deck can actually prevent adequate heating, with resulting poor weld penetration and poor weld quality.

It is not uncommon for the washer to reduce or virtually eliminate fusion to the substrate when welds are made through sheets of 22 gage (0.0295") or thicker deck.

Typical 3/8" x 16 gage (0.060") washers are not recommended with deck design thicknesses equal to or greater than 0.028 inches because their use may actually reduce the weld penetration. Weld washers are recommended for welding in deck panels thinner than 0.028 inches.

What is the most common filler metal used for welding steel deck?

The most common filler metal used for welding steel deck is an E6022 electrode, due to the ability of that electrode to produce welds with good penetration and wetting of the weld puddle perimeter. Additionally, load tables for most roof deck and some non-composite (form) deck are based on a specified minimum yield strength of 33 ksi. Accordingly, an E6022 electrode is the "matching" electrode for composite deck, roof deck, and non-composite floor deck with thicknesses of 22 gage or greater.

Deck thinner than 22 gage is usually manufactured from steel with higher yield strength, therefore E7014 electrodes are recommended with weld washers. Electrodes with strengths greater than 70 ksi are not necessary because the heat produced by the welding will anneal the deck in the vicinity of the weld, locally reducing its ultimate strength.

Additionally, the use of low-hydrogen electrodes is seldom necessary and may actually reduce the weld quality due to the higher amperages usually required for these electrodes.

What Welding Parameters Should be Used?

Welding machine power settings required usually are well below those needed for welding in hot-rolled steels. The settings should be such that electrode burn-off rates are between 0.15 inches and 0.25 inches of rod per second in typical E6022 or E7014, 5/32 inch diameter rods. The time required per weld may vary between 3 to 6 seconds or more depending on the properties of parts being connected. Heavier support steel requires more welding time, but increased power settings may burn out the deck faster than electrode material can be deposited.

A preliminary field quality check (Figure 4) can be made by placing a pair of welds in adjacent valleys at one end of a panel. An inspection should show the weld material in fused contact over most of the weld perimeter. Spotty contact may indicate power settings that are excessive. The opposite end of the panel can be rotated, within the panel plane, placing the welds in shear, and continued rotation can lead to separation. Separation, leaving no apparent external perimeter distress, but occurring at the sheet-to structure plane, may indicate insufficient welding time and poor fusion with the support steel. Failure around the external weld perimeter, showing bearing deformations within the panel, but the weld still attached to the support steel, indicates a higher quality weld. The ending of the welding operation may not permit complete fusion on the whole perimeter. Good fusion should be visible over no less than 90 percent of the weld perimeter (Clause 6.1.1.4 of AWS D1.3 permits undercut on 12% of the weld perimeter).

Are Welding Procedure Specification (WPS) documents required for arc spot welding?

Yes. The deck installation contractor is responsible for following AWS D1.3 and Welding Procedure Specification (WPS) documents. A WPS is a detailed document providing required variables for a specific welding application to assure repeatability by properly trained welders and welding operators. WPS documents must be written for all welds permitted as prequalified and all welds qualified in conformance with Clause 4 of AWS D1.3.

Each deck installation contractor must be responsible for inspection and testing of WPS qualification tests and welder performance testing as described in AWS D1.3. Arc spot weld

WPS are not described in Clause 3 of AWS D1.3 and, therefore, must be qualified by testing and recorded on a Procedure Qualification Record (PQR.)

What inspection is required for deck welding?

Visual inspection is required to determine if a weld meets the acceptance criteria of AWS D1.3. It is the deck installation contractor's responsibility to ensure that all WPSs and welders are qualified. The EOR may accept previously qualified or prequalified WPS. However, if the EOR does not accept such evidence, the deck installation contractor must successfully complete the required tests prior to welding.

The SDI has developed the ANSI/SDI QA/QC-2017 "Standard for Quality Control and Quality Assurance for Installation of Steel Deck" which provides requirements for steel deck installation quality in a mandatory format that can be used for inspection purposes. This Standard is available for free download from the SDI website (www.sdi.org) and it is highly recommended that designers require compliance with the quality procedures in the standard through incorporation of the standard in project specifications.

What are the Key Take-Away Points?

1. Arc spot welding is a viable method of deck attachment, however weld quality must be monitored. A proper arc spot weld requires between 3 to 6 seconds, or perhaps longer, depending on the total deck thickness, welding equipment and settings, and environmental factors. It is impossible to make a proper weld with proper fusion in less time. Arc times should be monitored as one aspect of project quality control.
2. Weld washers, due to their heat-sink effect, may actually create welds of lower quality and strength when used with 22 gage or thicker deck. Do not specify weld washers with 22 gage deck.
3. Contractually require the use of the ANSI/SDI QA/QC-2017 "Standard for Quality Control and Quality Assurance for Installation of Steel Deck" to promote quality in deck installation.

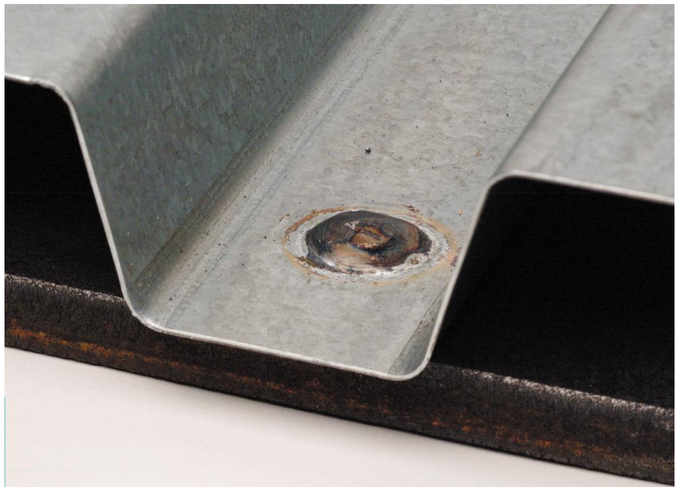

Figure 1. **Arc spot weld**

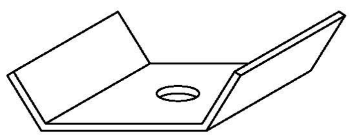

Figure 2. **Typical weld washer**

Figure 3. Arc spot weld with weld washer

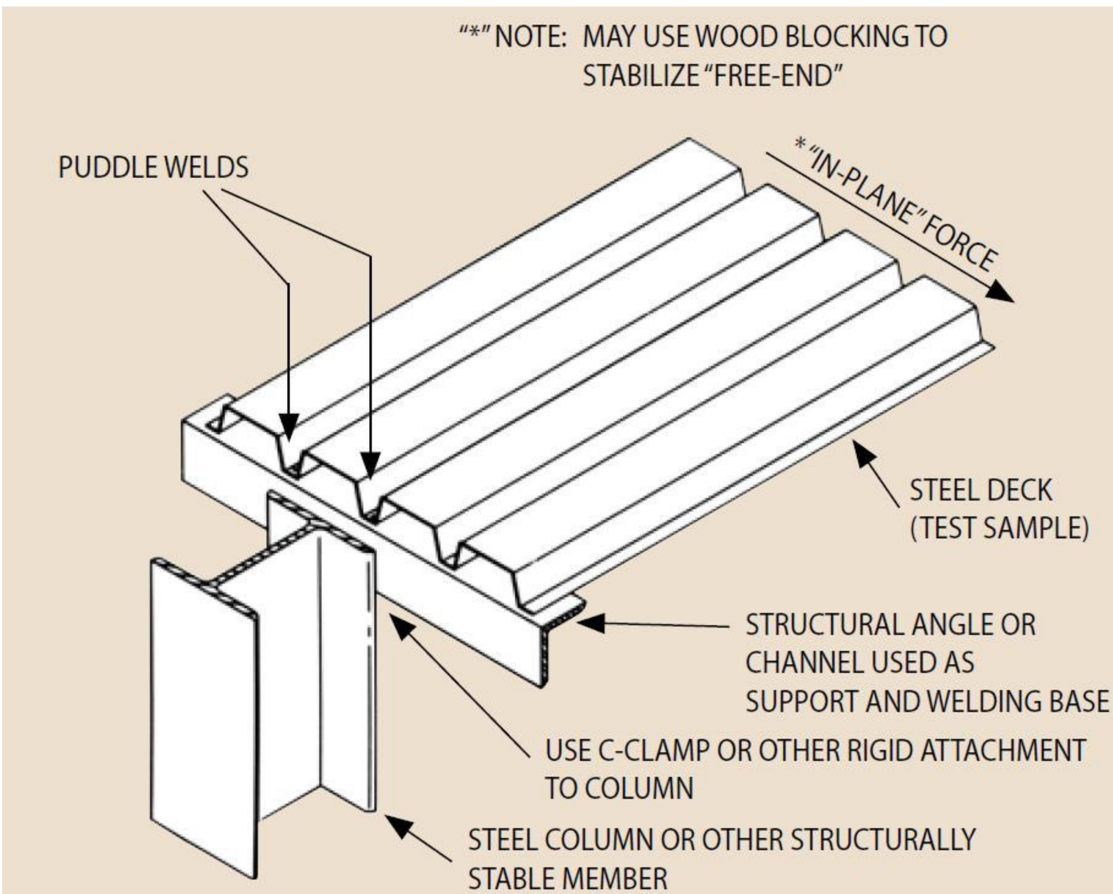

Figure 4. Field quality check procedure

Quality Assurance for Welding Steel Deck

Thomas Sputo, Ph.D., P.E., S.E.

Weld quality is a necessity for welded deck construction. This Technical Note covers quality assurance requirements to develop proper arc spot and arc seam welds.

Quality Assurance (QA) is process oriented and Quality Control (QC) is product oriented. Testing of in-place welds is product oriented and thus is in the QC domain. Testing for quality isn't assuring quality, it is controlling it. Quality Assurance makes sure that quality welds are being made.

AWS D1.3 Requirements

Regarding QA for welds, AWS D1.3:2018 provides a very clear path of what is required. Arc spot and arc seam welds are NOT included as a prequalified weld in Clause 5. Therefore, every arc spot and arc seam weld process MUST be specifically qualified for the specific application. Clause 6 requires the following to qualify an arc spot or arc seam weld process:

> Subclause 6.2 requires that a Welding Procedure Specification (WPS) be prepared (Assembly 6.4 for arc spot or Assembly 6.5A for arc seam). A Procedure Qualification Record (PQR) that records the actual values used to qualify a WPS must be written.
>
> Excerpting from Table 6.2 lists "PQR Essential Variable Changes Requiring WPS Requalification" as follows:

1. Change in classification of electrode (for instance, a change from E6022 to E6010).
2. Change increasing the filler metal strength (for instance a change from E60xx to E70xx, but not vice versa).
3. Change in diameter of the electrode.
4. Changes of more than 10% above or below the melting rate, amperage, or wire feed speed; in the case of arc spot, or arc seam welds, a reduction in melting rate, welding current, or wire feed speed of more than 5%. (these essential variables are basically fixed and cannot be changed without requalification)
5. Change in the type of welding current (AC or DC) or polarity.

6. Change in base metal thickness by more than 10%. (this would require a qualification for every different deck gage)
7. Change in the type of coating material, or addition, but not deletion, of coating material on base metal (qualification with painted deck would qualify for bare deck, but not galvanized deck)
8. An increase exceeding 30% in the thickness of coating of sheet steel. (Change from G30 to G60 to G90 galvanizing is greater than 30%. Qualification with G90 galvanizing would be acceptable for welding G60 deck, but not vice versa)
9. A change in position (Arc spot and arc seam welds are limited to the flat position which is +- 15 degrees from horizontal. Beyond this range requires specific qualification.
10. A decrease in weld design size. (A 5/8" weld would qualify a 3/4" weld)
11. For arc spot welds, a decrease in weld time (Any decrease in weld time for the process will require requalification)
12. For arc seam welds, an increase in travel speed. (Any increase in weld speed for the process will require requalification)

From the essential variables in Table 6.2, it can be seen that qualification of an arc spot or arc seam weld is very specific situation dependent. To reiterate two very key points:

1. A specific WPS is required for each deck thickness (gage) and each number of sheets being welded through (single, or double or quadruple thickness).
2. Arc time and melt rate must be controlled and used as part of Quality Assurance.

Research on Weld Quality

Snow and Easterling (2008) conducted an extensive study of the effects of arc time on arc spot weld quality. The following excerpt is extracted directly from the referenced paper.

"4.1 Weld Arc Time

The three variables having the greatest influence on weld arc time were sheet steel thickness, current setting and weld size. A greater thickness of sheet steel requires more arc time than a thinner sheet for a given current setting and weld size. Higher current settings form larger welds in a smaller amount of time. And smaller weld sizes generally take less time to form than larger weld sizes.

Tests show that the time required to form full-time arc spot welds varies little with respect to the sheet steel thickness. This near constant behavior can be attributed to higher currents being used in thicker steel sheets. Because thicker sheets increase required arc time and higher current settings decrease it, the two essentially offset each other, leaving weld size as the only variable to have an affect on the required arc time.

Tests indicate that the average time required to form a 3/4 in. weld is 12.8 seconds and that the average time required to form a 5/8 in. weld is 8.1 seconds.

4.2 Weld Size and Penetration

Arc time has a significant impact on the overall size of a given weld. When the current setting and the electrode type are held constant, a reduction in arc time will always result in a smaller weld being formed, often far less than the intended nominal size. Measured visual diameters were an average of 7 percent smaller in 2/3-time welds and 21 percent smaller in 1/3-time welds than those seen in full-time welds.

Specimen sectioning indicated that penetration is not directly affected by weld arc time. If the current setting is properly set for the amount of sheet steel being attached, proper penetration can be achieved.

4.3 Comparisons between Measured Dimensions and the 2001 AISI Specification

Although reducing the weld arc time significantly reduces the overall weld size, it has very little effect on the basic weld shape. Both 2/3-time and 1/3-time welds have approximately the same visual diameter to average diameter and visual diameter to effective diameter ratios as those observed in full-time welds. Using the measured visual diameter, comparisons were made between the measured average and effective diameters and those calculated using the 2001 AISI specification. The comparisons prove that the specification *adequately estimates average and effective weld diameters regardless of arc time, given a known visual diameter.*

4.4 Weld Shear Strength

Arc time had a significant impact on weld strength. Full-time welds were an average of 11 percent stronger than 2/3-time welds and 44 percent stronger than 1/3-time welds.

Differences between the strength of full-time welds and reduced time welds increase as the sheet steel thickness is increased. This can be attributed to the slightly smaller effective diameter noticed in reduced time welds.

4.5 Comparisons between Observed Shear Strength and the 2001 AISI Specification

The lower shear strength observed in reduced time welds is directly proportional to the decreased size of the welds. Using the measured visual diameter and not the nominal diameter, the 2001 AISI specification satisfactorily estimates the strength of full-time welds, 2/3-time welds, and 1/3-time welds.

5.1 Requirements for Weld Arc Time

This research has proven that arc time has a tremendous influence on arc spot weld shear strength. It is therefore imperative that measures be taken to insure welds formed in the field are completed using the proper arc time. Currently, welders must be certified at the beginning of each project they undertake that involves deck welding. The welder must form the weld using the same exact electrode and current setting that he/she will be using on the remainder of the project. This weld is then inspected by an AWS certified professional who deems the quality of the weld to be sufficient or insufficient. Provided the weld is sufficient, the welder is allowed to proceed with welding arc spot welds for the project. The chief recommendation concerning the certification process is that it be modified to include arc time. This would give the welder three items *to hold constant; the electrode, the current setting and the arc time (within a certain tolerance). Holding these three items constant would ensure that welds consistent in quality with the initially inspected weld are formed throughout the project."*

Key points from Snow and Easterling (2008) can be summarized as follows:

1. It takes an appreciable time to make a proper arc spot weld. In excess of 8 seconds for a 5/8" diameter weld, and in excess of 13 seconds for a 3/4" diameter weld.

2. Arc time is perhaps the most critical variable to control during field welding, and probably the most violated parameter of the WPS.

Recommendations:

1. All deck installations should be covered by a QA/QC plan. The ANSI/SDI QA/QC Standard is required by the International Building Code for buildings which require special inspections, and can be made a part of the construction contract by incorporation into project specifications for buildings which do not require code mandated special inspection.

2. The requirements for weld qualification contained in AWS D1.3 (and incorporated by reference in ANSI/SDI QA/QC) should be a point of emphasis in all quality plans. Arc time during field installation should be carefully monitored as part of Quality Assurance.

3. Mechanical fasteners (such as screws and power actuated fasteners) also require quality assurance and quality control procedures under ANSI/AWS D1.3, but should be considered as an alternate to welded construction.

References:

AWS D1.3/D1.3M:2018 "Structural Welding Code: Sheet Steel." American Welding Society; Miami, FL.

Snow, Gregory L. and Easterling, Samuel, "Strength of Arc Spot Welds Made in Single and Multiple Steel Sheets" (2008). International Specialty Conference on Cold-Formed Steel Structures. 9. https://scholarsmine.mst.edu/isccss/19iccfss/19iccfss-session9/9

ANSI/SDI QA/QC-2017 "Standard for Quality Control and Quality Assurance for Installation of Steel Deck," Steel Deck Institute; Glenshaw, PA.

Commentary on Application of AWS D1.3-2018 to Welding of Steel Deck

Thomas Sputo, Ph.D., P.E., S.E.

Introduction

The new 2018 Edition of AWS D1.3, *Structural Welding Code - Sheet Steel*, which replaces the previous 2008 Edition, has several changes which effect the welding of steel deck. This document lists content of the Code that is of interest to specifiers, installers, and inspectors of steel deck. The reader of this paper is encouraged to obtain and study the complete AWS D1.3:2018 Code.

As part of the updating process for AWS D1.3, the Code was reformatted to meet the current AWS editorial requirements, which required Clauses 2 through 8 to be rearranged in the 2018 Edition. The reader is alerted to this reformatting

Weld Qualification and Pre-Qualification

AWS D1.3, Clause 5 states that "Prequalification of WPS's (Weld Procedure Specifications) shall be defined as an exemption from the WPS qualification testing in Clause 6." Prequalified joints are limited to square groove welds in butt joints, fillet welds, flare groove welds in butt or corner joints, and flare bevel welds in lap joints. Prequalified welds still require written WPS's, but the testing required in Clause 6 is waived.

All other welds are not considered to be prequalified, including arc spot welds, arc seam welds, and fillet welds on steel thinner than 18 gage, which are commonly used when installing steel deck. These welds require a written WPS and testing as required by Clause 6.

The testing required by Clause 6 will be used to generate a PQR (Procedure Qualification Record) that records the actual values to qualify the WPS. Clause 6.3 permits the engineer to accept the results of previous WPS qualifications.

Therefore, most welding of steel deck is not prequalified, and requires testing to develop a PQR.

This information is a synopsis and the user is urged to study the complete text in AWS D1.3.

Position of Arc Spot Welds

AWS D1.3, Clause 4.3.6.1 states the following regarding the welding position for arc spot welds:

> "These welds are restricted to the welding of sheet steel to supporting structural member in a flat position."

AWS A3.0:2010, *Standard Welding Terms and Definitions* defines the flat position as being plus or minus 15 degrees from level. Fifteen degrees equates to a roof slope of 3.2/12.

However, AWS D1.3, Clause 1.1.2 does permit variance from flat position limit by stating:

> "The fundamental premise of the code is to provide general requirements applicable to any situation. Acceptance criteria for production welds different from those specified in the code shall be permitted for a particular application, provided they are suitably documented by the proposer and approved by the Engineer. These alternate acceptance criteria shall be based upon evaluation of suitability for service using past experience, experimental evidence, or engineering analysis considering material type, service load effects, and environmental factors."

Based on this, an arc spot weld in a position other than flat would be permitted if suitably documented by the proposer and approved by the Engineer. The documentation and acceptance criteria required by Clause 1.1.2 could include Welding Procedure Specifications (WPS) and Procedure Qualification Records (PQR) prepared for welds performed at the intended roof slope. Information regarding WPS and PQR are found in AWS D1.3, Clause 6. As previously noted, arc spot welds in any position are not considered prequalified in Clause 5, and would require WPS and PQR's even in the flat position.

Non-Matching Filler Metals

Clause 1.6.2 was modified and commentary was added to make clear that the use of matching filler metals is not a requirement of AWS D1.3.

> **1.6.2 Other Base Metal-Filler Combinations.** Base metal-filler metal combinations other than those described in 1.4.1 shall be permitted when approved by the Engineer.
> **C-1.6.2 Other Base Metal-Filler Combinations.** The use of undermatching filler metals is an accepted practice in the installation of steel deck in buildings and other structural applications. Attention must should be paid by the Engineer to calculate the strength of the welds.

An example of this would be using an E6022 electrode when arc spot welding ASTM A653 SS Grade 50-2 (F_u = 70 ksi) is welded to steel beams of ASTM A992 (F_u = 65 ksi). A matching electrode (E70) would be based on the ultimate strength of the steel beam. However, the E6022 electrode would be permitted, and the strength of the resulting weld would need to be calculated.

The SDI Diaphragm Design Manual, 4th Edition (DDM04) calculates diaphragm resistance using E60 electrodes, regardless of the deck steel ultimate strength.

Matching Filler Metals

While there is no requirement that matching filler metal be used, when it is desired to use matching filler metal, Clause 1.6.1 of D1.3 has clarified to indicate that when dissimilar steels are welded, that the lower tensile strength base steel controls the electrode.

> **1.6.1 Matching Filler Metals**. When using the indicated weld process, the filler metals listed in Table 1.2 provide a weld joint with strengths matching that of the base metal. When base metals of dissimilar strengths are welded, the filler metal tensile strength shall be equal to or greater than that of the lowest tensile strength base metal.

Therefore, if deck manufactured using ASTM A653 SS Grade 80 (F_u = 90 ksi) is welded to steel beams of ASTM A992 (F_u = 65 ksi), the lower strength steel beam would control what is a matching filler metal.

Requirements for Low-Hydrogen Electrodes

Confusion has existed regarding the need for using low-hydrogen electrodes. To address this confusion, Clause 1.6.4.3 was added to AWS D1.3 to specifically call attention to Note 1 in Table A.1 of Annex A.

> **1.6.4.3 Non Low-Hydrogen Electrodes.** Non low-hydrogen electrodes may be used in a qualified WPS for arc spot, arc seam, and arc plug welds of sheet metal in the flat position to primary structural members thicker than ¼ in [6.4 mm], as limited by Annex A Table A.1 Note 1.
>
> **C-1.6.4.3 Non Low-Hydrogen Electrodes.** Non Low-hydrogen electrodes may be used for arc spot, seam and plug welds. These welds and electrodes are most commonly used for attaching sheet steel deck to structural steel in building construction.

Note 1 of Table A.1 of AWS D1.3 applies to decking in the flat position, using arc spot welds, arc seam welds, or arc plug welds. This Note states that the requirements of AWS D1.1, Clause 5.6 for preheat do not apply when Shielded Metal Arc Welding (SMAW) is used and the WPS has been qualified per AWS D1.3, Clause 6 using non-low hydrogen electrodes and the ambient temperature is greater than or equal to 32 degrees F (0 degrees C).

Therefore, if the ambient temperature is 32 degrees or higher, and the weld was qualified using non-low hydrogen electrodes, the use of low-hydrogen electrodes is not required.

Low hydrogen electrodes fall into the EXX15, EXX16, and EXX18 series, and the low hydrogen designation applies to the moisture content of the flux on the Shielded Metal Arc Weld (SMAW) electrode. Low hydrogen electrodes are typically require greater skill to make acceptable arc spot welds, therefore a non-low hydrogen electrode is preferred. A E6022 electrode is a preferred electrode for SMAW of deck by many installers, and the use of this electrode should not be unnecessarily restricted by designers.

Use of AISI S100 for Calculation of Weld Strength

The International Building Code (IBC) has referenced the AISI S100 Standard for the design of cold-formed steel members and connections and the SDI C, NC, and RD Standards for the design of steel deck. The SDI Standards refer to the AISI S100 Standard for the strength design of welds. However, the IBC also references AWS D1.3 for weld design and qualification. This has led to a potential conflict where AWS D1.3 and AISI S100 have different strength design equations for welds.

The strength equations in AWS D1.3, Clause 4 are written in Allowable Strength Design (ASD) format, with the factor of safety being directly incorporated into the equations. Additionally, the AWS strength design equations have not been updated to include the results of research on weld strength.

In order to address this potential conflict, AWS D1.3 has added Clause 4.2 which specifically permits the use of AISI S100 strength design equations.

> **4.2 Alternate Allowable Load Capacities in Weld Joints.** Load capacities shall be determined by the applicable section of AISI S100 "Specification for the Design of Cold-Formed Steel Structural Members.", or as described in clauses 4.2.2 to 4.2.6.
>
> **C-4.2. Alternate Determination of Load Capacity in Weld Joints.** Subclauses 4.2.1, 4.2.2, 4.2.3, 4.2.4, and 4.2.5 may be substituted by the applicable section of AISI S100 "Specification for the Design of Cold-Formed Steel Structural Members."

AISI S100 still requires the application of AWS D1.3 for methods of making welds and weld quality and qualification.

Base Metal Preparation

New clarifying text has been added to AWS D1.3, Clause 7.2 to address the level of base steel preparation prior to welding.

7.2.1 General. Base metal shall be sufficiently clean such that welds will meet the quality requirements of this code.

7.2.2 Mill-Induced Surface Defects. Welds shall not be placed on surfaces that contain fins, tears, cracks, slag, or other base metal defects as defined in the base metal specifications.

7.2.3 Scale and Rust. Loose scale, heavy scale, and heavy rust shall be removed from the surfaces to be welded, and from surfaces adjacent to the weld. Welds may be made on surfaces that contain mill scale and rust if the mill scale and rust can withstand vigorous hand wire brushing and if the applicable quality requirements of this code are met.

The clarified requirements of Clause 7.2.3 permit normal surface preparation that is used for structural steel framing to be accepted as minimal base metal preparation for welding.

Water or Paint on Base Metal

Previous editions of AWS D1.3 required dry surfaces with no moisture. This requirement is not practical in application on job sites. Indeed, testing has been performed that showed that it is possible to make acceptable arc spot welds through standing water. In light of this, and other testing on galvanized and painted surfaces, Clause 7.2.4 has been modified to permit residual amounts of water and galvanizing and paint. The Commentary to this Clause provide good clarification.

7.2.4 Foreign materials.

7.2.4.1 Surfaces to be welded, and surfaces adjacent to the weld, shall be cleaned to remove excessive quantities of the following:

(1) Water

(2) Oil

(3) Grease

(4) Other hydrocarbon based materials

Welding on surfaces containing residual amounts of foreign materials is permitted providing the quality requirements of this code are met.

7.2.4.2 Welds are permitted to be made on surfaces with surface protective coatings or anti-spatter compounds providing the quality requirements of this code are met.

C-7.2 Preparation of Base Metal

C-7.2.1 General. For quality welds, base metal cleanliness is important. However, it is neither required nor necessary for base metal to be perfectly clean before welds are made. It is difficult both to establish quantifiable limits of cleanliness and to measure to those limits therefore, this provision uses the practical standard of the resultant weld quality. If the base metal is sufficiently clean so as to facilitate a weld to be made that meets the requirements of this code, it is clean enough. If the resultant welds do not meet the quality requirements of this code, cleaner base metal may be required.

C-7.2.2 Mill-Induced Surface Defects. The base metal to which welds are attached must be sufficiently sound so as to not affect the strength of the connection. Base metal defects may be repaired prior to the deposition of the prescribed weld. This clause does not limit base metal repairs by welding. Defects that may be exposed on cut edges are governed by Clause 7.2.1.

C-7.2.3 Scale and Rust. Excessive rust or scale can negatively affect weld quality. The code permits welding on surfaces that contain mill scale, providing both:

1) the mill scale remains intact after wire brushing and

2) the resultant weld quality is not adversely affected. See C-7.2.1

C-7.2.4 Foreign materials. This clause prohibits volumetric (three dimensional) quantities of contaminants to be left in place on the surface to be welded and adjacent areas. Surfaces contaminated by the materials listed in Clause 7.2.4.1 must be cleaned, such as by wiping prior to welding. Special consideration should be given to the removal of surface contaminants containing hydrocarbons or condensed moisture, as the hydrogen released into the molten weld pool can cause serious weld imperfections, e.g., cracking. The cleaning operations, which may involve just wiping, need not remove all foreign contaminants nor do they require the use of solvents; welding through thin layers of remaining contaminants is acceptable, unless they degrade the quality requirements of this code resulting in unacceptable welds.

Concern about hydrogen from water or hydrocarbons contributing to hydrogen embitterment are not valid because hydrogen embitterment does not occur in steels with ultimate strengths of less than 150 ksi, which is substantially higher than any steel used for deck or framing.

Conclusions

Changes to the AWS D1.3 Code provide clarification on requirements for welding of steel deck. The 2015 and 2018 Editions of the International Building Code continue to reference the 2008 Edition of AWS D1.3 as a sub-reference through the SDI Standards in Chapter 22, however, with the approval of the Authority Having Jurisdiction (AHJ), more current editions of referenced documents may be used. Because the 2018 Edition of AWS D1.3 clarifies several topics, the use of this more recent edition is recommended.

References

AWS A3.0:2010, *Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying,* American Welding Society, Miami FL, 2010.

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SDI C-2017, Standard for Composite Steel Floor Deck-Slabs, Steel Deck Institute, Glenshaw PA, 2017.

SDI DDM04, Diaphragm Design Manual, 4th Edition, Steel Deck Institute, Glenshaw PA, 2016.

SDI NC-2017, Standard for Non-composite Steel Floor Deck, Steel Deck Institute, Glenshaw PA, 2017.

SDI RD-2017, Standard for Steel Roof Deck, Steel Deck Institute, Glenshaw PA, 2017.

Welding Steel Deck – Quiz

Updated 4-6-2020

1. An arc spot weld is also referred to as a(n) ____________________.

a. Fillet Weld
b. Plug Weld
c. Puddle Weld
d. Seam Weld

2. A quality arc spot weld should take no less than __________ seconds to form.

a. 6
b. 8
c. 10
d. None of the above

3. Weld washers are not recommended with deck design thicknesses equal to or greater than _______ inches

a. 0.028
b. 0.030
c. 0.026
d. 0.023

4. The most common filler metal used for welding steel deck is an ______ electrode

a. E8022
b. E5014
c. E7014
d. E6022

5. An arc spot weld is not a prequalified weld.

a. True
b. False

6. Allowable load capacities for welds in sheet steel can be calculated using _____.

a. AWS D1.3
b. AISI S100
c. AISC 360
d. Either a. or b.

7. AWS D1.3 requires surfaces to be welded to be perfectly clean.

a. True
b. False

8. Which is a change to an essential variable requiring a WPS requalification?

a. Deletion of coating material on sheet steel
b. An increase of 10% in the thickness of coating of sheet steel
c. A decrease in the filler metal strength.
d. An increase in weld design size.

9. Good fusion should be visible over no less than ___ percent of the weld perimeter.

a. 70
b. 80
c. 90
d. 95

10. _________ is perhaps the most critical variable to control during field welding, and probably the most violated parameter of the WPS

a. Amperage
b. Arc time
c. Surface Preparation
d. Electrode Selection