Summary of Changes in

ASME Section IX, 2004 Edition

Published in the Welding Journal
October, 2004

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The following is a summary of the changes that appear in 2004 addenda of ASME Section IX. These changes and related discussion are reported by Walter J. Sperko, P.E., Vice-chairman of Subcommittee IX; Readers are advised that the opinions expressed in this article are those of Mr. Sperko and not the official opinion of Subcommittee IX.

Welding Procedure (QW-200) Changes

Section IX has always permitted WPSs to specify more than one welding process and it has permitted test coupons to be welded with more than one process; however, previous rules in QW-200.4 covering this used the term "procedure" somewhat loosely, making its real meaning elusive. In this addenda, QW-200.2 has been changed to require that the approximate weld deposit thickness for each process, filler metal and set of variables be recorded when a test coupon is welded and more than one process, filler metal or other essential variable is used,. For example, if a test coupon is welded using GMAW and a portion is welded using short circuiting transfer and the remainder using spray transfer, the approximate deposit thickness for each transfer mode has to be recorded.

The term "procedure" in QW-200.4 has been replaced with WPS, making it clear that multiple WPSs may be used to weld a single production joint. In addition, when a WPS specifies multiple welding processes or sets of variables, QW-200.4 permits individual welding processes and sets of variables be used independently provided one stays within the limits of the variables for that process. That is, for a WPS specifying GMAW in both the short-circuiting and spray transfer modes, each transfer mode variation may be used independently provided the weld deposit limits, preheat and interpass temperature limits, etc for each variation are met during production welding.

QW-404.12 and QW-404.33 were the subject of an inquiry by a user who was unclear what an "SFA filler metal specification classification" was. This paragraph first phrase now reads: "A change in the filler metal classification within an SFA specification." QW-404.12 always intended that the classification of the filler metal (e.g., E7018, ER70S-6, etc) be specified in the WPS and, for impact tested applications, QW-404.33 always intended that the filler metal in the WPS be limited to the classification that was used on the test coupon.

There is an errata in the side bend test specimen Figure QW-462.2 that was discovered after the addenda was printed; where the figure shows the radius along the edge of the specimen as 1/8 in *minimum*, it should be *maximum*. This will be corrected in the next addenda, but will also be published at www.asme.org under Codes and Standards.

The biggest change in this addenda was the addition of QW-290 for writing and qualifying WPSs for temper bead welding. Development of these rules began in 1999.

Temper bead welding is a technique in which the properties of the heat-affected zone (HAZ) or the previously deposited weld metal are controlled (i.e., "tempered") by the manner in which subsequent layers of weld metal are deposited. The most common reason to use temper bead welding is as an alternative to postweld heat treatment when post weld heat treatment is impractical. Temper bead is permitted today mostly for maintenance and repair applications.

Subcommittee IX developed temper bead rules because various Construction Codes (i.e, Section III, Section VIII, B31.3, etc.) and National Board Inspection Code had adopted a variety rules for temper bead welding that were neither uniform nor consistent. The Section IX temper bead rules will correct this. In addition, Section IX's rules replace prescriptive requirements with the more traditional Section IX approach of making the manufacturer or contractor responsible for determining how to make a specific type of weld, then having him qualify his WPS accordingly. This will provide more flexibility to users than the present prescriptive requirements allow.

QW-290 requires bend testing of test coupons and provides for either hardness testing or impact testing to be specified by the Construction Code as well as acceptance criteria. In the event that they do not specify a test method, the default test method is hardness testing with hardness data recorded for information only. When qualification by impact testing is required, the Construction Codes will be responsible for specifying the extent of testing (i.e., weld metal, HAZ and base metal) and location within each region as well as the test temperature.

Just as supplementary essential variables are "turned on" when a Construction Code requires that a WPS be qualified with impact testing, so, too, use of temper bead welding in accordance with QW-290 must be specified by the Construction Code.

Also paralleling impact testing rules, an existing WPS that is not qualified for temper bead welding may be upgraded simply by preparing a separate test coupon and performing the required testing for temper bead welding. If the basis for qualification for temper bead welding is impact testing, the WPS being upgraded must be qualified with supplemental essential variables. Partial penetration welds (such as repair welds) may be qualified by making a partial penetration weld, but full-penetration groove welds must be qualified by making full-penetration groove welds. Partial or full penetration groove welds qualify fillet welds.

All consumable electrode welding processes and machine GTAW are permitted to be used for temper bead welding. Manual GTAW is prohibited because, unlike consumable electrode welding, there is no correlation between the arc energy and the size of the weld bead associated with that energy. For machine GTAW, an advanced heat input formula that takes into account the ratio of heat input to the filler metal size and feed rate is specified. In-process repairs using manual GTAW are permitted, but a special WPS that is based on machine welding qualifications must be developed, and special welder qualification is required.

The variables for temper bead welding are covered in table QW-290.4. This table has separate columns of essential variables for qualification by hardness testing and by impact testing. The test method specified by the Construction Code determines the column that applies to the qualification. If no test method is specified, the hardness testing column applies. The nonessential variables column always applies.

It is interesting to compare the requirements for temper bead qualification using hardness testing vs. impact testing as the basis for qualification. Since increased hardness is the result of *faster* cooling and loss of toughness is caused by *slower* cooling, the variables in each column are frequently opposites. For example, when hardness testing is the basis for acceptance, *increasing* the thickness of the base metal beyond the thickness qualified is not permitted, but when impact testing is the basis for acceptance, *decreasing* the thickness below the thickness qualified is not permitted.

The most novel concept in the temper bead rules is controlling the ratios of heat input between weld bead layers. In order to control properties, the heat input or bead size of the first layer of weld metal against the base metal in the test coupon is measured. Then the heat input or bead size of the second layer is measured, and so on. When doing production welding, the ratio of heat input or bead size between the weld metal that is against the base metal and the layer of weld metal on top of that layer must be controlled to within a percentage of the ratio qualified, and so on for each subsequent pair of layers until at least 3/16 in. (5 mm) of weld metal has been deposited. At that point, the heat input or bead size is the *maximum* used on the test coupon if impact testing is the basis for qualification, and it is the *minimum* used on the test coupon if hardness testing is the basis for qualification.

Another interesting aspect of temper bead welding is the use of a surface temper bead reinforcing layer. This is weld metal that is added after welding is essentially complete. The function of this layer is to temper the final layer of weld metal, particularly the HAZ at the toe of the weld. Controlling the distance from the toe of the completed weld to the edge of the surface temper bead reinforcing layer is critical to tempering the HAZ. If the distance is too close, the HAZ will reharden on cooling; if it is too far, the desired tempering will not occur. The optimum distance depends on the heat input of the tempering bead, but is typically around 1/8 in (3 mm). Surface Temper bead reinforcing layers are usually removed by grinding, but sometimes that is not necessary depending on the properties of the weld metal.

Anyone who performs qualification of WPSs for temper bead welding should document the following in addition to the variables in QW-290 since, due to early industry feedback, the Subcommittee is considering imposing them as essential variables in the next addenda:

1) bead overlap
2) Grinding to remove a portion of beads (e.g., flat topping or half-bead grinding) prior to depositing the next layer
3) Surface temper weld bead placement relative to the toe of the weld.

QW-290 is not presently permitted by any Construction Codes, but a Section XI Code Case is being prepared to permit its use. Other Sections and codes will follow. Long term, the temper bead rules will offer a method for improving toughness and ductility of welds as an alternative to postweld heat treatment..

Welder Qualification (QW-300) Changes

There are no changes for welder or welding operator qualifications

Base Metals and Filler Metals

S-numbers have always been somewhat confusing to Code users, particularly occasional users. QW-420.2, for instance, said that S-number materials were "optional." The fact is that S-number materials behave the same as P-numbers -- except that they are different. S-numbers, as readers will recall from previous articles, are assigned to materials that are found in the ASME B31 Code for Pressure Piping, but are not recognized materials in the Boiler and Pressure Vessel Code; ASME policy prohibits these materials from being assigned P-numbers.

P-numbers and S-numbers are assigned to materials on the same technical basis -- weldability. From a welding viewpoint, materials that are assigned to the same P- or S-Number have equivalent weldability. (i.e., all materials assigned S-3 require the same welding practices as materials assigned P-3). QW-420.2 has been revised to simplify the rules regarding S-numbers and their restrictions and limitations. According to this paragraph, P-number materials are fully interchangeable with S-number materials for welder qualification. In contrast, if a WPS is qualified using P-number materials, equivalent S-number materials may also be welded; however, if the WPS is qualified using S-number materials, only S-number materials are qualified. With apologies to Dickens, 'tis a far, far better thing to weld test coupons using materials assigned P-numbers than to weld materials assigned S-numbers . . . .

To take this clarification one step further, QW-423, which allows substitution of alternate base metals for welder qualification, has been revised to say that qualification with *either* P-number or S-number materials qualifies the welder for *both* P-number and S-number materials. QW-424, which controls qualification of base metals for procedure qualification, now says that when P-number materials are used for procedure qualification, such a qualification supports welding corresponding P-number and S-number materials. One still has to read QW-420.2 to find out that procedures qualified with S-number materials only qualify corresponding S-number materials.

A new family of alloys, UNS R31233, has been added to the P-number listing as P-49. This is a cobalt-based alloy with 26% chromium, 9% nickel, 5% molybdenum, iron and tungsten., Nickel and cobalt are interchangeable from a weldability viewpoint, so this alloy fits in the general category of the other nickel alloys. Interestingly, the Subcommittee elected to skip P-numbers 47 and 48 to leave room for new "true" nickel alloys.

For those with internet access, finding the P or S-number of a base metal can be done at www.pnumbers.com. This site is not an ASME-sanctioned site, but it contains a table of all the metals listed in QW/QB-422. This table can be sorted by any column in QW/QB-422 (i.e., by specification, grade, P-number, product form, etc.). There is also a site www.fnumbers.com that covers filler metals.

Standard Welding Procedure Specifications (SWPSs)

Five new SWPSs have been added to Appendix E. They cover P/S-1 to P/S-8 base metals from 1/8 to 1-1/2 inches in thickness. Welding is permitted with SMAW and GTAW using type 309 and 309L filler. Separate SWPSs using GTAW with and without consumable inserts are provided.

Brazing (QB) Changes

The tensile test specimens used for brazing have been revised to allow use of specimens that are pinned to the tensile testing machine using a hole through the wide section of the specimen through which a dowel is inserted above the jaws of the tensile testing machine prior to loading. With a pinned specimen, the load into the specimen passes through the pin, eliminating deformation of the specimen due to the clamping action of the jaws. Clamping action of the jaws sometimes deforms the specimen so much that failure occurs at the edge of the deformation outside the reduced section -- nowhere near the weld. . This is test specimen is consistent with AWS B2.2 and C3.2 requirements.

Metrication

This edition will include metric units throughout all Sections. Metric conversions in Section IX are rational conversions, not mathematical conversions. That is we selected the metric units that we would have selected had we been working in metric all along. For example, if a test coupon was 1-1-/2 inches (38 mm) thick, the base metal thickness range qualified used to be 3/16 to 8 inches or 4.8 to 203 mm. In this addenda, the metric range qualified is 5 to 200 mm, which makes more sense if one is working in the metric system.

The foreword states that the Code user must elect to work in either US customary units or in metric units and that he must use one system for all phases of construction (materials, design, fabrication, etc.) without mixing of units. Appendix F permits conversion of US Customary units to metric using three significant figures where conversions are not provided by the Code. It would be reasonable to apply this practice to those values found on PQRs in the event that one is required to prepare metric WPSs. There is no intention to require requalification using metric-unit materials in order to write metric-version WPSs.

Coming Attractions

.As mentioned above, the committee has already received comments on the temper bead rules, and some new requirements will be added. There are changes being made to resistance welding, including changes to variables to bring them up to current technology and a new, more meaningful set of tests will be imposed.

Readers are advised that ASME Code Committee meetings are open to the public; the schedule is available on the writer's web site and at www.asme.org.

Mr. Sperko is President of Sperko Engineering, a company that provides consulting services in welding, metallurgy, corrosion and ASME Code issues located at www.sperkoengineering.com. He also teaches publicly offered seminars sponsored by ASME on how to efficiently and competently use Section IX. He can be reached at 336-674-0600, FAX at 336-674-0202 and by e-mail at: sperko@asme.org.

Sketch showing Temper Bead Layers