Summary of Changes in

ASME Section IX, 2010 Edition

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The following is a summary of the changes that appear in 2010 Edition, of ASME Section IX. Significant changes and related discussion are reported by Walter J. Sperko, P.E., Vice-chairman of Subcommittee IX; minor changes, such as editorial corrections, are readily identified in the "Summary of Changes" which begins on page (c) of the Addenda. Readers are advised that the opinions expressed in this article are those of Mr. Sperko and not the official opinion of BPV Standards Committee IX. These changes become mandatory January 1, 2011.

Welding Procedure (QW-200) Changes

Compared to last year's changes, the changes to Section IX for the 2010 edition are mild. No new P-numbers and no big changes to the P-number table. Let us rejoice!

Most of us in the welding industry are aware that equipment manufacturers have moved from motor-generator welding power supplies to solid-state power supplies over the last 30 years. This trend, like advancements with computers, has made power supplies smaller, more efficient and more versatile. The latest innovation introduced "waveform shape control technology" that allows the power source to respond very rapidly to conditions at the arc; with the proper programming of the power source computer, welding, particularly GMAW, is easier to learn to use and is more productive than welding with previous generations of power supplies.

Waveform shape controlled power supplies sense the volts and amps at sampling frequencies as high as 10 kHz; this allows the power source designer to do things that were impossible before, such as suppress the high-current surge that occurs in GMAW-S as the molten droplet of metal on the end of the wire touches the weld pool at the beginning of a short circuit; this virtually eliminates spatter. This ability to rapidly control the volts and amps also allows the programmer to control the transfer of metal across the arc very closely in spray pulse welding, precisely controlling the droplet shape, the bead shape, penetration, wetting and arc energy.

One down side of this technology is that ordinary volt and ammeters, even RMS meters, do not measure the arc energy (i.e., volts X amps) accurately, and, even worse, the deviation from true energy when using ordinary meters can deviate 30% over *or under* the true arc energy. Further, there is no predictable pattern, so a simple offset value cannot be used. If the arc energy readings are off, that means that any readings on volt or ammeters are of questionable accuracy. The other down of this technology is that it is not cheap.

Let's examine the easy change to Section IX first. GMAW waveform controlled power supplies require the welder to input the wire type and size, the shielding gas composition and the wire feed speed; this allows the programming to control the volts and the amps very precisely and rapidly during welding. While the welder can adjust the arc force (referred to as the "Arc Length" or "Trim" by different power source manufacturers), there is no way for the welder to set the voltage since the computer controls it -- and the amperage. This presents a problem when writing a WPS since QW-409.8 requires that the voltage be specified for GMAW.

BPV Committee IX recognized that there was no longer a way for the welder to set the voltage when using when using waveform controlled power supplies, and, of course, that any volt and ammeter readings are of questionable accuracy. Accordingly, the Committee tweaked QW-409.8 to exempt WPSs that specify use of a waveform controlled welding from specifying the voltage, just like it exempts SMAW and GTAW because the welder cannot set or control the voltage with those processes either. While voltage does not have to be specified when using these power supplies, the WPS will have to provide the welder with the wire type and size, shielding gas and any other information the power source needs to activate the correct program to control the arc. Since amperage is meaningless when using these power supplies, the WPSs should also specify the wire feed speed range to provide meaningful direction to the welder.

How does one recognize a waveform controlled power source? Power sources that support rapidly pulsing processes (e.g., GMAW-P) are the most common waveform controlled power sources. Power sources that are marketed as synergic, programmable or microprocessor controlled are generally capable of waveform controlled welding. To assist in defining what a waveform controlled power supply is, Section IX has two new definitions:

> *Waveform controlled welding*: A welding process modification of the voltage and/or current wave shape to control characteristics such as droplet shape, penetration, wetting, bead shape or transfer mode(s).
>
> *Instantaneous power or energy*: As used for waveform controlled welding, the determination of power or energy using the product of current and voltage measurements made at rapid intervals which capture brief changes in the welding waveform.

If in doubt, ask the power source manufacturer.

Most waveform controlled power sources can also be used without the waveform shape controls active; if that is permitted by the WPS, then voltage must be specified in the WPS when waveform control is inactive.

It should be noted that waveform control does not automatically imply that the transfer mode is pulsed transfer, even though the power may be pulsing. Waveform controlled power sources that have programs that are suitable for welding open root joints made from one side will be operating in the short-circuiting transfer mode. If in doubt, ask the power source manufacturer what the transfer mode is for your particular setup.

On to the more challenging aspect of this technology – measuring heat input. With waveform control of the power source, ordinary volt and ammeters are useless for determining arc energy; the only way to measure the arc energy is to measure the volts and amps *instantaneously* and to integrate those measurements over time. Scary, huh. . . One can buy specialized hand-held meter such as the Fluke 345 Power Quality Clamp Meter that will sample the volts and amps at high frequency and provide the required integration to give a power reading, and for some old pulsing power supplies, this may the only route available. Fortunately for most of us, computer controlled power supplies are capable of measuring and recording the volts and amps at the same frequency that the computers control those volts and amps. Since they are computers, they can perform the necessary calculations of instantaneous arc energy over time to provide a display of accumulated Joules used during the arc-on time or instantaneous energy (Joules/second or Watts). The formulae for heat input using instantaneous energy or power measurements are:

QW-409.1 specifies the following for instantaneous energy measurements in joules (J):

$$\text{Heat input [J/in. (J/mm)]} = \frac{\text{Energy (J)}}{\text{Weld Bead Length [in. (mm)]}}$$

For instantaneous power measurements in joules per second (J/s) or Watts (W):

$$\text{Heat input [J/in. (J/mm)]} = \frac{\text{Power (J/s or W) x arc time (s)}}{\text{Weld Bead Length [in. (mm)]}}$$

Other work where the control of heat input is required is for the application of corrosion-resistant weld metal overlay and temper bead welding; the heat input variables in these variables refer back to QW-409.1 for the appropriate formula when using waveform controlled power sources. When waveform controlled power sources are operating in the non-waveform controlled mode, the ordinary heat input formula is applicable:

$$\text{Heat input [J/in. (J/mm)]} = \frac{\text{Volts X Amps X 60}}{\text{Travel Speed [in./min(mm/min)]}}$$

Appropriate instruction needs to be provided to the welder on how to apply the meter readings to determine the required travel speed for the power that he will be using. Section IX does not require any separate testing of the welder when using waveform controlled power sources, but they are sufficiently different that a welder qualified with an ordinary power source should get training in how to use his new waveform controlled power supply, and he should practice with it before going into production. Similarly, if a welder has learned to weld using a waveform controlled power source, he should practice using a non-waveform controlled power source if he will use one in production. The last section of Appendix H further addresses these concerns, but it provides no requirements.

What if you have a waveform controlled power source but it does not show a Joules, power or Watts in the display? Contact the manufacturer – an upgrade may be available; for many units, this will be a software upgrade. For those who have older waveform controlled power sources that cannot be upgraded, the only route to measure power is to purchase add-on meters which are expected to be on the market soon.

You will be pleased to know that Forms QW-482 and QW-483 for the WPS and PQR respectively have been revised to show a new column for "Power or Energy" and also "wire feed speed." Remember that the forms are nonmandatory – you may also develop and use your own forms as long as every essential, nonessential and, when the construction code requires that the WPS be qualified with impact testing, the supplementary essential variables are addressed.

Now for the tricky part. What if you have WPSs qualified with non-waveform controlled power sources and you need to write WPSs for use with waveform controlled power sources? How about the reverse of that scenario? The committee prepared Appendix H which provides guidance on these matters. In brief, when qualifying a new WPS that will specify using a waveform controlled power source, the instantaneous power or energy must be used to calculate the heat input qualified using the appropriate instantaneous power formula. When a waveform controlled power source is used in a non-waveform mode, either the instantaneous power or energy or the traditional formula using volts and amps shall be used to calculate the heat input. Once the heat input is determined and recorded on the PQR, the WPS must specify the heat input limits. When the WPS specifies waveform controlled welding, the instantaneous power or energy per unit length of weld bead must be specified. When the WPS specifies non-waveform controlled welding using a waveform controlled power source, either the instantaneous power or energy per unit length of weld bead or the more traditional volts, amp and travel speed limits must be specified. When the WPS specifies a conventional power source, the WPS must specify the more traditional volts, amps and travel speed limits.

One obvious conclusion is that WPSs that have been qualified using traditional non-waveform controlled power supplies may be revised to specify power or energy per unit length of weld bead when specifying use of a waveform controlled power source without requalification. For waveform controlled power supplies that cannot be upgraded to show power or energy, the use of an external instantaneous power meter is necessary to accurately measure arc power or energy; for PQRs where the test coupon was welded using waveform controlled power supplies without knowing the instantaneous power or energy (i.e. those that you qualified before you knew about the need to measure instantaneous power), it may be possible to establish the true heat input if sufficient data was recorded on the PQR showing the power source settings and the energy or power is established by welding a bead on plate using an instantaneous power meter.

Alternatively, if the exact power source settings had been recorded and those settings are what is specified on the WPS, it would not be necessary to establish the instantaneous power or energy. Unfortunately, this approach would be manufacturer, model and program-specific to be valid, so requalification of the WPS may be necessary. If this is your situation, keep in mind that the test coupon you weld for impact tested qualifications only has to be big enough to extract the required impact test specimens and that tension and bend testing normally does not have to be repeated; see QW-401.3.

Anytime heat input limits are specified, the direction to the welder should be given in a form that is easy for the welder to work with. Using the power or energy route, the WPS can specify that the power or energy per inch of weld may not exceed some value. The welder deposits a weld bead of some length, measures that length and divides it into the power or energy X seconds shown on the power or energy meter. That is, if the maximum heat input qualified is 39 kJ/in. and the welder deposits a weld bead 10 inches long, the welder is within the heat input limit of 39 kJ/in. if the energy meter shows less than 390 kJ to make that weld bead. For the more traditional measurement, a convenient way to give the welder guidance is with a table. Again, assuming the same qualified maximum heat input, one might specify a voltage range of 28 to 30, then using 30 volts, prepare the following table:

Amps	Maximum Volts	Minimum Travel Speed (ipm)
70 to 85	26	3.4
86 to100	26	4.0
100 to 115	26	4.6
116 to140	26	5.6
141 to 160	27	6.4
161 to 180	27	7.2
181 to 210	28	8.5
211 to 250	30	10.0

This way the welder only has to determine his travel speed. WPSs should not simply specify that the "Heat input shall not exceed 39,000 joules per inch" unless welders have has very specific and special training to know how to figure out the required travel speed for any given set of volts and amps.

On to simpler changes. Table QW-451 has a new footnote limiting the thickness of base metal and weld metal qualified to 2T or 2t respectively for electrogas welding. There was no limit the way the table was written before.

Several supplementary essential variables such as QW-403.6, QW-406.3, QW-407.4, QW-409.1 and QW-410.9 state that they do not apply when the weld is heat treated above the upper transformation temperature or an austenitic material is given a solution heat treatment because the effects of base material thickness, interpass temperature and heat input are wiped away by these heat treatments. Solution heat treating a duplex stainless steel has the same effect, and these addenda revised the above variables to make them not applicable when either an austenitic or a duplex stainless steel is solution heat treated. Duplex stainless steel is P-10H.

Welder Qualification (QW-300) Changes

Welders and welding operator test coupons and production welds will be allowed to be ultrasonically examined as of the 2010 Edition of Section IX. Generally where the term "radiography" or its derivatives have been used in Section IX in the past, the phrase "or ultrasonic examination" has been added or "volumetric NDE" is used. QW-191.2 on the ultrasonic examination method has been added, and, paralleling the requirements for radiography, refers to ASME BPV Section V for technique. The acceptance criteria are similar to those for radiography. It also specifies that technicians performing ultrasonic examinations have to be qualified in accordance with the manufacturer or contractor's written practice which has to meet ASNT SNT-TC-1A, or they may be qualified by ASNT Central Certification or CP-189.

The limits of QW-304 for welders and QW-305 for welding operators regarding using radiography instead of visual examination plus bend testing apply when the test coupon will be ultrasonically examined, except that ultrasonic examination *may* be used to examine test coupons that were welded using GMAW in the short-circuiting transfer mode. While lack of fusion defects, the rogue flaw characteristic of GMAW-S can be difficult to find using radiography, that is not the case when using ultrasonic examination.

The big limit on using ultrasonic examination on performance qualification tests, however, is that the coupon or production weld must be ½ inch thick or thicker.

Forms QW-484A and QW-484B have been revised to add a check box choice of RT or UT when volumetric NDE is performed.

One subtle change that was not directly associated with addition of ultrasonic examination of performance test coupons but resulted from discussion during the meeting is that QW-191.1.2.3, was revised. That paragraph said that when a welder qualified on a production weld, the acceptance criteria were that specified in the Code Section applicable to the component that was being built. No more. When a welder or operator is qualified on a production weld, the acceptance criteria are the same as for a test coupon.

Sketches in QW-462.4 and QW-462.5 were revised to eliminate hidden lines where cuts were to be made for examination of metallographic cross-sections. The sketches now show only cut lines.

Last year I mentioned inquiry IX-07-11 which asked if a person making adjustments of the volts, amps, wire feed speed or other settings at the direction of a qualified welder or welding operator had to also be a qualified welder or welding operator, and the reply was no. The following definitions were revised (*shown in italics*) to address the issue:

welding, operator: one who operates *or directs the operation* of machine or automatic welding equipment.

welding, machine: welding with equipment that has controls that are manually adjusted by the welding operator *or adjusted under the welding operator's direction* in response to visual observation of the welding, with the torch, gun, or electrode holder held by a mechanical device.

It's always reassuring to know that if a welding operator hollers: "Joe, gimme 5 more amps!" that Joe does not have to be qualified to run the machine.

Finally, Table QW-452.5, which covers qualification of welders by fillet weld test, has been revised to allow use of test coupons 3/16 inches thick or greater; previously, the first line of the table required test coupons to be 3/16 to 3/8 in. (5 to 10 mm) thick. This change was the result of an intent interpretation that asked if the committee really meant to limit the test coupon thickness – and we couldn't find a good reason for the limit – so we made it more open and flexible. You can use a test coupon of any thickness over 3/16 in. (5 mm). The second line of the table covers test coupons less than 3/16 in (5 mm) and is unchanged.

Base Metals and Filler Metals

As a result of last year's removal of S-numbers, some materials were reevaluated and deleted from QW/QB-422. This was due to inadequate chemical composition limits in the specifications. The deleted are: A-148, structural castings, A-521, die forgings, and A-688, high-strength forgings. Tensile strengths listed for some materials previously were removed and replaced with "• • • " because the material specification did not have a specified minimum tensile strength. A sentence was also added to QW-420 saying that, for materials listed in QW/QB-422, only those that have a specified minimum tensile strength may be used for groove weld procedure qualification test coupons.

A pile of new materials were added to QW/QB-422, including several European materials. SA/EN 10028-1, Grades P335GH of C-Mn-Si plate similar to SA-516 grade 70 was added as P-1, Group 2, and Grade P275NM, similar to SA-516 grade 60 was added as P-1, group 1. SA/EN 10222-2, grades P-280GH, P305GH, 13CrMo4-5, 13CrMo9-10 and X10CrMoVNb9-1 were assigned to P-1, Group 1, P-1, Group 2, P-4, Group 1, P-5A, Group 1, and P-15E, Group 1 respectively. SA/EN 10216-2, grades P235GH, P265GH, 16Mo3, 13CrMo4-5, 13CrMo9-10 and X10CrMoVNb9-1 were assigned to P-1, Group 1, P-1, Group 1, P-3, Group 1, P-4, Group 1, P-5A, Group 1, and P-15E, Group 1 respectively. SA/EN-10088-2, grade S235JR plate and SA/EN 10217 grade P235TR2 ERW tube were added as P-1, Group 1 and SA/EN 10088-2, X6CrNiMoTi 17-12-2 was added as P-8, Group 1. SA/EN 10028-4, Grades X7Ni9 and X8Ni9, Quenched and tempered 9% nickel steel, was added as P-11A, Group 1. Finally, SA/EN 10028-2, Grade 13CrMoSi5-5+ QT was added as P-4, Group 1.

I encourage readers outside the USA to bring materials manufactured to local specifications for pressure applications to ASME for incorporation into the Boiler Code. See ASME Section II Part D, Mandatory Appendix 5 for more details about the information that is required in order for materials to be adopted.

ASTM A-199 seamless alloy tube, Grades T11, T22, T21, T5 and T9 were added with P-numbers of 4, 5A, 5A, 5B and 5B respectively. These grades were also added as A-234 fittings. A-691, fusion welded pipe, was added as Grade 91 with a P-number of P-15E, Group 1; it should be noted that the ASTM specification for this material requires it to be normalized and tempered after welding. UNS S34565 was added as a superaustenitic stainless steel was added as P-8, Group 4 for various product forms. SA-213, 310HCbN tube was added as P-8, Group 1. Finally, SA-299, Grade A was added as P-1, Group 2 and Grade B was added as P-1 Group 3.

A new classification of titanium, Ti3Al-2.5V-0.1Ru, was added for various specifications, and a matching filler metal, ERTi-28 was added to the F-number table.

Brazing (QB) Changes

If you ever have to braze a small part like a valve seat to a large part like a casting, QB-451.3 has been revised to make qualifying the BPS simpler and more meaningful. This table requires that 2 tension test and 2 peel tests be performed, and it sets limits on the thickness qualified based on two times the thickness of the test coupon. Tension testing becomes difficult to fulfill and is of questionable value for brazing where one part is large and the other small, so a footnote was added that allows one to validate the properties of the joint by making tension and peel test specimens using any convenient thickness of test coupon, then to supplement that PQR with an additional test piece following QB-451.5 workmanship coupons. While QB-451.5 thickness ranges qualified are identical to those of QB-451.3, only sectioning of the specimens is required.

In addition, footnote 1 of QB-452.1 on performance qualification was clarified to make it clear that when one cannot do a peel test, section testing is permitted.

Inquiries

One question I get periodically is on welder testing - can one welder weld one side of a 6G pipe test coupon using GTAW followed by SMAW and another welder weld the other side and both welders be considered to be qualified for all positions; after all, both welders weld some overhead, some uphill and some horizontal That question was answered by the following:

Question (1): If radiographic examination per QW-302.2 is done for qualification of 2 welders on a single pipe coupon welded in the 6G position, must each welder complete the entire circumference of the pipe coupon?

Reply (1): Yes.

The rationale for this reply is that there is different skill is required on a 6G coupon welding up one side versus welding up the other side – kind of like welding one side right-handed and the other side left-handed. So the welders need to weld the entire circumference.

Question 2: If mechanical testing per QW-302.1 is done for qualification of 2 welders on a single pipe coupon welded in the 6G position, must each welder complete the entire circumference of the pipe coupon in order to remove the required bend specimens in accordance with QW-463.2(d) or QW-463.2(e)?

Reply (2): Yes.

The same rationale for this is the same as the previous question, but in addition, if the welders do not weld the entire circumference, the required bend test specimens cannot be removed for each welder.

For those who have old Grade 91 qualified WPSs and are unsure what to do with the WPSs and PQRs, inquiry 09-490 provides a checklist of questions about what may or must be revised on the PQRs and WPSs to bring them up to date. While useful guidance, be careful in reading the questions because some are “may” questions and some are “Is it required” questions , and the implications are different.

Coming Attractions

Section IX has part QW that covers welding and Part QB that covers brazing. The next addenda will contain Part “QP” covering joining of plastic. While the final decision about the moniker “QP” is not decided, the new part will cover joining of high-density polyethylene (HDPE) which is already permitted by Code Cases.

If that's not enough to excite you, ASME Boiler and Pressure Vessel Code will no longer publish addenda soon. As of 2013, the Code, all 20,000 pages of it, will be republished biennially without addenda. That means that you won't be spending time in front of the Tube inserting addenda anymore. Alleluia! Mechanisms for advising users of errata and errors will be developed so that anybody who buys a Code book will notified of such matters, and we should expect to see more use of Code Cases to provide interim rules between editions so that new technology can be implemented in a timely manner without getting hung up by publication cycles. ASME has advised that the price of Code books will be adjusted to be "revenue neutral;" exactly what that means remains to be seen.

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, brazing, 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.