maximum thickness of the thicker production member provided qualification was made on base metal having a thickness of 1\(\frac{1}{2}\) in. (38 mm) or more.

More than one procedure qualification may be required to qualify for some dissimilar thickness combinations.

**QW-202.5 Stud Welding.** Procedure qualification tests for stud welds shall be made in accordance with QW-192. The procedure qualification tests shall qualify the welding procedures for use within the range of the essential variables of Table QW-261. For studs welded to other than P-No. 1 metals, five additional welds shall be made and subjected to a macro-test, except that this is not required for studs used for extended heating surfaces.

**QW-202.6 Tube-to-Tubesheet Qualification.** When the applicable Code Section requires the use of QW-193 for tube-to-tubesheet demonstration mockup qualification tests, QW-193.1 shall apply. If specific qualification test requirements are not specified by the applicable Code Section, tube-to-tubesheet welds shall be qualified with one of the following methods:

(a) groove welds per the requirements of QW-202.2 and QW-202.4

(b) a demonstration mockup per the requirements of QW-193.1

(c) fillet welds per the requirements of QW-202.2(c) (for nonpressure-retaining tube-to-tubesheet welds only)

**QW-203 LIMITS OF QUALIFIED POSITIONS FOR PROCEDURES**

Unless specifically required otherwise by the welding variables (QW-250), a qualification in any position qualifies the procedure for all positions. The welding process and electrodes must be suitable for use in the positions permitted by the WPS. A welder or welding operator making and passing the WPS qualification test is qualified for the position tested. see QW-301.2.

**QW-210 PREPARATION OF TEST COUPON**

**QW-211 BASE METAL**

The base metals may consist of either plate, pipe, or other product forms. Qualification in plate also qualifies for pipe welding and vice versa. The dimensions of the test coupon shall be sufficient to provide the required test specimens.

**QW-211.1** A weld metal overlay deposited on the base metal following a qualified WPS may be considered as the same P-Number as any base metal having a nominally matching chemical analysis.

**QW-212 TYPE AND DIMENSIONS OF GROOVE WELDS**

Except as otherwise provided in QW-250, the type and dimensions of the welding groove are not essential variables.

**QW-214 CORROSION-RESISTANT OVERLAY**

**QW-214.1** The size of test coupons, limits of qualification, required examinations and tests, and test specimens shall be as specified in QW-214.2 and Table QW-453.

**QW-214.2** The qualification test coupon for procedure qualification shall consist of base metal not less than 6 in. (150 mm) × 6 in. (150 mm). The weld overlay cladding shall be a minimum of 1\(\frac{1}{2}\) in. (38 mm) wide by approximately 6 in. (150 mm) long. For qualification on pipe, the pipe length shall be a minimum of 6 in. (150 mm) and the diameter shall be the minimum needed to allow the required number of test specimens. The weld overlay shall be continuous around the circumference of the test coupon.

(a) The corrosion-resistant surface shall be examined by the liquid penetrant method and shall meet the acceptance standards as specified in QW-195.

(b) Following the liquid penetrant examination, four guided side-bend tests shall be made from the test coupon in accordance with QW-161. The test specimens shall be cut so that there are either two specimens parallel and two specimens perpendicular to the direction of the welding, or four specimens perpendicular to the direction of the welding. For coupons that are less than \(\frac{3}{8}\) in. (10 mm) thick, the width of the side-bend specimens may be reduced to the thickness of the test coupon. The side-bend specimens shall be removed from locations specified in Figure QW-462.5(c) or Figure QW-462.5(d).

(c) When a chemical composition is specified in the WPS, chemical analysis specimens shall be removed at locations specified in Figure QW-462.5(b) or Figure QW-462.5(e). The chemical analysis shall be performed in accordance with Figure QW-462.5(a) and shall be within the range specified in the WPS. This chemical analysis is not required when a chemical composition is not specified on the WPS.

**QW-214.3** Essential variables shall be as specified in QW-250 for the applicable welding process.

**QW-215 ELECTRON BEAM WELDING, LASER BEAM WELDING, AND LOW-POWER DENSITY LASER BEAM WELDING**

**QW-215.1** For electron beam welding and laser beam welding (excluding low-power density laser beam welding), the WPS qualification test coupon shall be prepared with the joint geometry duplicating that to be used in production. If the production weld is to include a lap-over (completing the weld by rewelding over the starting area of the weld, as for a girth weld), such lap-over shall be included in the WPS qualification test coupon.

**QW-215.2** The mechanical testing requirements of QW-451 shall apply.


QW-216.1 The size of test coupons, limits of qualification, required examinations and tests, and test specimens shall be as specified in Table QW-453.

QW-216.2 The test base metal coupon for procedure qualification shall have minimum dimensions of 6 in. (150 mm) wide × approximately 6 in. (150 mm) long with a hard-faced layer a minimum of 1/2 in. (38 mm) wide × 6 in. (150 mm) long. The minimum hard-faced thickness shall be as specified in the WPS. Alternatively, the qualification may be performed on a test base metal coupon that represents the size of the production part. For qualification on pipe, the pipe length shall be 6 in. (150 mm) minimum and the diameter shall be the minimum needed to allow the required number of test specimens. The weld overlay shall be continuous around the circumference of the test coupon.

(a) The hard-facing surface shall be examined by the liquid penetrant method and shall meet the acceptance standards in QW-195.2 or as specified in the WPS. Surface conditioning prior to liquid penetrant examination is permitted.

(b) After surface conditioning to the minimum thickness specified in the WPS, a minimum of three hardness readings shall be made on each of the specimens from the locations shown in Figure QW-462.5(b) or Figure QW-462.5(e). All readings shall meet the requirements of the WPS.

(c) The base metal shall be sectioned transversely to the direction of the hard-facing overlay. The two faces of the hard facing exposed by sectioning shall be polished and etched with a suitable etchant and shall be visually examined with 5X magnification for cracks in the base metal or the heat-affected zone, lack of fusion, or other linear defects. The overlay and base metal shall meet the requirements specified in the WPS. All exposed faces shall be examined. See Figure QW-462.5(b) for pipe and Figure QW-462.5(e) for plate.

(d) When a chemical composition is specified in the WPS, chemical analysis specimens shall be removed at locations specified in Figure QW-462.5(b) or Figure QW-462.5(e). The chemical analysis shall be performed in accordance with Figure QW-462.5(a) and shall be within the range specified in the WPS. This chemical analysis is not required when a chemical composition is not specified on the WPS.

QW-216.3 Welding variables shall be as specified in QW-250 for the applicable process.

QW-216.4 Where Spray Fuse methods of hard facing (e.g., Oxyfuel and Plasma Arc) are to be used, the coupons for these methods shall be prepared and welding variables applied in accordance with QW-216.1 and QW-216.3, respectively.

QW-216.5 If a weld deposit is to be used under a hard-facing weld metal overlay, a base metal with an assigned P-Number and a chemical analysis nominally matching the weld deposit chemical analysis may be substituted to qualify the PQR.

QW-217 JOINING OF CLAD MATERIALS

The WPS for groove welds in clad metal shall be qualified as provided in (a) when any part of the cladding thickness, as permitted by the referencing Code Section, is included in the design calculations. Either (a) or (b) may be used when the cladding thickness is not included in the design calculations.

(a) The essential and nonessential variables of QW-250 shall apply for each welding process used in production. The procedure qualification test coupon shall be made using the same P-Number base metal, cladding, and welding process, and filler metal combination to be used in production welding. For metal not included in Table QW/QB-422, the metal used in the test plate shall be within the range of chemical composition of that to be used in production. The qualified thickness range for the base metal and filler metal(s) shall be based on the actual test coupon thickness for each as applied to QW-451, except that the minimum thickness of filler metal joining the cladding portion of the weldment shall be based on a chemical analysis performed in accordance with Table 453. Tensile and bend tests required in QW-451 for groove welds shall be made, and they shall contain the full thickness of cladding through the reduced section of the specimen. The bond line between the original cladding and the base metal may be disregarded when evaluating side-bend tests if the cladding was applied by a process other than fusion welding.

(b) The essential and nonessential variables of QW-250 shall apply for each welding process used in production for joining the base metal portion of the weldment. The PQRs that support this portion of the WPS need not be based on test coupons made with clad metal. For the corrosion-resistant overlay portion of the weld, the essential variables of QW-251.4 shall apply and the test coupon and testing shall be in accordance with Table QW-453. The WPS shall limit the depth of the groove, which will receive the corrosion-resistant overlay in order to ensure development of the full strength of the underlying weld in the base metal.
QW-218 APPLIED LININGS

QW-218.1 WPSs for attaching applied linings shall be qualified in accordance with QW-202.2(a), QW-202.2(b), or QW-202.2(c).

QW-218.2 As an alternative to the above, each process to be used in attaching applied linings to base metal shall be qualified on a test coupon welded into the form and arrangement to be used in construction using materials that are within the range of chemical composition of the metal to be used for the base plate, the lining, and the weld metal. The welding variables of QW-250 shall apply except for those regarding base metal or weld metal thickness. Qualification tests shall be made for each position to be used in production welding in accordance with Table QW-461.9, except that qualification in the vertical position, uphill progression shall qualify for all positions. One cross-section for each position tested shall be sectioned, polished, and etched to clearly show the demarcation between the base metal and the weld metal. In order to be acceptable, each specimen shall exhibit complete fusion of the weld metal with the base metal and freedom from cracks.

QW-218.3 When chemical analysis of the weld deposit for any elements is required, a chemical analysis shall be performed per Table QW-453, Note 9 for those elements.

QW-219 FLASH WELDING

Flash welding shall be limited to automatic electrical resistance flash welding. Procedure qualification tests shall be conducted in accordance with QW-199.1.

QW-219.1 Tolerances on Variables. Flash welding variables that may require adjustment during production welding are synergistically related. Accordingly, even though the variables shown in Table QW-265 provide tolerances on many welding variables, the WPS shall specify the same specific variables shown on the PQR with tolerance shown for no more than one variable (e.g., if it is desired to provide a tolerance on the upset current, all other variables shown on the PQR must be the same as they are shown on the PQR). If it is desired to provide tolerances in the WPS for two variables, the first variable with a tolerance shall be set at the midpoint of its tolerance and two test coupons shall be welded with each of the upper and lower extremes of the tolerance for the second variable (i.e., four coupons must be welded). These coupons shall be examined and tested in accordance with QW-199.1.3.

If it is desired to provide tolerance for a third variable, the first two variables shall be set at the midpoint of their tolerance, and two test coupons shall be welded with each of the upper and lower extremes of the new tolerances for the third variable (i.e., four coupons must be welded). These coupons shall be examined and tested in accordance with QW-199.1.3.

QW-220 HYBRID WELDING PROCEDURE VARIABLES

Requirements of QW-221 through QW-223 shall be observed for all hybrid welding procedure qualifications.

QW-221 ESSENTIAL VARIABLES FOR HYBRID WELDING

The following essential variables are in addition to the welding variables for each welding process used during hybrid welding provided in QW-250:

(a) an addition or deletion of welding processes used in a hybrid welding process from those used during qualification.

(b) a change in the process sequence used in a hybrid welding process from that used during qualification.

(c) a change in the process separation used in a hybrid welding process greater than 10% from that used during qualification (e.g., measured at the weld surface, measured between the welding torch and laser, etc.)

(d) a change in any angle, between each individual welding process used in a hybrid welding process or a change in any angle between the hybrid welding process and the material to be welded, of greater than 10 deg from that used during qualification.

(e) a change in the height between the individual welding processes used in a hybrid welding process and the material surface or a change in the height between the hybrid welding process and the material surface greater than 10% from that used during qualification.

QW-222 WELDING PROCESS RESTRICTIONS

The hybrid welding process shall be limited to machine or automatic welding.

QW-223 TEST COUPON PREPARATION AND TESTING

The hybrid welding procedure qualification test coupon shall be prepared in accordance with the rules in QW-210 and tested in accordance with the rules in QW-202.

QW-250 WELDING VARIABLES

QW-251 GENERAL

QW-251.1 Types of Variables for Welding Procedure Specifications (WPS). These variables (listed for each welding process in Tables QW-252 through QW-267) are subdivided into essential variables, supplementary essential variables, and nonessential variables.
Question:

In the 2019 Edition, QW-217(a) and QW-218.3 require chemical analysis be performed in accordance with Table QW-453. Is it the intent that reference to Table QW-453 in these paragraphs be replaced with QW-216.2(d) QW-214.2(c)?

Reply:

Yes