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**Table QW-253
Welding Variables Procedure Specifications (WPS) — Shielded Metal-Arc Welding (SMAW)**

Paragraph	Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-402 Joints	.1 ϕ Groove design			X
	.4 - Backing			X
	.10 ϕ Root spacing			X
	.11 \pm Retainers			X
QW-403 Base Metals	.5 ϕ Group Number		X	
	.6 T Limits toughness		X	
	.8 ϕ T Qualified	X		
	.9 t Pass > 1/2 in. (13 mm)	X		
	.11 ϕ P-No. qualified	X		
QW-404 Filler Metals	.4 ϕ F-Number	X		
	.5 ϕ A-Number	X		
	.6 ϕ Diameter			X
	.7 ϕ Diameter > 1/4 in. (6 mm)		X	
	.12 ϕ Classification		X	
	.30 ϕ t	X		
QW-405 Positions	.33 ϕ Classification			X
	.1 + Position			X
	.3 ϕ $\uparrow\downarrow$ Vertical welding			X
QW-406 Preheat	.1 Decrease > 100°F (55°C)	X		
	.2 ϕ Preheat maint.			X
	.3 Increase > 100°F (55°C) (IP)		X	
QW-407 PWHT	.1 ϕ PWHT	X		
	.2 ϕ PWHT (T & T range)		X	
QW-409 Electrical Characteristics	.1 > Heat input		X	
	.4 ϕ Current or polarity		X	X
	.8 ϕ I & E range			X
QW-410 Technique	.1 ϕ String or weave			X
	.5 ϕ Method cleaning			X
	.6 ϕ Method back gouge			X
	.9 ϕ Multiple to single pass/side		X	X
	.25 ϕ Manual or automatic			X
	.26 \pm Peening			X
.64	Use of thermal processes	X		

Legend:

- | | | | | |
|------------|----------------------------|-----------------------|------------------------|---------------|
| + Addition | > Increase or greater than | \uparrow Uphill | \leftarrow Forehand | ϕ Change |
| - Deletion | < Decrease or less than | \downarrow Downhill | \rightarrow Backhand | |

Table QW-255
Welding Variables Procedure Specifications (WPS) — Gas Metal-Arc Welding (GMAW and FCAW)

Paragraph	Brief of Variables	Essential	Supplementary Essential	Nonessential
QW-402 Joints	.1 ϕ Groove design			X
	.4 - Backing			X
	.10 ϕ Root spacing			X
	.11 \pm Retainers			X
QW-403 Base Metals	.5 ϕ Group Number		X	
	.6 T Limits		X	
	.8 ϕ T Qualified	X		
	.9 t Pass > 1/2 in. (13 mm)	X		
	.10 T limits (S. cir. arc)	X		
	.11 ϕ P-No. qualified	X		
QW-404 Filler Metals	.4 ϕ F-Number	X		
	.5 ϕ A-Number	X		
	.6 ϕ Diameter			X
	.12 ϕ Classification		X	
	.23 ϕ Filler metal product form	X		
	.24 \pm or ϕ Supplemental	X		
	.27 ϕ Alloy elements	X		
	.30 ϕ t	X		
	.32 t Limits (S. cir. arc)	X		
	.33 ϕ Classification			X
QW-405 Positions	.1 + Position			X
	.3 ϕ $\uparrow \downarrow$ Vertical welding			X
QW-406 Preheat	.1 Decrease > 100°F (55°C)	X		
	.2 ϕ Preheat maint.			X
	.3 Increase > 100°F (55°C) (IP)		X	
QW-407 PWHT	.1 ϕ PWHT	X		
	.2 ϕ PWHT (T & T range)		X	
QW-408 Gas	.1 \pm Trail or ϕ comp.			X
	.2 ϕ Single, mixture, or %	X		
	.3 ϕ Flow rate			X
	.5 \pm or ϕ Backing flow			X
	.9 - Backing or ϕ comp.	X		
	.10 - Trail or ϕ comp.	X		
QW-409 Electrical Characteristics	.1 > Heat input		X	
	.2 ϕ Transfer mode	X		
	.4 ϕ Current or polarity		X	X
	.8 ϕ I & E range			X

Table QW-255
Welding Variables Procedure Specifications (WPS) — Gas Metal-Arc Welding (GMAW and FCAW)
(Cont'd)

Paragraph	Brief of Variables	Essential	Supplementary Essential	Nonessential	
QW-410 Technique	.1	ϕ String or weave			X
	.3	ϕ Orifice, cup, or nozzle size			X
	.5	ϕ Method cleaning			X
	.6	ϕ Method back gouge			X
	.7	ϕ Oscillation			X
	.8	ϕ Tube-work distance			X
	.9	ϕ Multiple to single pass per side		X	X
	.10	ϕ Single to multiple electrodes		X	X
	.15	ϕ Electrode spacing			X
	.25	ϕ Manual or automatic			X
	.26	\pm Peening			X
.64	Use of thermal processes	X			

Legend:

+ Addition	> Increase or greater than	↑ Uphill	← Forehand	ϕ Change
- Deletion	< Decrease or less than	↓ Downhill	→ Backhand	

QW-350 WELDING VARIABLES FOR WELDERS

**Table QW-416
Welding Variables
Welder Performance**

Paragraph [Note (1)]	Brief of Variables	Essential						
		OFW Table QW-352	SMAW Table QW-353	SAW Table QW-354	GMAW [Note (2)] Table QW-355	GTAW Table QW-356	PAW Table QW-357	
QW-402 Joints	.4	– Backing		X		X	X	X
	.7	+ Backing	X					
QW-403 Base Metal	.2	Maximum qualified	X					
	.16	ϕ Pipe diameter		X	X	X	X	X
	.18	ϕ P-Number	X	X	X	X	X	X
QW-404 Filler Metals	.14	\pm Filler	X				X	X
	.15	ϕ F-Number	X	X	X	X	X	X
	.22	\pm Inserts					X	X
	.23	ϕ Filler metal product form					X	X
	.30	ϕ <i>t</i> Weld deposit		X	X	X	X	X
	.31	ϕ <i>t</i> Weld deposit	X					
QW-405 Positions	.14	\pm Filler					X	X
	.15	ϕ F-Number	X	X	X	X	X	X
	.22	\pm Inserts					X	X
QW-408 Gas	.7	ϕ Type fuel gas	X					
	.8	– Inert backing				X	X	X
QW-409 Electrical	.2	ϕ Transfer mode				X		
	.4	ϕ Current or polarity					X	
Welding Processes:								
	OFW	Oxyfuel gas welding						
	SMAW	Shielded metal-arc welding						
	SAW	Submerged-arc welding						
	GMAW	Gas metal-arc welding						
	GTAW	Gas tungsten-arc welding						
	PAW	Plasma-arc welding						
Legend:								
ϕ	Change			<i>t</i>	Thickness			
+	Addition			↑	Uphill			
-	Deletion			↓	Downhill			
NOTES:								
(1) For description, see Article IV.								
(2) Flux-cored arc welding as shown in Table QW-355 , with or without additional shielding from an externally supplied gas or gas mixture, is included.								

ARTICLE IV WELDING DATA

QW-400 VARIABLES

QW-401 GENERAL

Each welding variable described in this Article is applicable as an essential, supplementary essential, or non-essential variable for procedure qualification when referenced in [QW-250](#) for each specific welding process. Essential variables for performance qualification are referenced in [QW-350](#) for each specific welding process. A change from one welding process to another welding process is an essential variable and requires requalification.

QW-401.1 Supplementary Essential Variable (Procedure). Supplementary essential variables are in addition to the essential variables for each welding process.

When a procedure has been previously qualified to satisfy all requirements other than toughness, it is then necessary only to prepare an additional test coupon using the same procedure with the same essential variables, but additionally with all of the required supplementary essential variables, with the coupon long enough to provide the necessary toughness specimens.

When a procedure has been previously qualified to satisfy all requirements including toughness, but one or more supplementary essential variable is changed, then it is only necessary to prepare an additional test coupon using the same welding procedure and the new supplementary essential variable(s), with the coupon long enough to provide the necessary toughness specimens. If a previously qualified weld procedure has satisfactory toughness values in the weld metal, then it is necessary only to test toughness specimens from the heat-affected zone when such are required.

When essential variables are qualified by one or more PQRs and supplementary essential variables are qualified by other PQRs, the ranges of essential variables established by the former PQRs are only affected by the latter to the extent specified in the applicable supplementary essential variable (e.g., essential variable [QW-403.8](#) governs the minimum and maximum thickness of base metal qualified. When supplementary essential variable [QW-403.6](#) applies, it modifies only the minimum thickness qualified, not the maximum).

QW-401.2 The welding data includes the welding variables grouped as joints, base metals, filler metals, position, preheat, postweld heat treatment, gas, electrical

characteristics, and technique. For convenience, variables for each welding process are summarized in [Table QW-416](#) for performance qualification.

QW-402 JOINTS

QW-402.1 A change in the type of groove (Vee-groove, U-groove, single-bevel, double-bevel, etc.).

QW-402.2 The addition or deletion of a backing.

QW-402.3 A change in the nominal composition of the backing.

QW-402.4 The deletion of the backing in single-welded groove welds. Double-welded groove welds are considered welding with backing.

QW-402.5 The addition of a backing or a change in its nominal composition.

QW-402.6 An increase in the fit-up gap, beyond that initially qualified.

QW-402.7 The addition of backing.

QW-402.8 A change in nominal size or shape of the stud at the section to be welded.

QW-402.9 In stud welding, a change in shielding as a result of ferrule or flux type.

QW-402.10 A change in the specified root spacing.

QW-402.11 The addition or deletion of nonmetallic retainers or nonfusing metal retainers.

QW-402.12 The welding procedure qualification test shall duplicate the joint configuration to be used in production within the limits listed, except that pipe or tube to pipe or tube may be used for qualification of a pipe or tube to other shapes, and solid round to solid round may be used for qualification of a solid round to other shapes

(a) any change exceeding ± 10 deg in the angle measured for the plane of either face to be joined, to the axis of rotation

(b) a change in cross-sectional area of the weld joint greater than 10%

(c) a change in the outside diameter of the cylindrical weld interface of the assembly greater than $\pm 10\%$

(d) a change from solid to tubular cross section at the joint or vice versa regardless of (b)

QW-402.13 A change in the method of joining from spot to projection to seam or vice versa.

QW-402.14 An increase or decrease of more than 10% in the spacing of the welds when they are within two diameters of each other.

QW-402.15 A change in the size or shape of the projection in projection welding.

QW-402.16 A decrease in the distance between the approximate weld interface and the final surface of the production corrosion-resistant or hard-facing weld metal overlay below the minimum thickness qualified as shown in [Figures QW-462.5\(a\)](#) through [QW-462.5\(e\)](#). There is no limit on the maximum thickness for corrosion-resistant or hard-facing weld metal overlay that may be used in production.

QW-402.17 An increase in the thickness of the production spray fuse hard-facing deposit above the thickness deposited on the procedure qualification test coupon.

QW-402.18 For lap joints,
 (a) a decrease of more than 10% in the distance to the edge of the material
 (b) an increase in the number of layers of material
 (c) a change in surface preparation or finish from that qualified

QW-402.19 A change in the nominal diameter or nominal thickness for tubular cross sections, or an increase in the total cross section area beyond that qualified for all nontubular cross sections.

δ19P **QW-402.20**

DELETED

QW-402.21 A change in the method or equipment used to minimize internal flash.

QW-402.22 A change in the end preparation method.

QW-402.23 For test coupons less than 1½ in. (38 mm) thick, the addition of a cooling medium (water, flowing gas, etc.) to the back side of the weld. Qualification on test coupons less than 1½ in. (38 mm) thick with a cooling medium on the back side of the weld qualifies base metal thickness equal to or greater than the test coupon thickness with and without coolant.

QW-402.24 Qualification with a cooling medium (water, flowing gas, etc.) on the root side of a test coupon weld that is welded from one side qualifies all thicknesses of base metal with cooling medium down to the thickness of the test coupon at the root or ½ in. (13 mm), whichever is less.

QW-402.25 A change from lap joint to groove welding, and vice versa.

QW-402.26 A reduction of more than 5 deg in the edge preparation bevel angle for groove welds.

QW-402.27 A change in material of fixed backing anvils (when used). A change in backing anvil design that affects the weld cooling rate (e.g., a change from air-cooled to water-cooled, and vice versa). This variable is not applicable to tube-to-tubesheet or double-sided welds with overlapping fusion zones, or welds completed using self-reacting pins.

QW-402.28 A change in joint design from that qualified, including edge preparation geometry (e.g., a change from square butt edge to beveled edge), reductions in the smallest joint path radius to less than the shoulder radius, or joint paths crossing themselves or another HAZ.

QW-402.29 A change in joint spacing greater than ±10% of the qualification test coupon thickness. For WPSs qualified using intimate edge contact, the maximum allowable joint spacing is 1/16 in. (1.5 mm).

QW-402.30 A decrease of 10% or more in the specified width of the ligament between tube holes when the specified width of the ligament is less than the greater of 3/8 in. (10 mm) or three times the specified tube wall thickness. δ19P

QW-402.31 For tube-to-tubesheet welding: an increase in the depth by more than 10%, an increase or decrease in the preparation angle of the weld groove by more than 5 deg, or a change in the groove type. δ19P

QW-403 BASE METALS

QW-403.1 A change from a base metal listed under one P-Number in [Table QW/QB-422](#) to a metal listed under another P-Number or to any other base metal. When joints are made between two base metals that have different P-Numbers, a procedure qualification shall be made for the applicable combination of P-Numbers, even though qualification tests have been made for each of the two base metals welded to itself.

QW-403.2 The maximum thickness qualified is the thickness of the test coupon.

QW-403.3

(a) For full penetration single-sided welds without backing where the verification of penetration can be made, an increase of more than 20% in base metal thickness when the test coupon thickness is less than or equal to 1 in. (25 mm), and more than 10% in base metal thickness when the test coupon thickness is greater than 1 in. (25 mm).

(b) For all other welds, an increase of more than 10% in base metal thickness when the test coupon thickness is less than or equal to 1 in. (25 mm), and more than 5% in base metal thickness when the test coupon thickness is greater than 1 in. (25 mm).

QW-403.4 Welding procedure qualifications shall be made using a base metal of the same type or grade or another base metal listed in the same group (see [Table QW/QB-422](#)) as the base metal to be used in production

welding. When joints are to be made between base metals from two different groups, a procedure qualification must be made for the applicable combination of base metals, even though procedure qualification tests have been made for each of the two base metals welded to itself.

δ19P **QW-403.5** Welding procedure specifications shall be qualified using one of the following:

(a) the same base metal (including type or grade) to be used in production welding

(b) for ferrous materials, a base metal listed in the same P-Number Group Number in [Table QW/QB-422](#) as the base metal to be used in production welding

(c) for nonferrous materials, a base metal listed with the same P-Number UNS Number in [Table QW/QB-422](#) as the base metal to be used in production welding

For ferrous materials in [Table QW/QB-422](#), a procedure qualification shall be made for each P-Number Group Number combination of base metals, even though procedure qualification tests have been made for each of the two base metals welded to itself. If, however, two or more qualification records have the same essential and supplementary essential variables, except that the base metals are assigned to different Group Numbers within the same P-Number, then the combination of base metals is also qualified. In addition, when base metals of two different Group Numbers within the same P-Number are qualified using a single test coupon, that coupon qualifies the welding of those two Group Numbers within the same P-Number to themselves as well as to each other using the variables qualified.

This variable does not apply when toughness testing of the heat-affected zone is not required by other Sections.

QW-403.6 The minimum base metal thickness qualified is the thickness of the test coupon T or $5/8$ in. (16 mm), whichever is less. However, where T is $1/4$ in. (6 mm) or less, the minimum thickness qualified is $1/2T$. This variable does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic or P-No. 10H material is solution annealed after welding.

QW-403.8 A change in base metal thickness beyond the range qualified in [QW-451](#), except as otherwise permitted by [QW-202.4\(b\)](#).

QW-403.9 For single-pass or multipass welding in which any pass is greater than $1/2$ in. (13 mm) thick, an increase in base metal thickness beyond 1.1 times that of the qualification test coupon.

QW-403.10 For the short-circuiting transfer mode of the gas metal-arc process, when the qualification test coupon thickness is less than $1/2$ in. (13 mm), an increase in thickness beyond 1.1 times that of the qualification test coupon. For thicknesses of $1/2$ in. (13 mm) and greater, use [Table QW-451.1](#) or [Table QW-451.2](#), as applicable.

QW-403.11 Base metals specified in the WPS shall be qualified by a procedure qualification test that was made using base metals in accordance with [QW-424](#).

QW-403.12 A change from a base metal listed under one P-Number of [Table QW/QB-422](#) to a base metal listed under another P-Number. When joints are made between two base metals that have different P-Numbers, requalification is required even though the two base metals have been independently qualified using the same procedure. When the melt-in technique is used for joining P-No. 1, P-No. 3, P-No. 4, and P-No. 5A, a procedure qualification test with one P-Number metal shall also qualify for that P-Number metal welded to each of the lower P-Number metals, but not vice versa.

QW-403.15 Welding procedure qualifications for electron beam welding shall be made using a base metal of the same type or grade or another base metal listed in the same P-Number (and the same group where given — see [Table QW/QB-422](#)) as the base metal to be used in production welding. When joints are to be made between base metals from two different P-Numbers (or two different groups), a procedure qualification must be made for the applicable combination of base metals even though procedure qualification tests have been made for each of the two base metals welded to itself.

QW-403.16 A change in the pipe diameter beyond the range qualified in [QW-452](#), except as otherwise permitted in [QW-303.1](#), [QW-303.2](#), [QW-381.2\(c\)](#), or [QW-382.1\(f\)](#). For tube-to-tubesheet welding: an increase or decrease greater than 10% of the specified tube diameter.

(a) For a groove weld attaching a set-on nozzle or branch (with the weld preparation on the nozzle or branch), the range qualified from [Table QW-452.3](#) shall be based on the nozzle or branch pipe O.D.

(b) For a groove weld attaching a set-in nozzle or branch (with the weld preparation on the shell, head, or run pipe), the range qualified from [Table QW-452.3](#) shall be based on the shell, head, or run pipe O.D.

QW-403.17 In stud welding, a change in combination of base metal listed under one P-Number in [Table QW/QB-422](#) and stud metal P-Number (as defined in the following Note), or to any other base metal and stud metal combination.

NOTE: Stud metal shall be classified by nominal chemical composition and can be assigned a P-Number when it meets the nominal composition of any one of the P-Number metals.

QW-403.18 A change from one P-Number to any other P-Number or to a base metal not listed in [Table QW/QB-422](#), except as permitted in [QW-423](#), and in [QW-420](#). For tube-to-tubesheet welding: a change in the P-Number or A-Number of the tubesheet cladding material (if the cladding material is part of the weld).

QW-403.19 A change to another base material type or grade (type or grade are materials of the same nominal chemical analysis and mechanical property range, even though of different product form), or to any other base material type or grade. When joints are made between two different types or grades of base material, a procedure qualification must be made for the applicable combinations of materials, even though procedure qualification tests have been made for each of the two base materials welded to itself.

δ19P **QW-403.20** If the chemical composition of the weld metal overlay is specified in the WPS, a change in the P-Number listed in Table QW/QB-422 to another P-Number or unlisted base metal, or a change in Group Number for P-No. 10 or P-No. 11 base metals.

If the chemical composition of the weld metal overlay is not specified in the WPS, qualification on P-No. 5A or any lower P-Number base metal also qualifies for weld metal overlay on all lower P-Number base metals.

QW-403.21 The addition or deletion of a coating, plating or cladding, or a change in the nominal chemical analysis or thickness range of the plating or cladding, or a change in type of coating as specified in the WPS.

QW-403.22 A change in the base metal thickness exceeding 10% of the thickness of the total joint from that qualified.

QW-403.23 A change in base metal thickness beyond the range qualified in Table QW-453.

QW-403.24 A change in the specification, type, or grade of the base metal. When joints are to be made between two different base metals, a procedure qualification must be made for the applicable combination even though procedure qualifications have been made for each of the two base metals welded to themselves.

QW-403.25 Welding procedure qualifications shall be made using a base metal of the same P-Number and Group Number as the base metal to be temper bead welded. When joints are to be made between base metals from two different P-Number and Group Number combinations, a temper bead procedure qualification must be made for each base metal P-Number and Group Number combination to be used in production; this may be done in separate test coupons or in combination on a single test coupon. When base metals of different P-Number and Group Number combinations are tested in the same coupon, the welding variables utilized and test results on each member of the coupon shall be documented independently but may be reported on the same qualification record. Where temper bead welding is to be applied to only one member of a joint (e.g., on the P-No. 1 member of a joint between P-No. 1 and P-No. 8 metals) or where cladding is being applied or repaired using temper bead techniques, qualification in accordance with QW-290 is required only for the portion of the WPS that applies to welding on the member to be temper bead welded.

QW-403.26 An increase in the base metal carbon equivalent using the following equation:

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

QW-403.27 The maximum thickness qualified is the thickness of the test coupon, T , or it is unlimited if the test coupon is $1\frac{1}{2}$ in. (38 mm) thick or thicker. However, where T is $\frac{1}{4}$ in. (6 mm) or less, the maximum thickness qualified is $2T$. This limitation applies to fillet welds as well as to groove welds.

QW-403.28 A change to another base metal type, grade, or UNS number.

QW-403.29 A change in the surface finish as defined by the material specification or established surface roughness range as measured in accordance with ASME B46.1-2006.

QW-403.30 A change in base metal thickness greater than 20%

(a) of the test coupon thickness for fixed-pin and retracting-pin rotating tools

(b) beyond the minimum and maximum thickness or thickness transition slopes of the test coupon for self-reacting rotating tools

QW-403.31 For tubes of specified wall thickness of 0.100 in. (2.5 mm) or less, a change in tube wall thickness to increase it to more than $2T$ or to decrease it to less than $\frac{1}{2}T$. For tubes of specified wall thickness greater than 0.100 in. (2.5 mm), only one qualification test is required. δ19P

QW-403.32 A change in the P-Number of either the tube or tubesheet material. Where the cladding or overlay material is part of the weld, a change in the P-Number or A-Number or in the nominal composition of the tubesheet cladding or overlay material when a P-Number or A-Number is not assigned. δ19P

QW-403.33 A change in the specified tube wall thickness or diameter greater than 10% for all diameters and wall thicknesses. δ19P

QW-404 FILLER METALS

QW-404.1 An increase of greater than 10% in the cross-sectional area of the filler metal added (excluding buttering) or in the wire-feed speed beyond that qualified.

QW-404.2 A decrease in the thickness or change in nominal specified chemical analysis of weld metal buttering beyond that qualified. (Buttering or surfacing is the deposition of weld metal on one or both faces of the joint prior to preparation of the joint for final electron beam welding.)

QW-404.3 A change in the size of the filler metal.

QW-404.4 A change from one F-Number in [Table QW-432](#) to any other F-Number or to any other filler metal not listed in [Table QW-432](#).

δ19P **QW-404.5** (Applicable only to ferrous metals.) A change in the chemical composition of the weld deposit from one A-Number to any other A-Number in [Table QW-442](#). Qualification with A-No. 1 shall qualify for A-No. 2 and vice versa.

The weld metal chemical composition may be determined by any of the following:

(a) For all welding processes — from the chemical analysis of the weld deposit taken from the procedure qualification test coupon.

(b) For SMAW, GTAW, LBW, and PAW — from the chemical analysis of the weld deposit prepared according to the filler metal specification, or from the chemical composition as reported either in the filler metal specification or the manufacturer's or supplier's certificate of compliance.

(c) For GMAW and EGW — from the chemical analysis of the weld deposit prepared according to the filler metal specification or the manufacturer's or supplier's certificate of compliance when the shielding gas used was the same as that used to weld the procedure qualification test coupon.

(d) For SAW — from the chemical analysis of the weld deposit prepared according to the filler metal specification or the manufacturer's or supplier's certificate of compliance when the flux used was the same as that used to weld the procedure qualification test coupon.

In lieu of an A-Number designation, the nominal chemical composition of the weld deposit shall be indicated on the WPS and on the PQR. Designation of nominal chemical composition may also be by reference to the AWS classification except for the "G" suffix classification, by the manufacturer's trade name, or by other established procurement documents.

QW-404.6 A change in the nominal size of the electrode or electrodes specified in the WPS.

QW-404.7 A change in the nominal diameter of the electrode to over $\frac{1}{4}$ in. (6 mm). This variable does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.

QW-404.8 Addition or deletion, or a change of more than 10% in the nominal amount or composition of supplementary deoxidation material (in addition to filler metal) beyond that qualified.

QW-404.9

(a) A change in the indicator for minimum tensile strength (e.g., the 7 in F7A2-EM12K) when the flux wire combination is classified in Section II, Part C.

(b) A change in either the flux trade name or wire trade name when neither the flux nor the wire is classified in Section II, Part C.

(c) A change in the flux trade name when the wire is classified in Section II, Part C but the flux is not classified. A change in the wire classification within the requirements of [QW-404.5](#) does not require requalification.

(d) A change in the flux trade name for A-No. 8 deposits.

QW-404.10 Where the alloy content of the weld metal is largely dependent upon the composition of the flux used, any change in any part of the welding procedure which would result in the important alloying elements in the weld metal being outside of the specification range of chemistry given in the Welding Procedure Specification.

QW-404.12 A change in the filler metal classification within an SFA specification, or for a filler metal not covered by an SFA specification or a filler metal with a "G" suffix within an SFA specification, a change in the trade name of the filler metal.

When a filler metal conforms to a filler metal classification, within an SFA specification, except for the "G" suffix classification, requalification is not required if a change is made in any of the following:

(a) from a filler metal that is designated as moisture-resistant to one that is not designated as moisture-resistant and vice versa (i.e., from E7018R to E7018)

(b) from one diffusible hydrogen level to another (i.e., from E7018-H8 to E7018-H16)

(c) for carbon, low alloy, and stainless steel filler metals having the same minimum tensile strength and the same nominal chemical composition, a change from one low hydrogen coating type to another low hydrogen coating type (i.e., a change among EXX15, 16, or 18 or EXXX15, 16, or 17 classifications)

(d) from one position-usability designation to another for flux-cored electrodes (i.e., a change from E70T-1 to E71T-1 or vice versa)

(e) from a classification that requires toughness testing to the same classification which has a suffix which indicates that toughness testing was performed at a lower temperature or exhibited greater toughness at the required temperature or both, as compared to the classification which was used during procedure qualification (i.e., a change from E7018 to E7018-1)

(f) from the classification qualified to another filler metal within the same SFA specification when the weld metal is exempt from toughness testing by other Sections

This exemption does not apply to hard-facing and corrosion-resistant overlays

QW-404.14 The deletion or addition of filler metal.

QW-404.15 A change from one F-Number in [Table QW-432](#) to any other F-Number or to any other filler metal, except as permitted in [QW-433](#).

QW-404.17 A change in the type of flux or composition of the flux.

QW-404.18 A change from wire to plate electrodes, and vice versa.

QW-404.19 A change from consumable guide to non-consumable guide, and vice versa.

QW-404.20 Any change in the method by which filler metal is added, such as preplaced shim, top strip, wire, wire feed, or prior weld metal buttering of one or both joint faces.

QW-404.21 For filler metal additions, any change from the nominal specified analysis of the filler metal qualified.

QW-404.22 The omission or addition of consumable inserts. Qualification in a single-welded butt joint, with or without consumable inserts, qualifies for fillet welds and single-welded butt joints with backing or double-welded butt joints. Consumable inserts that conform to SFA-5.30, except that the chemical analysis of the insert conforms to an analysis for any bare wire given in any SFA specification or AWS Classification, shall be considered as having the same F-Number as that bare wire as given in [Table QW-432](#).

QW-404.23 A change from one of the following filler metal product forms to another:

- (a) bare (solid or metal cored)
- (b) flux cored
- (c) flux coated (solid or metal cored)
- (d) powder

QW-404.24 The addition, deletion, or change of more than 10% in the volume of supplemental filler metal.

QW-404.27 Where the alloy content of the weld metal is largely dependent upon the composition of the supplemental filler metal (including powder filler metal for PAW), any change in any part of the welding procedure that would result in the important alloying elements in the weld metal being outside of the specification range of chemistry given in the Welding Procedure Specification.

QW-404.29 A change in the flux trade name and designation.

QW-404.30 A change in deposited weld metal thickness beyond that qualified in accordance with [QW-451](#) for procedure qualification or [QW-452](#) for performance qualification, except as otherwise permitted in [QW-303.1](#) and [QW-303.2](#). When a welder is qualified using volumetric examination, the maximum thickness stated in [Table QW-452.1\(b\)](#) applies.

QW-404.31 The maximum thickness qualified is the thickness of the test coupon.

QW-404.32 For the low voltage short-circuiting type of gas metal-arc process when the deposited weld metal thickness is less than $1/2$ in. (13 mm), an increase in deposited weld metal thickness beyond 1.1 times that of the qualification test deposited weld metal thickness. For

weld metal thicknesses of $1/2$ in. (13 mm) and greater, use [Table QW-451.1](#), [Table QW-451.2](#), or [Tables QW-452.1\(a\)](#) and [QW-452.1\(b\)](#), as applicable.

QW-404.33 A change in the filler metal classification within an SFA specification, or, if not conforming to a filler metal classification within an SFA specification, a change in the manufacturer's trade name for the filler metal. When optional supplemental designators, such as those which indicate moisture resistance (i.e., XXXXR), diffusible hydrogen (i.e., XXXX H16, H8, etc.), and supplemental toughness testing (i.e., XXXX-1 or EXXXXM), are specified on the WPS, only filler metals which conform to the classification with the optional supplemental designator(s) specified on the WPS shall be used.

QW-404.34 A change in flux type (i.e., neutral to active or vice versa) for multilayer deposits in P-No. 1 materials.

QW-404.35 A change in the flux-wire classification or a change in either the electrode or flux trade name when the flux-wire combination is not classified to an SFA specification. Requalification is not required when a flux-wire combination conforms to an SFA specification and the change in classification is

- (a) from one diffusible hydrogen level to another (e.g., a change from F7A2-EA1-A1-H4 to F7A2-EA1-A1-H16), or
- (b) to a larger number in the indicator for toughness, indicating classification at a lower toughness testing temperature (e.g., a change from F 7A2 - EM12K to F7A4-EM12K)

This variable does not apply when the weld metal is exempt from toughness testing by other Sections. This exemption does not apply to hard-facing and corrosion-resistant overlays.

QW-404.36 When flux from recrushed slag is used, each batch or blend, as defined in SFA-5.01, shall be tested in accordance with Section II, Part C by either the manufacturer or user, or qualified as an unclassified flux in accordance with [QW-404.9](#).

QW-404.37 A change in the composition of the deposited weld metal from one A-Number in [Table QW-442](#) to any other A-Number, or to an analysis not listed in the table. A change in the UNS number for each AWS classification of A-No. 8 or A-No. 9 analysis of [Table QW-442](#), or each nonferrous alloy in [Table QW-432](#), shall require separate WPS qualification. A-Numbers may be determined in accordance with [QW-404.5](#).

QW-404.38 A change in the nominal electrode diameter used for the first layer of deposit.

QW-404.39 For submerged-arc welding and electroslag welding, a change in the nominal composition or type of flux used. Requalification is not required for a change in flux particle size.

QW-404.41 A change of more than 10% in the powdered metal feed rate recorded on the PQR.

QW-404.42 A change of more than 5% in the particle size range of the powder.

QW-404.43 A change in the powdered metal particle size range recorded on the PQR.

QW-404.44 A change from a homogeneous powdered metal to a mechanical mixed powdered metal or vice versa.

QW-404.46 A change in the powder feed rate range qualified.

QW-404.47 A change of more than 10% in the filler metal size and/or powder metal particle size.

QW-404.48 A change of more than 10% in the powder metal density.

QW-404.49 A change of more than 10% in the filler metal or powder metal feed rate.

QW-404.50 The addition or deletion of flux to the face of a weld joint for the purpose of affecting weld penetration.

QW-404.51 The method of control of moisture pick-up during storage and distribution for SMAW and GMAW-FC electrodes and flux for SAW (e.g., purchasing in hermetically sealed containers and storage in heated ovens, controlled distribution time, high-temperature baking prior to use).

QW-404.52 An increase in the diffusible hydrogen designator (e.g., from E7018-H8 to E7018-H16) or to no diffusible hydrogen designator.

QW-404.53 The addition or deletion of filler metal and, when used, a change in the filler metal nominal composition.

QW-404.55 An increase in the thickness or width of preplaced filler metal.

QW-404.56 A change to another type or grade of preplaced filler metal (type or grade are materials of the same nominal chemical analysis and mechanical property range, even though of different product form).

QW-404.57 An increase in the nominal thickness or width of the electrode for strip filler metals used with the SAW and ESW processes for corrosion-resistant and hard-facing weld metal overlay.

δ19P **QW-404.58** The addition or deletion of preplaced filler metal.

δ19P **QW-404.59** If filler metal is added, a change in the A-Number of the weld deposit or a change in the nominal composition of the deposited weld metal when an A-Number is not assigned.

QW-405 POSITIONS

QW-405.1 The addition of other welding positions than those already qualified. see [QW-120](#), [QW-130](#), [QW-203](#), and [QW-303](#).

QW-405.2

DELETED

QW-405.3 A change from upward to downward, or from downward to upward, in the progression specified for any pass of a vertical weld, except that the cover or wash pass may be up or down. The root pass may also be run either up or down when the root pass is removed to sound weld metal in the preparation for welding the second side.

QW-405.4 Except as specified below, the addition of other welding positions than already qualified.

(a) Qualification in the horizontal, vertical, or overhead position shall also qualify for the flat position. Qualification in the horizontal fixed position, 5G, shall qualify for the flat, vertical, and overhead positions. Qualification in the horizontal, vertical, and overhead positions shall qualify for all positions. Qualification in the inclined fixed position, 6G, shall qualify for all positions.

(b) An organization who does production welding in a particular orientation may make the tests for procedure qualification in this particular orientation. Such qualifications are valid only for the positions actually tested, except that an angular deviation of ± 15 deg is permitted in the inclination of the weld axis and the rotation of the weld face as defined in [Figure QW-461.1](#). A test specimen shall be taken from the test coupon in each special orientation.

(c) For hard-facing and corrosion-resistant weld metal overlay, qualification in the 3G, 5G, or 6G positions, where 5G or 6G pipe coupons include at least one vertical segment completed utilizing the up-hill progression or a 3G plate coupon is completed utilizing the up-hill progression, shall qualify for all positions. Chemical analysis, hardness, macro-etch, and at least two of the bend tests, as required in [Table QW-453](#), shall be removed from the vertical uphill overlaid segment as shown in [Figure QW-462.5\(b\)](#).

(d) A change from the vertical down to vertical up-hill progression shall require requalification.

QW-406 PREHEAT

QW-406.1 A decrease of more than 100°F (55°C) in the preheat temperature qualified. The minimum temperature for welding shall be specified in the WPS.

QW-406.2 A change in the maintenance or reduction of preheat upon completion of welding prior to any required postweld heat treatment.

QW-406.3 An increase of more than 100°F (55°C) in the maximum interpass temperature recorded on the PQR. This variable does not apply when a WPS is qualified

with a PWHT above the upper transformation temperature or when an austenitic or P-No. 10H material is solution annealed after welding.

QW-406.4 A decrease of more than 100°F (55°C) in the preheat temperature qualified or an increase in the maximum interpass temperature recorded on the PQR. The minimum temperature for welding shall be specified in the WPS.

QW-406.5 A change in the maintenance or reduction of preheat upon completion of spraying and prior to fusing.

QW-406.7 A change of more than 10% in the amplitude or number of preheating cycles from that qualified, or if other preheating methods are employed, a change in the preheating temperature of more than 25°F (15°C).

QW-406.9 A decrease in the preheat temperature from that achieved on the test coupon and recorded on the PQR.

QW-406.10 The minimum preheating soaking time prior to the start of welding.

QW-406.11 The addition or deletion of a postweld hydrogen bakeout. When specified, the minimum soaking temperature and time shall be specified.

QW-407 POSTWELD HEAT TREATMENT

QW-407.1 A separate procedure qualification is required for each of the following:

(a) For P-Numbers 1 through 6 and 9 through 15F materials, the following postweld heat treatment conditions apply:

(1) no PWHT

(2) PWHT below the lower transformation temperature

(3) PWHT above the upper transformation temperature (e.g., normalizing)

(4) PWHT above the upper transformation temperature followed by heat treatment below the lower transformation temperature (e.g., normalizing or quenching followed by tempering)

(5) PWHT between the upper and lower transformation temperatures

(b) For all other materials, the following postweld heat treatment conditions apply:

(1) no PWHT

(2) PWHT within a specified temperature range

QW-407.2 A change in the postweld heat treatment (see [QW-407.1](#)) temperature and time range

The procedure qualification test shall be subjected to PWHT essentially equivalent to that encountered in the fabrication of production welds, including at least 80% of the aggregate times at temperature(s). The PWHT total time(s) at temperature(s) may be applied in one heating cycle.

QW-407.6 A change in postweld heat treatment condition in [QW-407.1](#) or an increase of 25% or more in total time at postweld heat treating temperature.

QW-407.7 A change in the heat treatment temperature range qualified if heat treatment is applied after fusing.

QW-407.8 A separate PQR is required for each of the following:

(a) no PWHT

(b) a change of more than 10% in the number of PWHT heating current cycles following the welding cycle

(c) PWHT within a specified temperature and time range if heat treatment is performed separately from the welding operation

QW-407.9 A separate procedure qualification is required for each of the following:

(a) For weld corrosion-resistant overlay of A-No. 8 on all base materials, a change in postweld heat treatment condition in [QW-407.1](#), or when the total time at postweld heat treatment encountered in fabrication exceeds 20 hr, an increase of 25% or more in total time at postweld heat treating temperature.

(b) For weld corrosion-resistant overlay of A-No. 9 on all base materials, a change in postweld heat treatment condition in [QW-407.1](#), or an increase of 25% or more in total time at postweld heat treating temperature.

(c) For all other weld corrosion-resistant overlays on all base materials, a change in postweld heat treatment condition in [QW-407.1](#).

QW-407.10 The addition or deletion of PWHT, or a change of $\pm 45^\circ\text{F}$ ($\pm 25^\circ\text{C}$) in PWHT temperature or an increase in the holding time by more than 25% or change in the method of cooling (e.g., furnace, air, quench).

QW-408 GAS

QW-408.1 The addition or deletion of trailing gas and/or a change in its composition.

QW-408.2 A separate procedure qualification is required for each of the following:

(a) a change from a single shielding gas to any other single shielding gas

(b) a change from a single shielding gas to a mixture of shielding gasses, and vice versa

(c) a change in the specified percentage composition of a shielding gas mixture

(d) the addition or omission of shielding gas

The AWS classification of SFA-5.32 may be used to specify the shielding gas composition.

QW-408.3 A change in the specified flow rate range of the shielding gas or mixture of gases.

QW-408.4 A change in the composition of the orifice or shielding gas.

QW-408.5 The addition or deletion of backing gas, a change in backing gas composition, or a change in the specified flow rate range of the backing gas.

QW-408.6 A change of environment shielding such as from vacuum to an inert gas, or vice versa.

QW-408.7 A change in the type of fuel gas.

QW-408.8 The omission of backing gas except that requalification is not required when welding a single-welded butt joint with a backing strip or a double-welded butt joint or a fillet weld. This exception does not apply to P-No. 51 through P-No. 53, P-No. 61 through P-No. 62, and P-No. 10I metals.

QW-408.9 For groove welds in P-No. 41 through P-No. 49 and all welds of P-No. 10I, P-No. 10J, P-No. 10K, P-No. 51 through P-No. 53, and P-No. 61 through P-No. 62 metals, the deletion of backing gas or a change in the nominal composition of the backing gas from an inert gas to a mixture including non-inert gas(es).

QW-408.10 For P-No. 10I, P-No. 10J, P-No. 10K, P-No. 51 through P-No. 53, and P-No. 61 through P-No. 62 metals, the deletion of trailing gas, or a change in the nominal composition of the trailing gas from an inert gas to a mixture including non-inert gas(es), or a decrease of 10% or more in the trailing gas flow rate.

QW-408.11 The addition or deletion of one or more of the following:

- (a) shielding gas
- (b) trailing gas
- (c) backing gas
- (d) plasma-removing gas

QW-408.12 A decrease of more than 10% in the flow rate of one or more of the following: shielding gas, trailing gas, backing gas, and plasma-removing gas.

QW-408.14 A change in the oxygen or fuel gas pressure beyond the range qualified.

QW-408.16 A change of more than 5% in the flow rate of the plasma-arc gas or powdered metal feed gas recorded on the PQR.

QW-408.17 A change in the plasma-arc gas, shielding gas, or powdered metal feed gas from a single gas to any other single gas, or to a mixture of gases, or vice versa.

QW-408.18 A change of more than 10% in the gas mixture composition of the plasma-arc gas, shielding gas, or powdered metal feed gas recorded on the PQR.

QW-408.19 A change in the nominal composition of the powder feed gas or (plasma-arc spray) plasma gas qualified.

QW-408.20 A change of more than 5% in the plasma gas flow rate range qualified.

QW-408.21 A change in the flow rate of the orifice or shielding gas.

QW-408.22 A change in the shielding gas type, gas pressure, or purging time.

QW-408.23 For titanium, zirconium, and their alloys, the deletion of one or more of the following:

- (a) shielding gas
- (b) trailing gas
- (c) backing gas

QW-408.24 For gas-shielded processes, the maximum moisture content (dew point) of the shielding gas. Moisture control may be by specification of shielding gas classifications in SFA-5.32.

QW-408.25 A change in the furnace atmosphere from that qualified.

QW-408.26 For friction stir welding of P-No. 6, P-No. 7, P-No. 8, P-No. 10H, P-No. 10I, P-No. 41 through P-No. 47, P-No. 51 through P-No. 53, and P-No. 61 through P-No. 62, the addition or deletion of trailing or tool shielding gas, or a change in gas composition or flow rate.

QW-409 ELECTRICAL CHARACTERISTICS

QW-409.1 An increase in heat input, or an increase in volume of weld metal deposited per unit length of weld, for each process recorded on the PQR. For arc welding, the increase shall be determined by (a), (b), or (c) for non-waveform controlled welding, or by (b) or (c) for waveform controlled welding. See [Nonmandatory Appendix H](#). For low-power density laser beam welding (LLBW), the increase shall be determined by (d).

(a) Heat input [J/in. (J/mm)]

$$= \frac{\text{Voltage} \times \text{Amperage} \times 60}{\text{Travel Speed} \left[\frac{\text{in.}}{\text{min}} \left(\frac{\text{mm}}{\text{min}} \right) \right]}$$

(b) Volume of weld metal measured by

- (1) an increase in bead size (width × thickness), or
- (2) a decrease in length of weld bead per unit length of electrode

(c) Heat input determined using instantaneous energy or power by

- (1) for instantaneous energy measurements in joules (J) *Heat input [J/in. (J/mm)]*

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

- (2) for instantaneous power measurements in joules per second (J/s) or Watts (W) *Heat input [J/in. (J/mm)]*

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

(d) LLBW Heat input [J/in. (J/mm)]

$$= \frac{\text{Power (W)} \times 60}{\text{Travel Speed [in./min (mm/min)]}}$$

where Power is the power delivered to the work surface as measured by calorimeter or other suitable methods.

The requirement for measuring the heat input or volume of deposited weld metal does not apply when the WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic or P-No. 10H material is solution annealed after welding.

QW-409.2 A change from globular, spray or pulsed spray transfer welding to short-circuiting transfer welding or vice versa.

QW-409.3 The addition or deletion of pulsing current to dc power source.

QW-409.4 A change from AC to DC, or vice versa; and in DC welding, a change from electrode negative (straight polarity) to electrode positive (reverse polarity), or vice versa.

QW-409.5 A change of $\pm 15\%$ in the amperage or voltage range.

QW-409.6 A change in the beam current of more than $\pm 5\%$, voltage of more than $\pm 2\%$, welding speed of more than $\pm 2\%$, beam focus current of more than $\pm 5\%$, gun-to-work distance of more than $\pm 5\%$, or a change in oscillation length or width of more than $\pm 20\%$.

QW-409.7 Any change in the beam pulsing frequency duration.

QW-409.8 A change in the range of amperage, or except for SMAW, GTAW, or waveform controlled welding, a change in the range of voltage. A change in the range of electrode wire feed speed may be used as an alternative to amperage. See [Nonmandatory Appendix H](#):

QW-409.9 A change in the arc timing of more than $\pm 1/10$ sec.

QW-409.10 A change in amperage of more than $\pm 10\%$.

QW-409.11 A change in the power source from one model to another.

QW-409.12 A change in type or size of tungsten electrode.

QW-409.13 A change from one Resistance Welding Manufacturer's Association (RWMA) electrode class to another. In addition, a change in the following:

(a) for spot and projection welding, a change in the nominal shape or more than 10% of the contact area of the welding electrode

(b) for seam welding, a change of thickness, profile, orientation, or diameter of electrodes exceeding 10%

QW-409.14 Addition or deletion of upslope or downslope current control, or a change of more than 10% in the slope current time or amplitude.

QW-409.15

(a) A change of more than 5% in any of the following:

(1) preheating current

(2) preheating current amplitude

(3) preheating current time duration

(4) electrode pressure

(5) welding current

(6) welding current time duration

(b) A change from AC to DC or vice versa.

(c) The addition or deletion of pulsing current to a DC power source.

(d) When using pulsing DC current, a change of more than 5% in the pulse amplitude, frequency, or number of pulses per cycle.

(e) A change of more than 5% in the post-heating current time duration.

QW-409.17 A change in the power supply primary voltage or frequency, or in the transformer turns ratio, tap setting, choke position, secondary open circuit voltage or phase control setting.

QW-409.18 A change in the procedure or frequency of tip cleaning.

QW-409.19 Any change of more than $\pm 10\%$ in the beam pulsing frequency and pulse duration.

QW-409.20 Any change in the following variables: mode of operation (from pulsed to continuous and vice versa), energy distribution across the beam (i.e., multi-mode or gaussian).

QW-409.21 A decrease of more than 10% in the power delivered to the work surface as measured by calorimeter or other suitable methods.

QW-409.22 An increase of more than 10% in the amperage used in application for the first layer.

QW-409.23 A change of more than 10% in the range of amperage or voltage.

QW-409.24 A change of more than 10% in the filler wire wattage recorded on the PQR. Wattage is a function of current voltage, and stickout dimension.

QW-409.25 A change of more than 10% in the plasma-arc current or voltage recorded on the PQR.

QW-409.26 For the first layer only, an increase in heat input of more than 10% or an increase in volume of weld metal deposited per unit length of weld of more than 10%. The increase shall be determined by the methods of [QW-409.1](#).

When using strip filler metal, the heat input shall be calculated as follows:

$$\text{Heat Input [J/in.}^2 \text{ (J/mm}^2\text{)]} = \frac{\text{Voltage} \times \text{Amperage} \times 60}{\text{Travel Speed [in./min (mm/min)]} \times \text{Strip Width [in. (mm)]}}$$

QW-409.27 A change in the flashing time of more than 10%.

QW-409.28 A change in the upset current time by more than 10%.

QW-409.29

(a) A change in heat input beyond the following (see Figure QW-462.12):

(1) An increase or decrease in the ratio of heat input between the first tempering bead layer and the weld beads deposited against the base metal of more than 20% for P-No. 1 and P-No. 3 metals and 10% for all other P-Number metals.

(2) An increase or decrease in the ratio of heat input between the second tempering bead layer and the first tempering bead layer of more than 20% for P-No. 1 and P-No. 3 metals and 10% for all other P-Number metals.

(3) The ratio of heat input between subsequent layers shall be maintained until a minimum of $\frac{3}{16}$ in. (5 mm) of weld metal has been deposited over the base metal.

(4) Where the basis for acceptance is toughness testing and the filler metal is exempt from temper bead qualification, the heat input may not exceed 50% above the heat input qualified for the remaining fill passes.

(5) Where the basis for acceptance is hardness testing, a decrease of more than 20% in heat input for the remainder of the fill passes.

(b) Heat input shall be determined using the following methods:

(1) For machine or automatic GTAW or PAW, an increase or decrease of 10% in the power ratio measured as:

$$\text{Power Ratio} = \frac{\text{Amperage} \times \text{Voltage}}{[(WFS / TS) \times A_f]}$$

where

A_f = the cross-section area of the filler metal wire

TS = the welding travel speed

WFS = the filler metal wire feed speed

(2) For processes other than machine or automatic GTAW or PAW, heat input shall be determined by the method of QW-409.1.

(3) If manual GTAW or PAW is used for making in-process repairs in accordance with QW-290.5, a record of bead size shall be made.

QW-410 TECHNIQUE

QW-410.1 For manual or semiautomatic welding, a change from the stringer bead technique to the weave bead technique, or vice versa.

QW-410.2 A change in the nature of the flame, oxidizing to reducing, or vice versa.

QW-410.3 A change in the orifice, cup, or nozzle size.

QW-410.4 A change in the welding technique, forehand to backhand, or vice versa.

QW-410.5 A change in the method of initial and inter-pass cleaning (brushing, grinding, etc.).

QW-410.6 A change in the method of back gouging.

QW-410.7 For the machine or automatic welding process, a change of more than $\pm 10\%$ in width, frequency, or dwell time of oscillation technique.

QW-410.8 A change in the contact tube to work distance.

QW-410.9 A change from multipass per side to single pass per side. This variable does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic or P-No. 10H material is solution annealed after welding.

QW-410.10 A change from single electrode to multiple electrode, or vice versa, for machine or automatic welding only. This variable does not apply when a WPS is qualified with a PWHT above the upper transformation temperature or when an austenitic or P-No. 10H material is solution annealed after welding.

QW-410.11 A change from closed chamber to out-of-chamber conventional torch welding in P-No. 51 through P-No. 53 metals, but not vice versa.

QW-410.12 A change from the melt-in technique to the keyhole technique of welding, or vice versa, or the inclusion of both techniques though each has been individually qualified.

QW-410.14 A change of more than ± 10 deg in the relative angle between the axis of the beam and the workpiece. δ19P

QW-410.15 A change in the spacing of multiple electrodes for machine or automatic welding.

QW-410.17 A change in the type or model of the welding equipment.

QW-410.18 An increase in the absolute pressure of the vacuum welding environment beyond that qualified.

QW-410.19 Any change in filament type, size, or shape.

QW-410.20 The addition of a wash pass.

QW-410.21 For full penetration groove welds, a change of welding from both sides to welding from one side only, but not vice versa.

QW-410.22 A change in either of the following stud welding parameters: a change of stud gun model; a change in the lift more than $\pm \frac{1}{32}$ in. (0.8 mm).

QW-410.25 A change from manual or semiautomatic to machine or automatic welding and vice versa.

QW-410.26 The addition or deletion of peening.

QW-410.27 A change in the rotational speed producing a change in the outside surface velocity [ft/min (m/min)] greater than $\pm 10\%$ of the outside surface velocity qualified.

QW-410.28 A change in the thrust load greater than $\pm 10\%$ of the thrust load qualified.

QW-410.29 A change in the rotational energy greater than $\pm 10\%$ of the rotational energy qualified.

QW-410.30 Any change in upset dimension (overall loss in length of parts being joined) greater than $\pm 10\%$ of the upset qualified.

QW-410.31 A change in the method of preparing the base metal prior to welding (e.g., changing from mechanical cleaning to chemical cleaning or to abrasive cleaning, or vice versa).

QW-410.32 A change of more than 10% in the holding (forging) pressure prior to or after welding. A change of more than 10% in the electrode holding time (electrode duration sequence).

QW-410.33 A change from one welding type to another, or modification of equipment, including Manufacturer, control panel, model number, electrical rating or capacity, type of electrical energy source, or method of applying pressure.

QW-410.34 Addition or deletion of an electrode cooling medium and where it is used.

QW-410.35 A change in the distance between arms or a change in the throat depth.

QW-410.37 A change from single to multiple pass or vice versa.

QW-410.38 A change from multiple-layer to single layer cladding/hardsurfacing, or vice versa.

QW-410.39 A change in the torch type or tip size.

QW-410.40 For submerged-arc welding and electroslag welding, the deletion of a supplementary device for controlling the magnetic field acting on the weld puddle.

QW-410.41 A change of more than 15% in the travel speed range recorded on the PQR.

QW-410.43 For the torch or workpiece, a change of more than 10% in the travel speed range qualified.

QW-410.44 A change of more than 15% in the spray-torch to workpiece distance qualified.

QW-410.45 A change in the method of surface preparation of the base metal to be hard-faced (example: sandblasting versus chemical cleaning).

QW-410.46 A change in the spray-torch model or tip orifice size.

QW-410.47 A change of more than 10% in the fusing temperature range qualified. A change in the rate of cooling from the fusing temperature of more than 50°F/hr (28°C/hr), a change in the fusing method (e.g., torch, furnace, induction).

QW-410.48 A change in the constricted arc from transferable to nontransferable or vice versa.

QW-410.49 A change in the diameter of the plasma torch-arc constricting orifice.

QW-410.50 A change in the number of electrodes acting on the same welding puddle.

QW-410.52 A change in the method of delivering the filler metal to the molten pool, such as from the leading or trailing edge of the torch, the sides of the torch, or through the torch.

QW-410.53 A change of more than 20% in the center-to-center weld bead distance.

QW-410.54 A change in the upset length or force of more than 10%.

QW-410.55 A change in the distance between the clamping dies of more than 10% or a change in the surface preparation of the clamping area.

QW-410.56 A change in the clamping force by more than 10%.

QW-410.57 A change in more than 10% of the forward or reverse speed.

QW-410.58 The deletion of surface temper beads (see [Figure QW-462.12](#)) or a change from surface temper beads that cover the weld surface to beads that are only deposited along the toes of the weld.

QW-410.59 A change from machine or automatic welding to manual or semiautomatic welding.

QW-410.60 The addition of thermal methods to prepare the surface to be welded unless the WPS requires that the metal be ground to bright metal before welding.

QW-410.61 The distance, S , from the toe of the weld to the edge of any tempering bead shall be limited to the distance measured on the test coupon $\pm 1/16$ in. (± 1.5 mm) (see [Figure QW-462.12](#)). Alternatively, a range for S may be established by locating temper beads at various distances from the toe of the weld followed by hardness traverses or toughness testing, as applicable. Temper reinforcing beads shall not be permitted to touch the toe of the weld. In addition, the ratios of heat input described in [QW-409.29](#) shall apply to temper beads.

QW-410.62 The method of removal of surface temper bead reinforcing layer when it will be removed, including provisions to prevent overheating of the weld surface.

QW-410.63 For weld beads against the base metal and for each tempering bead layer, the range of bead width, b , relative to overlap of the previous bead width, a , as shown in [Figure QW-462.13](#), shall be specified on the WPS. Overlap between 25% and 75% does not require qualification.

(a) Overlap greater than 75% shall be qualified by welding a test coupon using the desired overlap. The overlap qualified shall be the maximum overlap permitted and the minimum overlap shall be 50%.

(b) Overlap less than 25% shall be qualified by welding a test coupon using the desired overlap. The overlap qualified shall be the minimum overlap permitted and the maximum overlap shall be 50%.

QW-410.64 For vessels or parts of vessels constructed with P-No. 11A and P-No. 11B base metals, weld grooves for thicknesses less than $\frac{5}{8}$ in. (16 mm) shall be prepared by thermal processes when such processes are to be employed during fabrication. This groove preparation shall also include back gouging, back grooving, or removal of unsound weld metal by thermal processes when these processes are to be employed during fabrication.

QW-410.65 The addition or deletion of grinding beyond that required to clean the surface or remove minor surface flaws (i.e., use or nonuse of half-bead technique or similar technique).

QW-410.66 A change of more than $\pm 10\%$ in the travel speed, the ratio of the beam diameter to focal length, or the lens to work distance.

QW-410.67 A change in the optical technique used to focus the welding energy from that qualified.

QW-410.68 A change in welding equipment type (e.g., YAG, TAG, etc.).

QW-410.70 A change in the method of preparing the base metal surface prior to insertion into the furnace.

QW-410.71 A decrease in the percentage of block compression (original stack height compared to height after welding) from that of the test coupon.

QW-410.72 A decrease in the welding temperature or time from that used on the procedure qualification test coupon.

QW-410.73 A change in joint restraint fixtures from that qualified (e.g., fixed anvil to self-reacting, and vice versa) or from single-sided to two-sided welding, and vice versa.

QW-410.74 A change in the welding control method from that qualified (e.g., force control method to position control method, or vice versa, in the plunge direction; and force control method to travel control method, or vice versa, in the travel direction).

QW-410.75 A change in the rotating tool

(a) type or design from the qualified "family" to another (i.e., threaded pin, smooth pin, fluted, self-reacting, retracting-pin, or other tool types)

(b) configuration or dimensions from that qualified beyond the following limits (as applicable):

(1) shoulder diameter greater than 10%

(2) shoulder scroll pitch greater than 10%

(3) shoulder profile (e.g., addition or deletion of shoulder feature)

(4) pin diameter greater than 5%

(5) pin length greater than the lesser of 5% of qualified pin length or 1% of base metal thickness (not minimum pin length for retracting-pin tools, and not applicable for self-reacting rotating tools)

(6) pin taper angle greater than 5 deg

(7) flute pitch greater than 5%

(8) pin tip geometry or shape

(9) thread pitch greater than 10% (as applicable)

(10) flat design resulting in a change of the total flat surface area greater than 20%

(11) number of flats

(12) cooling characteristics of the rotating pin (e.g., change from water-cooled to air-cooled, and vice versa)

(c) pin material specification, nominal chemical composition, and minimum hardness

QW-410.76 A change in the rotating tool operation from that qualified beyond the following limits (as applicable):

(a) decrease in rotation speed, or increase greater than 10%

(b) direction of rotation

(c) plunge force greater than 10% or plunge position set point greater than 5% when controlling the plunge direction (except during ramp-up and ramp-down when starting and stopping)

(d) angular tilt greater than 1 deg in any direction

(e) travel force or travel speed greater than 10% when controlling travel direction (except during ramp-up and ramp-down when starting and stopping)

(f) range of relative motion between tool components when using self-reacting or retractable-pin tools

(g) reduction in the smallest radius of travel path curvature that results in reversing the travel direction of the pin or the shoulder

(h) manner or angle of intersection, or number of coincident intersections, within the same weld or between the weld and the HAZ of other welds

QW-410.77 A change in the laser wavelength (e.g., CO₂, Nd:YAG, fiber, disk, diode) from that qualified.

QW-410.80 A change of $\pm 5\%$ in the diameter of the focused spot size.

QW-410.81 The addition of tube expansion prior to welding. δ19P

QW-410.82 A change in the method of pressure application. δ19P

QW-410.83 A change in the type of explosive or a change in the energy content greater than $\pm 10\%$. δ19P

QW-410.84 A change in the distance between the explosive charge and the tubesheet face greater than $\pm 10\%$. δ19P

QW-410.85 A change in the specified clearance between the tube and the tubesheet greater than $\pm 10\%$. δ19P

**Table QW/QB-422
Ferrous and Nonferrous P-Numbers
Grouping of Base Metals for Qualification**

Spec. No.	Designation, Type, or Grade	UNS No.	Minimum Specified Tensile, ksi (MPa)	Welding		Brazing			Nominal Composition	Typical Product Form
				P-No.	Group No.	P-No.	AWS B2.2 BM	ISO 15608 Group		
Ferrous										
A/SA-36	...	...	58 (400)	1	1	101	100	11.1	C-Mn-Si	Plate, bar & shapes
A/SA-53	E, A	K02504	48 (330)	1	1	101	100	1.1	C	Resistance welded pipe
A/SA-53	S, A	K02504	48 (330)	1	1	101	100	1.1	C	Smls. pipe
A/SA-53	E, B	K03005	60 (415)	1	1	101	100	11.1	C-Mn	Resistance welded pipe
A/SA-53	F	K03005	48 (330)	1	1	101	100	11.1	C	Furnace welded pipe
A/SA-53	S, B	K03005	60 (415)	1	1	101	100	11.1	C-Mn	Smls. pipe
A/SA-105	...	K03504	70 (485)	1	2	101	100	11.1	C	Flanges & fittings
A/SA-106	A	K02501	48 (330)	1	1	101	100	1.1	C-Si	Smls. pipe
A/SA-106	B	K03006	60 (415)	1	1	101	100	11.1	C-Mn-Si	Smls. pipe
A/SA-106	C	K03501	70 (485)	1	2	101	100	11.1	C-Mn-Si	Smls. pipe
A108	1015	G10150	...	1	1	101	100	1.1	C	Bar
A108	1018	G10180	...	1	1	101	100	1.1	C	Bar
A108	1020	G10200	...	1	1	101	100	1.1	C	Bar
A108	8620	G86200	...	3	3	102	100	4.1	0.5Ni-0.5Cr-Mo	Bar
A/SA-134	SA283 A	K01400	45 (310)	1	1	101	100	1.1	C	Welded pipe
A/SA-134	SA285 A	K01700	45 (310)	1	1	101	100	1.1	C	Welded pipe
A/SA-134	SA283 B	K01702	50 (345)	1	1	101	100	1.1	C	Welded pipe
A/SA-134	SA285 B	K02200	50 (345)	1	1	101	100	1.1	C	Welded pipe
A/SA-134	SA283 C	K02401	55 (380)	1	1	101	100	1.1	C	Welded pipe
A/SA-134	SA283 D	K02702	60 (415)	1	1	101	100	11.1	C	Welded pipe
A/SA-134	SA285 C	K02801	55 (380)	1	1	101	100	11.1	C	Welded pipe
A/SA-135	A	K02509	48 (330)	1	1	101	100	1.1	C	E.R.W. pipe
A/SA-135	B	K03018	60 (415)	1	1	101	100	11.1	C	E.R.W. pipe
A139	A	K02508	48 (330)	1	1	101	100	1.1	C	Welded pipe
A139	B	K03003	60 (415)	1	1	101	100	11.1	C	Welded pipe
A139	C	K03004	60 (415)	1	1	101	100	11.1	C	Welded pipe
A139	D	K03010	60 (415)	1	1	101	100	11.1	C	Welded pipe
A139	E	K03012	66 (455)	1	1	101	100	11.1	C	Welded pipe
A167	302B	S30215	75 (515)	8	1	102	130	8.1	18Cr-8Ni-2Si	Plate, sheet & strip
A167	308	S30800	75 (515)	8	2	102	130	8.2	20Cr-10Ni	Plate, sheet & strip
A167	309	S30900	75 (515)	8	2	102	130	8.2	23Cr-12Ni	Plate, sheet & strip
A167	310	S31000	75 (515)	8	2	102	130	8.2	25Cr-20Ni	Plate, sheet & strip

**Table QW/QB-422
Ferrous and Nonferrous P-Numbers
Grouping of Base Metals for Qualification (Cont'd)**

Spec. No.	Designation, Type, or Grade	UNS No.	Minimum Specified Tensile, ksi (MPa)	Welding		Brazing			Nominal Composition	Typical Product Form
				P-No.	Group No.	P-No.	AWS B2.2 BM	ISO 15608 Group		
Ferrous (Cont'd)										
A/SA-178	A	K01200	47 (325)	1	1	101	100	1.1	C	E.R.W. tube
A/SA-178	D	K02709	70 (485)	1	2	101	100	11.1	C-Mn-Si	E.R.W. tube
A/SA-178	C	K03503	60 (415)	1	1	101	100	11.1	C	E.R.W. tube
A/SA-179	...	K01200	47 (325)	1	1	101	100	1.1	C	Smls. tube
A/SA-181	Cl. 60	K03502	60 (415)	1	1	101	100	11.1	C-Si	Pipe flange & fittings
A/SA-181	Cl. 70	K03502	70 (485)	1	2	101	100	11.1	C-Si	Pipe flange & fittings
A/SA-182	F12, Cl. 1	K11562	60 (415)	4	1	102	110	5.1	1Cr-0.5Mo	Forgings
A/SA-182	F12, Cl. 2	K11564	70 (485)	4	1	102	110	5.1	1Cr-0.5Mo	Forgings
A/SA-182	F11, Cl. 2	K11572	70 (485)	4	1	102	110	5.1	1.25Cr-0.5Mo-Si	Forgings
A/SA-182	F11, Cl. 3	K11572	75 (515)	4	1	102	110	5.1	1.25Cr-0.5Mo-Si	Forgings
A/SA-182	F11, Cl. 1	K11597	60 (415)	4	1	102	110	5.1	1.25Cr-0.5Mo-Si	Forgings
A/SA-182	F2	K12122	70 (485)	3	2	101	100	4.2	0.5Cr-0.5Mo	Forgings
A/SA-182	F1	K12822	70 (485)	3	2	101	100	1.1	C-0.5Mo	Forgings
A/SA-182	F22, Cl. 1	K21590	60 (415)	5A	1	102	110	5.2	2.25Cr-1Mo	Forgings
A/SA-182	F22, Cl. 3	K21590	75 (515)	5A	1	102	110	5.2	2.25Cr-1Mo	Forgings
A/SA-182	FR	K22035	63 (435)	9A	1	101	100	9.1	2Ni-1Cu	Forgings
A/SA-182	F3VCb	K31390	85 (585)	5C	1	102	110	6.2	3Cr-1Mo-0.25V-Cb-Ca	Forgings
A/SA-182	F21	K31545	75 (515)	5A	1	102	110	5.2	3Cr-1Mo	Forgings
A/SA-182	F3V	K31830	85 (585)	5C	1	102	120	6.2	3Cr-1Mo-V-Ti-B	Forgings
A/SA-182	F22V	K31835	85 (585)	5C	1	102	110	6.2	2.25Cr-1Mo-V	Forgings
A/SA-182	F5	K41545	70 (485)	5B	1	102	110	5.3	5Cr-0.5Mo	Forgings
A/SA-182	F5a	K42544	90 (620)	5B	1	102	110	5.3	5Cr-0.5Mo	Forgings
A/SA-182	F91	K90901	90 (620)	15E	1	102	110	6.4	9Cr-1Mo-V	Forgings
A/SA-182	F9	K90941	85 (585)	5B	1	102	110	5.4	9Cr-1Mo	Forgings
A/SA-182	F92	K92460	90 (620)	15E	1	102	110	6.4	9Cr-2W	Forgings
A/SA-182	...	N08367	95 (655)	45	...	111	420	8.2	46Fe-24Ni-21Cr-6Mo-N	Forgings
A/SA-182	F904L	N08904	71 (490)	45	...	111	150	8.2	44Fe-25Ni-21Cr-Mo	Forgings
A/SA-182	FXM-19	S20910	100 (690)	8	3	102	130	8.3	22Cr-13Ni-5Mn	Forgings
A/SA-182	FXM-11	S21904	90 (620)	8	3	102	130	8.3	21Cr-6Ni-9Mn	Forgings
A/SA-182	F304	S30400	70 (485)	8	1	102	130	8.1	18Cr-8Ni	Forgings > 5 in. (127 mm)
A/SA-182	F304	S30400	75 (515)	8	1	102	130	8.1	18Cr-8Ni	Forgings
A/SA-182	F304L	S30403	65 (450)	8	1	102	130	8.1	18Cr-8Ni	Forgings > 5 in. (127 mm)
A/SA-182	F304L	S30403	70 (485)	8	1	102	130	8.1	18Cr-8Ni	Forgings
A/SA-182	F304H	S30409	70 (485)	8	1	102	130	8.1	18Cr-8Ni	Forgings > 5 in. (127 mm)

QW-430 F-NUMBERS**QW-431 GENERAL**

The following F-Number grouping of electrodes and welding rods in [Table QW-432](#) is based essentially on their usability characteristics, which fundamentally determine the ability of welders to make satisfactory welds with a given filler metal. This grouping is made to reduce the number of welding procedure and performance

qualifications, where this can logically be done. The grouping does not imply that base metals or filler metals within a group may be indiscriminately substituted for a metal that was used in the qualification test without consideration of the compatibility of the base and filler metals from the standpoint of metallurgical properties, postweld heat treatment design and service requirements, and mechanical properties.

Table QW-432
F-Numbers
Grouping of Electrodes and Welding Rods for Qualification

F-No.	ASME Specification	AWS Classification	UNS No.
Steel and Steel Alloys			
1	SFA-5.1	EXX20	...
1	SFA-5.1	EXX22	...
1	SFA-5.1	EXX24	...
1	SFA-5.1	EXX27	...
1	SFA-5.1	EXX28	...
1	SFA-5.4	EXXX(X)-26	...
1	SFA-5.5	EXX20-X	...
1	SFA-5.5	EXX27-X	...
2	SFA-5.1	EXX12	...
2	SFA-5.1	EXX13	...
2	SFA-5.1	EXX14	...
2	SFA-5.1	EXX19	...
2	SFA-5.5	E(X)XX13-X	...
3	SFA-5.1	EXX10	...
3	SFA-5.1	EXX11	...
3	SFA-5.5	E(X)XX10-X	...
3	SFA-5.5	E(X)XX11-X	...
4	SFA-5.1	EXX15	...
4	SFA-5.1	EXX16	...
4	SFA-5.1	EXX18	...
4	SFA-5.1	EXX18M	...
4	SFA-5.1	EXX48	...
4	SFA-5.4 other than austenitic and duplex	EXXX(X)-15	...
4	SFA-5.4 other than austenitic and duplex	EXXX(X)-16	...
4	SFA-5.4 other than austenitic and duplex	EXXX(X)-17	...
4	SFA-5.5	E(X)XX15-X	...
4	SFA-5.5	E(X)XX16-X	...
4	SFA-5.5	E(X)XX18-X	...
4	SFA-5.5	E(X)XX18M	...
4	SFA-5.5	E(X)XX18M1	...
4	SFA-5.5	E(X)XX45	...
5	SFA-5.4 austenitic and duplex	EXXX(X)-15	...
5	SFA-5.4 austenitic and duplex	EXXX(X)-16	...
5	SFA-5.4 austenitic and duplex	EXXX(X)-17	...
6	SFA-5.2	All classifications	...
6	SFA-5.9	All classifications	...
6	SFA-5.17	All classifications	...
6	SFA-5.18	All classifications	...
6	SFA-5.20	All classifications	...

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Table QW-432
F-Numbers
Grouping of Electrodes and Welding Rods for Qualification (Cont'd)

F-No.	ASME Specification	AWS Classification	UNS No.
Steel and Steel Alloys (Cont'd)			
6	SFA-5.22	All classifications	...
6	SFA-5.23	All classifications	...
6	SFA-5.25	All classifications	...
6	SFA-5.26	All classifications	...
6	SFA-5.28	All classifications	...
6	SFA-5.29	All classifications	...
6	SFA-5.30	INMs-X	...
6	SFA-5.30	IN5XX	...
6	SFA-5.30	IN3XX(X)	...
6	SFA-5.36	All classifications	...
Aluminum and Aluminum Alloys			
21	SFA-5.3	E1100	A91100
21	SFA-5.3	E3003	A93003
21	SFA-5.10	ER1070	A91070
21	SFA-5.10	ER1080A	A91080
21	SFA-5.10	ER1100	A91100
21	SFA-5.10	ER1188	A91188
21	SFA-5.10	ER1200	A91200
21	SFA-5.10	ER1450	A91450
21	SFA-5.10	ER3103	A93103
21	SFA-5.10	R1070	A91070
21	SFA-5.10	R1080A	A91080
21	SFA-5.10	R1100	A91100
21	SFA-5.10	R1188	A91188
21	SFA-5.10	R1200	A91200
21	SFA-5.10	R1450	A91450
21	SFA-5.10	R3101	A93103
22	SFA-5.10	ER5087	A95087
22	SFA-5.10	ER5183	A95183
22	SFA-5.10	ER5183A	A95183
22	SFA-5.10	ER5187	A95187
22	SFA-5.10	ER5249	A95249
22	SFA-5.10	ER5356	A95356
22	SFA-5.10	ER5356A	A95356
22	SFA-5.10	ER5554	A95554
22	SFA-5.10	ER5556	A95556
22	SFA-5.10	ER5556A	A95556
22	SFA-5.10	ER5556B	A95556
22	SFA-5.10	ER5556C	A95556
22	SFA-5.10	ER5654	A95654
22	SFA-5.10	ER5654A	A95654
22	SFA-5.10	ER5754	A95754
22	SFA-5.10	R5087	A95087
22	SFA-5.10	R5183	A95183
22	SFA-5.10	R5183A	A95183
22	SFA-5.10	R5187	A95187
22	SFA-5.10	R5249	A95249
22	SFA-5.10	R5356	A95356
22	SFA-5.10	R5356A	A95356

QW-433 ALTERNATE F-NUMBERS FOR WELDER PERFORMANCE QUALIFICATION

The following tables identify the filler metal or electrode that the welder used during qualification testing as “Qualified With,” and the electrodes or filler metals that the welder is qualified to use in production welding as “Qualified For.” See [Table QW-432](#) for the F-Number assignments.

Qualified With →	F-No. 1 With Backing	F-No. 1 Without Backing	F-No. 2 With Backing	F-No. 2 Without Backing	F-No. 3 With Backing	F-No. 3 Without Backing	F-No. 4 With Backing	F-No. 4 Without Backing	F-No. 5 With Backing	F-No. 5 Without Backing
F-No. 1 With Backing	X	X	X	X	X	X	X	X	X	X
F-No. 1 Without Backing		X								
F-No. 2 With Backing			X	X	X	X	X	X		
F-No. 2 Without Backing				X						
F-No. 3 With Backing					X	X	X	X		
F-No. 3 Without Backing						X				
F-No. 4 With Backing							X	X		
F-No. 4 Without Backing								X		
F-No. 5 With Backing									X	X
F-No. 5 Without Backing										X

Qualified With	Qualified For
Any F-No. 6	All F-No. 6 [Note (1)]
Any F-No. 21 through F-No. 26	All F-No. 21 through F-No. 26
Any F-No. 31, F-No. 32, F-No. 33, F-No. 35, F-No. 36, or F-No. 37	Only the same F-Number as was used during the qualification test
F-No. 34 or any F-No. 41 through F-No. 46	F-No. 34 and all F-No. 41 through F-No. 46
Any F-No. 51 through F-No. 55	All F-No. 51 through F-No. 55
Any F-No. 61	All F-No. 61
Any F-No. 71 through F-No. 72	Only the same F-Number as was used during the qualification test

NOTE:
 (1) Deposited weld metal made using a bare rod not covered by an SFA Specification but which conforms to an analysis listed in [Table QW-442](#) shall be considered to be classified as F-No. 6.

QW-440 WELD METAL CHEMICAL COMPOSITION**QW-441 GENERAL**

Identification of weld metal chemical composition designated on the PQR and WPS shall be as given in [QW-404.5](#).

Table QW-442
A-Numbers
Classification of Ferrous Weld Metal Analysis for Procedure Qualification

A-No.	Types of Weld Deposit	Analysis, % [Note (1)] and [Note (2)]					
		C	Cr	Mo	Ni	Mn	Si
1	Mild Steel	0.20	0.20	0.30	0.50	1.60	1.0
2	Carbon-Molybdenum	0.15	0.50	0.40-0.65	0.50	1.60	1.0
3	Chrome (0.4% to 2%)-Molybdenum	0.15	0.40-2.00	0.40-0.65	0.50	1.60	1.0
4	Chrome (2% to 4%)-Molybdenum	0.15	2.00-4.00	0.40-1.50	0.50	1.60	2.0
5	Chrome (4% to 10.5%)-Molybdenum	0.15	4.00-10.5	0.40-1.50	0.80	1.20	2.0
6	Chrome-Martensitic	0.15	11.0-15.0	0.70	0.80	2.00	1.0
7	Chrome-Ferritic	0.15	11.0-30.0	1.00	0.80	1.00	3.0
8	Chromium-Nickel	0.15	14.5-30.0	4.00	7.50-15.0	2.50	1.0
9	Chromium-Nickel	0.30	19.0-30.0	6.00	15.0-37.0	2.50	1.0
10	Nickel to 4%	0.15	0.50	0.55	0.80-4.00	1.70	1.0
11	Manganese-Molybdenum	0.17	0.50	0.25-0.75	0.85	1.25-2.25	1.0
12	Nickel-Chrome—Molybdenum	0.15	1.50	0.25-0.80	1.25-2.80	0.75-2.25	1.0

NOTES:

(1) Single values shown above are maximum.

(2) Only listed elements are used to determine A-numbers.

QW-450 SPECIMENS

QW-451 PROCEDURE QUALIFICATION THICKNESS LIMITS AND TEST SPECIMENS

Table QW-451.1
Groove-Weld Tension Tests and Transverse-Bend Tests

Thickness T of Test Coupon, Welded, in. (mm)	Range of Thickness T of Base Metal, Qualified, in. (mm) [Note (1)] and [Note (2)]		Maximum Thickness t of Deposited Weld Metal, Qualified, in. (mm) [Note (1)] and [Note (2)]	Type and Number of Tests Required (Tension and Guided-Bend Tests) [Note (2)]			
	Min.	Max.		Tension, QW-150	Side Bend, QW-160	Face Bend, QW-160	Root Bend, QW-160
Less than $\frac{1}{16}$ (1.5)	T	$2T$	$2t$	2	...	2	2
$\frac{1}{16}$ to $\frac{3}{8}$ (1.5 to 10), incl.	$\frac{1}{16}$ (1.5)	$2T$	$2t$	2	[Note (5)]	2	2
Over $\frac{3}{8}$ (10), but less than $\frac{3}{4}$ (19)	$\frac{3}{16}$ (5)	$2T$	$2t$	2	[Note (5)]	2	2
$\frac{3}{4}$ (19) to less than $1\frac{1}{2}$ (38)	$\frac{3}{16}$ (5)	$2T$	$2t$ when $t < \frac{3}{4}$ (19)	2 [Note (4)]	4	...	...
$\frac{3}{4}$ (19) to less than $1\frac{1}{2}$ (38)	$\frac{3}{16}$ (5)	$2T$	$2T$ when $t \geq \frac{3}{4}$ (19)	2 [Note (4)]	4	...	...
$1\frac{1}{2}$ (38) to 6 (150), incl.	$\frac{3}{16}$ (5)	8 (200) [Note (3)]	$2t$ when $t < \frac{3}{4}$ (19)	2 [Note (4)]	4	...	...
$1\frac{1}{2}$ (38) to 6 (150), incl.	$\frac{3}{16}$ (5)	8 (200) [Note (3)]	8 (200) [Note (3)] when $t \geq \frac{3}{4}$ (19)	2 [Note (4)]	4	...	...
Over 6 (150) [Note (6)]	$\frac{3}{16}$ (5)	$1.33T$	$2t$ when $t < \frac{3}{4}$ (19)	2 [Note (4)]	4	...	...
Over 6 (150) [Note (6)]	$\frac{3}{16}$ (5)	$1.33T$	$1.33T$ when $t \geq \frac{3}{4}$ (19)	2 [Note (4)]	4	...	...

NOTES:

- (1) The following variables further restrict the limits shown in this table when they are referenced in [QW-250](#) for the process under consideration: [QW-403.9](#), [QW-403.10](#), and [QW-404.32](#). Also, [QW-202.2](#), [QW-202.3](#), and [QW-202.4](#) provide exemptions that supersede the limits of this table.
- (2) For combination of welding procedures, see [QW-200.4](#).
- (3) For the SMAW, SAW, GMAW, PAW, LLBW, and GTAW welding processes only; otherwise per Note (1) or $2T$, or $2t$, whichever is applicable.
- (4) see [QW-151.1](#), [QW-151.2](#), and [QW-151.3](#) for details on multiple specimens when coupon thicknesses are over 1 in. (25 mm).
- (5) Four side-bend tests may be substituted for the required face- and root-bend tests, when thickness T is $\frac{3}{8}$ in. (10 mm) and over.
- (6) For test coupons over 6 in. (150 mm) thick, the full thickness of the test coupon shall be welded.

QW-452 PERFORMANCE QUALIFICATION THICKNESS LIMITS AND TEST SPECIMENS

QW-452.1 Groove-Weld Test. The following tables identify the required type and number of tests and the thickness of weld metal qualified.

**Table QW-452.1(a)
Test Specimens**

Thickness of Weld Metal, in. (mm)	Type and Number of Examinations and Test Specimens Required			
	Visual Examination per QW-302.4	Side Bend QW-462.2 [Note (1)]	Face Bend QW-462.3(a) or QW-462.3(b) [Note (1)], [Note (2)]	Root Bend QW-462.3(a) or QW-462.3(b) [Note (1)], [Note (2)]
Less than 3/8 (10)	X	...	1	1
3/8 (10) to less than 3/4 (19)	X	2 [Note (3)]	...	...
3/4 (19) and over	X	2	...	...

GENERAL NOTE: The “Thickness of Weld Metal” is the total weld metal thickness deposited by all welders and all processes in the test coupon exclusive of the weld reinforcement.

NOTES:

- (1) To qualify using positions 5G or 6G, a total of four bend specimens are required. To qualify using a combination of 2G and 5G in a single test coupon, a total of six bend specimens are required. see QW-302.3. The type of bend test shall be based on weld metal thickness.
- (2) Coupons tested by face and root bends shall be limited to weld deposit made by one welder with one or two processes or two welders with one process each. Weld deposit by each welder and each process shall be present on the convex surface of the appropriate bent specimen.
- (3) One face and root bend may be substituted for the two side bends. For a test coupon welded in the 5G or 6G position, two face and two root bends may be substituted for the four side bends in accordance with Figure QW-463.2(d). For a test coupon welded using a combination of 2G and 5G positions, three face and three root bends may be substituted for the six side bends in accordance with Figure QW-463.2(f) or Figure QW-463.2(g).

**Table QW-452.1(b)
Thickness of Weld Metal Qualified**

Thickness, <i>t</i> , of Weld Metal in the Coupon, in. (mm) [Note (1)] and [Note (2)]	Thickness of Weld Metal Qualified [Note (3)]
All	2 <i>t</i>
1/2 (13) and over with a minimum of three layers	Maximum to be welded

NOTES:

- (1) When more than one welder, process, or set of essential variables is used during welding of a test coupon, the thickness, *t*, of the weld metal in the coupon deposited by each welder, for each process, and with each set of essential variables shall be determined and used individually in the “Thickness, *t*, of Weld Metal in the Coupon” column to determine the “Thickness of Weld Metal Qualified.”
- (2) Two or more pipe test coupons with different weld metal thickness may be used to determine the weld metal thickness qualified and that thickness may be applied to production welds to the smallest diameter for which the welder is qualified in accordance with Table QW-452.3.
- (3) Thickness of test coupon of 3/4 in. (19 mm) or over shall be used for qualifying a combination of three or more welders each of whom may use the same or a different welding process.

ø19P

Table QW-461.9
Performance Qualification — Position and Diameter Limitations
(Within the Other Limitations of QW-303)

Qualification Test		Position and Type Weld Qualified [Note (1)]		
		Groove		Fillet or Tack [Note (2)]
		Weld	Position	Plate and Pipe Over 24 in. (610 mm) O.D.	Pipe ≤ 24 in. (610 mm) O.D.	Plate and Pipe
Plate — Groove	1G	F	F [Note (3)]	F
	2G	F, H	F, H [Note (3)]	F, H
	3G	F, V	F [Note (3)]	F, H, V
	4G	F, O	F [Note (3)]	F, H, O
	3G and 4G	F, V, O	F [Note (3)]	All
	2G, 3G, and 4G	All	F, H [Note (3)]	All
	Special Positions (SP)	SP, F	SP, F	SP, F
Plate — Fillet	1F	...	...	F [Note (3)]
	2F	...	...	F, H [Note (3)]
	3F	...	...	F, H, V [Note (3)]
	4F	...	...	F, H, O [Note (3)]
	3F and 4F	...	...	All [Note (3)]
Special Positions (SP)	...	...	SP, F [Note (3)]	
Pipe — Groove [Note (4)]	1G	F	F	F
	2G	F, H	F, H	F, H
	5G	F, V, O	F, V, O	All
	6G	All	All	All
	2G and 5G	All	All	All
	Special Positions (SP)	SP, F	SP, F	SP, F
Pipe — Fillet [Note (4)]	1F	...	...	F
	2F	...	...	F, H
	2FR	...	...	F, H
	4F	...	...	F, H, O
	5F	...	...	All
	Special Positions (SP)	...	...	SP, F

NOTES:

(1) Positions of welding as shown in QW-461.1 and QW-461.2.

F = Flat

H = Horizontal

V = Vertical

O = Overhead

SP = Special Positions (see QW-303.3)

(2) Tack welds are not limited by pipe or tube diameters when their aggregate length does not exceed 25% of the weld circumference.

(3) Pipe 27/8 in. (73 mm) O.D. and over.

(4) See diameter restrictions in QW-452.3, QW-452.4, and QW-452.6.