CHAPTER 9: ASME IX

Before you read this chapter on welding, please look at the WPS that is in Annex 1 of this eBook. Try to realize what is wrong with it. Some Q&A from that document are at the end of this chapter.

One of the content areas that worked out best for me during my exam years ago, was welding. In the time I presented the exam, the number of questions was different from nowadays. From a total of 16 questions about welding, I got 15 right (nowadays they ask only 8). It helped me a lot knowing about welding.

The body of knowledge gives a broad guide of what will appear in the exam related to welding. It says:

The inspector should have the knowledge and skills required to review a Procedure Qualification Record and a Welding Procedure Specification or to answer questions requiring the same level of knowledge and skill. Questions covering the specific rules of Section IX will be limited in complexity and scope to the SMAW and SAW welding processes.

1. Questions will be based on:

a) No more than one process

b) Filler metals limited to one

c) Essential, non-essential, variables only will be covered

d) Number, type, and results of mechanical tests

e) Base metals limited to P1

f) Additional essential variables required by API-650 or API-653

2. The following are specifically excluded:

a) Dissimilar base metal joints

b) Supplemental powdered filler metals and consumable inserts

c) Special weld processes such as corrosion-resistant weld metal overlay, hard-facing overlay, and dissimilar metal welds with buttering

d) Charpy impact requirements and supplementary essential variables

e) Any PQR and WPS included on the examination will not include heat treatment requirements.
[.......]
As you can see, some of the questions are based on ASME IX.

The following point by point analysis will help you successfully read and review a WPS and a WPQ.

GENERALITIES

ASME IX "Welding, Brazing, and Fusing Qualifications. Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators" is a part of the ASME Boiler and Pressure Vessel Code, that regulates the design and construction of boilers and pressure vessels. API 650 trusts ASME IX for welding procedure and welder performance qualifications

Some important definitions found in QW-200

WPS: A **Welding Procedure Specification** (WPS) is a formal written document describing welding procedures, which provides direction to the welder or welding operators for making sound and quality production welds as per the code requirements
PQR: The **Procedure Qualification Record** is a Record containing information about the tests conducted over the welds made to a WPS, the variables used during welding of the test coupon, and the successful qualification of that WPS.
WPQ: A **Welder Performance Qualification** is a document recording the ability of a welder to deposit welds in the manner described in the WPS.
All of the three documents contain a set of variables to control. Variables that may be used in a welding procedure test are divided into 3 categories.

Essential Variables Are variables that have a significant effect on the mechanical properties of a joint. They must not be changed except within the limits specified by this code. e.g. Material thickness range, Material Group, welding process, etc. The PQR shall contain all the essential variables.

Non-Essential Variables Are variables that have no significant effect on mechanical properties. They can be changed without re qualification of the PQR.

Supplementary Variables Are variables that influence the impact properties of a joint. They are classed as Non-Essential if impact testing is not required. This kind of variables won´t show up in the exam.

All variables listed as ***essential*** and ***non-essential*** should be addressed on the WPS, while all listed as ***essential*** should be addressed in the PQR. ***Supplementary essential*** variables should be addressed in both documents when required (See QW-200 of ASME IX). If any of the variables do not apply to the particular application, then they should be specified as not applicable. The welding organization can have its own formats for these documents, as long as they meet the aforementioned requirements.

Understanding of the information that should a WPS and a PQR contain is critical. Several WPS can be written on the basis of the successful qualification of the initial preliminary WPS. There is no limit on the number of production WPSs that can be generated from a PQR. And as for the other way around, several PQR can be "summed up" to support a broad WPS, just making sure that the ranges of the variables in the PQRs are the same for the WPS generated.

HOW ASME IX IS ORGANIZED

ASME IX is divided in 4 parts

PART QG, General requirements

PART QW, Welding

PART QB, brazing

PART QF, plastic fusing

We will concentrate in Part QW, which in turn is divided in 5 articles.

• **Article I** – Welding general requirements
• **Article II** - Welding procedure qualifications
• **Article III** – Welding performance qualifications
• **Article IV** – Welding data
• **Article V** – Standard welding procedure specifications (SWPS)

In ASME IX, as much as 20 different welding processes are mentioned when it has to do with procedure qualification. Essential, non-essential and supplementary variables for welding processes can be found in tables QW-252 to QW-269.1 of ASME IX.

But remember "***Questions covering the specific rules of Section IX will be limited in complexity and scope to the* SMAW *and* SAW *welding processes***". Which are the essential variables needed for these 2 processes? We can find them in QW-253 and QW-254

The nonmandatory appendix B of ASME IX illustrates the different formats for welding procedure specifications, Procedure Qualification records and Welder Performance Qualifications, for the SMAW, SAW, GMAW and GTAW processes, and the basis for other welding processes may follow the general format as applicable. You should look at them.

In the exam, it is required from the candidate to proficiently review a WPS and its supporting PQR that will be given to him. That´s why it is a good idea to be familiar with the appendix B formats.

SIMPLE FLOWCHART OF A WPS AND ITS SUPPORTING PQR

As we said before, a PQR can be the basis of several WPSs and vice versa. The code only asks for the essential variables to be recorded in the PQR. But just complying with the standard may not be enough to make Welding Procedures of consistent quality. The fact is that a preliminary WPS can be made (although not mandatory), a test set up for this preliminary WPS where all variables should be recorded (essential, non-essential and supplementary), and a PQR containing all that variables created. After the weld is accepted by testing, now you can establish a WPS and make it into your procedures. With this recommendation, I created a simple drawing to understand the process.

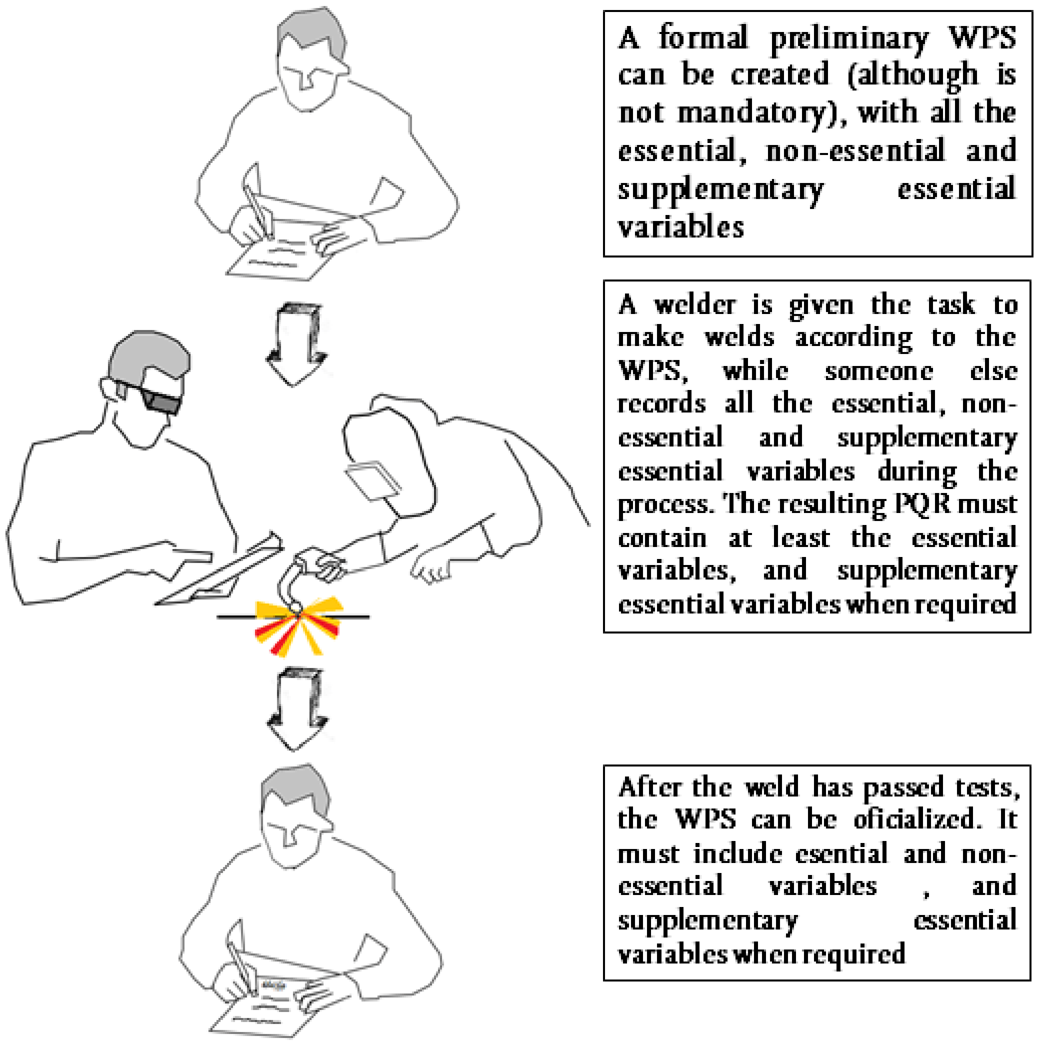

FIGURE 18 THE PROCESS OF A WPS

THE MAKING OF A WPS

THE VARIABLES IN A WPS

An aspiring API 653 certified inspector should understand a written WPS and its corresponding PQR. A reviewer of a WPS should verify that

•each WPS has an entry for every essential, (supplementary essential variable when required) and nonessential variable, as listed for the process in QW-250. For SMAW, there are 27 entries to be recorded.

•the WPS covers the ranges for the welding application for each variable listed for each process, as specified in QW-250.

•the WPS meets all other requirements of Section IX.

• the WPS meets all requirements of the construction code.

•the WPS has been properly supported by one or more PQRs, and the supporting PQRs are listed on the WPS.

•every variable range on the WPS is being followed during fabrication or repairs

During the variables review, remember the meanings of the following symbols:

Φ: It means change of a variable
+: It means addition of a variable
-: It means deletion of a variable

ESSENTIAL VARIABLES

As for the Body of Knowledge for the API 653, Essential and Non-Essential variables only will be covered in the exam. Let´s remember that essential variables are different for procedure specification and for performance qualification. The following are definitions of both, according to ASME IX.

QW-401.1 Essential Variable (Procedure). A change in a welding condition which will affect the mechanical properties (other than notch toughness) of the weldment (e.g., change in P-Number, welding process, filler metal, electrode, preheat or post-weld heat treatment).

QW-401.2 Essential Variable (Performance). A change in a welding condition which will affect the ability of a welder to deposit sound weld metal (such as a change in welding process, deletion of backing, electrode, F-Number, technique, etc.).

Next, we are going to make a point-by-point analysis of the 27 variables that should appear in a WPS for the SMAW process.

QW-402. JOINTS

TABLE QW-253 Welding Variables for Procedure Specification (WPS) - Shielded Metal Arc-Welding (SMAW)				
Paragraph		Brief of Variables	Essential	Non-Essential
QW-402 Joints	.1	ϕ Groove design		X
	.4	- Backing		X
	.10	ϕ Root spacing		X
	.11	± Retainers		X

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

A change in groove type, most of the times, won´t affect the mechanical properties of the weld, so it is considered a non-essential variable for most of the processes (for example, it is a supplementary essential variable for PAW and an essential variable for EBW). Groove type can, however change mechanical properties of a weld by changing the A-number (chemical properties), especially when welding dissimilar metals. But its non-essential for SMAW and SAW, the processes of our interest.

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

Backing is defined as material placed at the root of a ***weld*** joint for the purpose of supporting molten ***weld*** metal. Its function is to facilitate complete joint penetration. Backing can be part of the weld and fuse with the weld deposit, but is a non-essential variable for the WPS for SMAW and SAW. Correct removal of backing bars after welding has been completed won´t affect the transverse area of the weld. For the welder, if he is tested without backing, he can weld with or without backing, but if he is tested with backing, he can only weld with backing as in the test. If the procedure is qualified with a backing, you can weld without backing, provided the welder is qualified without backing

3. QW-402.10 A change in the specified root spacing.

Root spacing as a non-essential variable illustrates why non-essential variables are recorded into a WPS, given that a change in root spacing won´t affect the mechanical properties, but a too-much-wide root will likely increase the probability of defects if it is out of a range in accordance with sound engineering practices.

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

This is a difficult one. Not many sources deal with se subject of retainers. A retainer is a non-consumable material, either metallic or non-metallic, that is used to contain or shape the molten root run. It won´t fuse with the base metal, as backing does. It is not an essential variable

QW-403. BASE METALS

TABLE QW-253 Welding Variables for Procedure Specification (WPS) - Shielded Metal Arc-Welding (SMAW)				
Paragraph		Brief of Variables	Essential	Non-Essential
QW-403 Base Metals	.8	ϕ T Qualified	X	
	.9	t Pass > 1/2 in. (13mm)	X	
	.11	ϕ P-No Qualified	X	

5. QW-403.8. A change in base metal thickness beyond the range qualified in QW-451.

Welding strengths vary according to plate thickness and distance from the weld root. The risk of brittle fracture increases with thickness. Cracks susceptibility is more likely to happen with high thickness and high resistance. Those facts and others, shown by research, demonstrate why base metal thickness is an essential variable.

6. 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.

A weld pass > ½ inch thick will have sufficient heat input to anneal the HAZ, thus reducing the tensile strength of the weldment, or increase the time the HAZ is exposed to temperatures > 1900 °F, thus reducing the ductility of the weldment. When any single deposited weld pass is > ½ inch thick, the maximum base metal thickness qualified is less than that in table QW-451. Normally in SMAW, GTAW, GMAW, FCAW and SAW you don't exceed 13mm of weld metal thickness for each pass; it is more common for Electrogas and Electroslag welding.

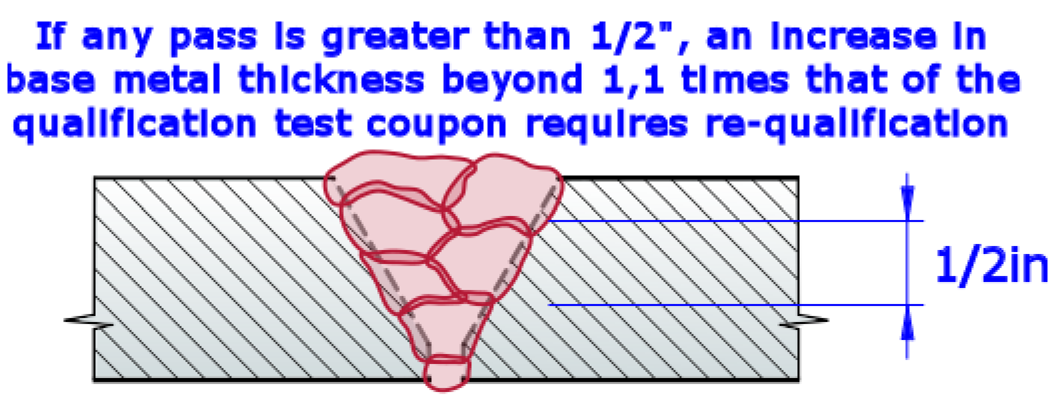

FIGURE 19 MULTIPASS WELDING

7. 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.

Welding standards usually group the base metals into families that have similar chemistry and weldability. P-Numbers are assigned to base metals for the purpose of reducing the number of welding and brazing procedure qualifications required. A change from one P-number group to another affects the mechanical properties; therefore, base metals are classified as essential variables.

QW-404. FILLER METAL

TABLE QW-253 Welding Variables for Procedure Specification (WPS) - Shielded Metal Arc-Welding (SMAW)				
Paragraph		Brief of Variables	Essential	Non-Essential
QW-404 Filler Metals	.4	ϕ F-Number	X	
	.5	ϕ A-Number	X	
	.6	ϕ Diameter		X
	.30	ϕ t	X	
	.37	ϕ Classification		X

8. 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.

Avoid confusing ASME IX with AWS D1.1 when it comes to F-numbers. Confusion of "if a welder/procedure is tested with an electrode with a higher F number, then he can weld with an electrode with lower F-number". In AWS D1.1, if a welder qualifies with an electrode with a higher F-number, he is qualified to weld with electrodes of lower F number. Regarding procedures, in ASME IX the procedure must be requalified if the F-number changes. The F-number is also an essential variable for performance qualification, but it's not as restrictive as the welding-procedure specification. For welders using F-1 through F-4 electrodes, the higher F-number electrode qualifies the lower just like in D1.1. Usually an F number is associated with an electrode specification.

9. 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.

(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, the manufacturer's trade designation, or other established procurement documents.

P- and S-numbers are groupings of base metals with similar weldability. F-numbers are groupings of filler metals, and A-numbers are weld deposit chemistries. A-numbers are applicable only for ferrous-based filler metals. A number is usually provided by the manufacturer of the filler metal, as he has had time to make all laboratory tests on deposited metal. In other cases, such as when welding dissimilar metals, you have to send a section of the weld deposit out for chemical analysis and then see what A-number it matches. Only qualification with A No. 1 shall qualify for A No. 2 and vice versa. This was an exam question back then in 2012. A-numbers play no role in performance qualifications.

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

In production welds, a higher diameter electrode can induce more slag into the joint or augment heat input to the base metal being welded. Depending on the weld position and electrode size, the welder will have difficulties controlling the appearance of weld defects. But electrode size will not affect mechanical properties. Having this in mind, it is just natural that it is a non-essential variable that you may want to control anyways.

11. 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.

Deposited weld metal is the sum of all the passes made with a single welding process. Where more than one different processes, is used in a joint, QW-451 shall be used to determine the range of maximum weld metal thickness qualified for each process. It is an essential variable.

12. 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 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 impact testing to the same classification which has a suffix which indicates that impact 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 Impact Testing by other Sections. This exemption does not apply to hard-facing and corrosion-resistant overlays

The "G" filler metal suffix stands for "general" classification. It is general because not all the particular requirements specified for the other designation classifications are specified for this classification. The intent for the general designation is to allow newly developed flux-cored electrodes that may differ in one way or another to all the other usability designations a way to still be classified according to the filler metal specification. This allows an electrode to be used right away, without having to wait potentially years for the filler metal specification to be revised to create a new usability designation. So, two electrodes having the 'G' suffix, but made by different manufacturers, could have different chemical compositions. For this reason, a WPS requiring impact testing qualified with an electrode having the 'G' suffix from manufacturer 'A' could not use an electrode having a 'G' suffix from manufacturer 'B' because the chemical composition could be different, resulting in different notch toughness properties of the weld metal. The WPS would have to be requalified.

(a) The "R" suffix identifies electrodes passing the absorbed moisture test after exposure to an environment of 80ºF(26.7ºC) and 80% relative humidity for a period of not less than 9 hours (A.7.6.4 of AWS A5.1).

(b) The preferred method of controlling the level of hydrogen in a weld deposit is to use the optional hydrogen designators as defined by the American Welding Society. These designators are in the form of a suffix on the electrode classification (e.g., H8, H4, and H2, the examples given in numeral b) **(c)** On the other hand, low-hydrogen electrodes of the EXX15, EXX16, EXX18, EXX(X)15, EXX(X)16 and EXX(X)18 types, do share the same F-number, and differ in several things, being the most important the type of electrode coating (sodium for E7015, potassium form E7016 and iron powder for E7018) (AWS a5.1)

(d) is self-explanatory.

(e) Electrodes of the EXX15, EXX16 and EXX18 classifications are specified as requiring impact testing in some welding positions (See table 4 of AWS A5.1). E7018-1 shielded metal arc welding (SMAW) electrodes provide improved impact toughness over plain E7018 electrodes. The -1 stands for it. **(f)** Not treated herein.

QW-405. POSITIONS

TABLE QW-253 Welding Variables for Procedure Specification (WPS) - Shielded Metal Arc-Welding (SMAW)				
Paragraph		Brief of Variables	Essential	Non-Essential
QW-405 Positions	.1	+ Position		X
	.3	ϕ Vertical welding		X

13. QW-405.1 The addition of other welding positions than those already qualified. See QW-120, QW-130, QW-203, and Qw-303.

A common mistake made by beginners is to think that the position chosen for procedure qualification limits the position of the production weld. In fact, qualifying a procedure in any welding position approves all positions providing no impact tests are required. Weld position is a non-essential variable.

14. 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.

In my country, welders usually think of themselves as API or ASME certified...... another mistake. They think that ASME welding is “upwards” and API 1104 welding is “downwards”. But the choice of weld progression doesn´t depend on the welding code, but usually in the electrode used and other considerations. Again, another non-essential variable for the WPS.

QW-406. PREHEAT

TABLE QW-253 Welding Variables for Procedure Specification (WPS) - Shielded Metal Arc-Welding (SMAW)				
Paragraph		Brief of Variables	Essential	Non-Essential
QW-406 Preheat	.1	Decrease > 100°F (55°C)	X	
	.2	ϕ Preheat maint		X

15. 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.

This was an exam question to get API 653 Certified back then in 2012. It had to be with the maximum temperature change allowed for preheat and the range of preheat qualified. As we can see, a decrease in preheat temperature higher than

100°F is considered to change mechanical properties (it also happens with interpass temperature)

16. Qw-406.2 A change in the maintenance or reduction of preheat upon completion of welding prior to any required post-weld heat treatment.

Preheat maintenance is used to assure freedom from hydrogen induced cracking prior to PWHT. Following a welding operation, the cooling and contracting of the weld metal cause stresses to be set up in the weld and in adjacent parts of the weldment which results to cracking and embrittlement in steel welds, depending of composition. The best way to minimize above difficulties is to reduce the heating and cooling rate of the parent metal and HAZ. Pre heating and/or Post heating have been widely employed in welding operation for preventing cold cracking.

QW-407. POST WELD HEAT TREATMENT

TABLE QW-253 Welding Variables for Procedure Specification (WPS) - Shielded Metal Arc-Welding (SMAW)				
Paragraph		Brief of Variables	Essential	Non-Essential
QW-407 PWHT	.1	ϕ PWHT	X	
	.4	T Limits	X	

Let´s review a couple definitions

Lower Transformation Temperature – Temperature at which structure begins to change from ferrite and pearlite to austenite if being heated, upon cooling, temperature at which structure completes change from austenite to ferrite and pearlite. The line BGH in the diagram is the lower transformation temperature.

Upper Transformation Temperature – Temperature at which structure completes change from ferrite and pearlite to austenite if being heated, upon cooling, temperature at which structure begins change from austenite to ferrite and pearlite. The line AGH in the diagram is the upper transformation temperature.

17. 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

If you qualified a procedure with PWHT, if you intend to use this same procedure without (or No) PWHT, it must be requalified with NO PWHT. PWHT is not usually required for material thickness 5/8″ (16mm) or less at the weld. All the possible configurations for QW-407.1 are illustrated in the Fe-c diagram below, as a guide.

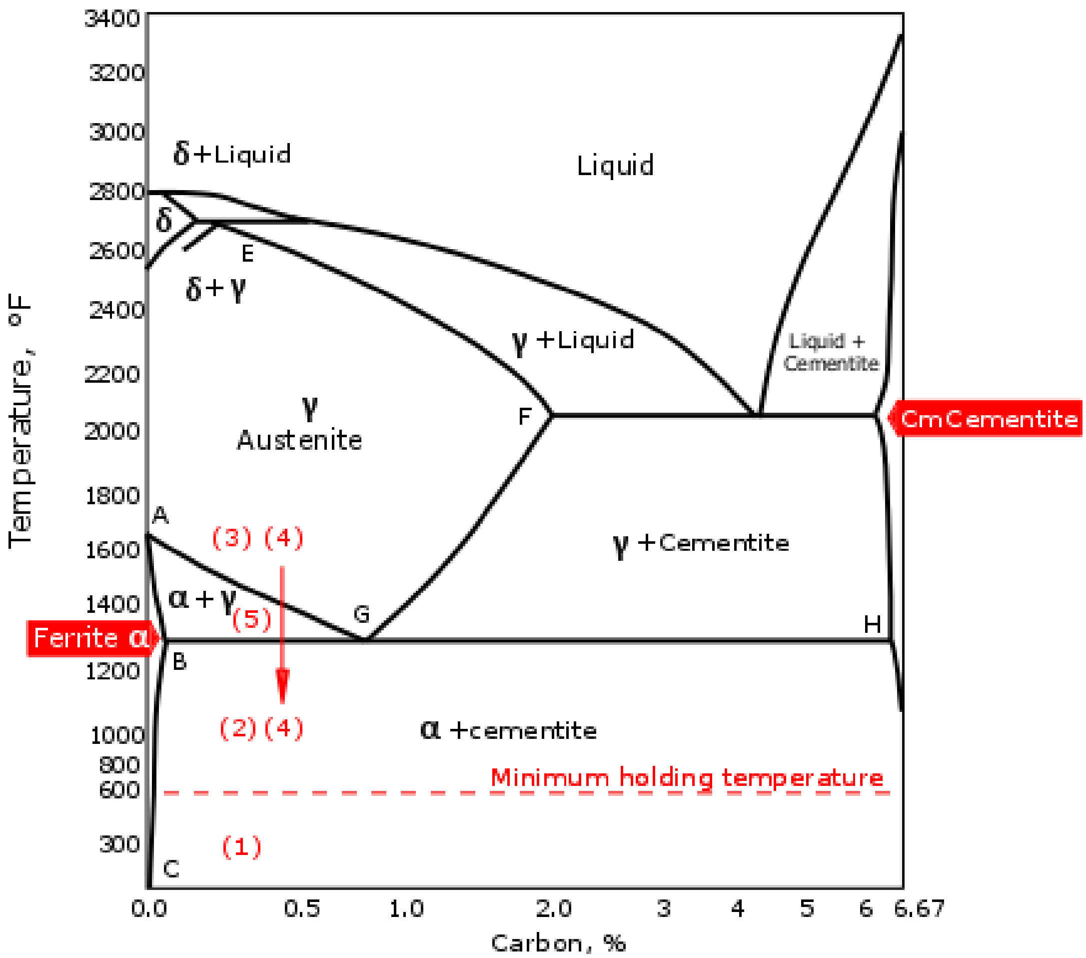

FIGURE 20 FE-C DIAGRAM

18. QW-407.4 For ferrous base metals other than P-No. 7, P-No. 8, and P-No. 45, when a procedure qualification test coupon receives a postweld heat treatment exceeding the upper transformation temperature or a solution heat treatment for P-No. 10H materials, the maximum qualified base metal thickness, T, shall not exceed 1.1 times the thickness of the test coupon.

Because the microstructure completely changes above the upper transformation temperature, whatever was done in welding is gone. The Code recognizes this metallurgical reality and allows an exception to the variable because of it.

QW-409 ELECTRICAL CHARACTERISTICS

TABLE QW-253 Welding Variables for Procedure Specification (WPS) - Shielded Metal Arc-Welding (SMAW)				
Paragraph		Brief of Variables	Essential	Non-Essential
QW-409 Electrical Carachteristics	.4	ϕ Current or polarity		X
	.8	ϕ I & E range		X

19. 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.

Power sources for welding produce DC with the electrode either positive or negative, or AC. The choice of current and polarity depends on the process, the type of electrode, the arc atmosphere and the metal being welded. A non-essential variable.

20. 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.

What are the effects of current and voltage during the welding process? Consider the following excerpt Lincoln website

Current effects the melt-off rate or consumption rate of the electrode, whether it be a stick electrode or wire electrode. The higher the current level, the faster the electrode melts or the higher the melt-off rate, measured in pounds per hour (lbs./hr.) or kilograms per hour (kg/hr.). The lower the current, the lower the electrode's melt-off rate becomes. Voltage controls the length of the welding arc, and resulting width and volume of the arc cone. As voltage increases, the arc length gets longer (and arc cone broader), while as it decreases, the arc length gets shorter (and arc cone narrower). SMAW and GTAW are considered largely manual processes, and CC is the preferred type of output from the power source, meaning you control voltage.

Regarding waveform, the following excerpt is taken form ASME IX, non-mandatory appendix H

> Advances in microprocessor controls and welding power source technology have resulted in the ability to develop waveforms for welding that improve the control of droplet shape, penetration, bead shape and wetting. Some welding characteristics that were previously controlled by the welder or welding operator are controlled by software or firmware internal to the power source. It is recognized that the use of controlled waveforms in welding can result in improvements in productivity and quality.

Electrical characteristics as amperage and voltage are non-essential variables.

QW-410 TECHNIQUE

TABLE QW-253

Welding Variables for Procedure Specification (WPS) - Shielded Metal Arc-Welding (SMAW)

Paragraph		Brief of Variables	Essential	Non-Essential
QW-410 Technique	.1	φ String/weave		X
	.5	φ Method of cleaning		X
	.6	φ Method of back gouge		X
	.9	φ Multiple to single pass/side		X
	.25	φ Manual or automatic		X
	.26	± Peening		X
	.64	Use of thermal processes	X	

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

Stringer bead a type of bead which is made by moving the welding electrode in a direction parallel to the axis of the bead, without appreciable transverse oscillation. Weave bead is a weld bead which is made with oscillations along the bead which are transverse to the length of the bead. Either technique can produce a sound weld with the mechanical properties the code requires. The election of one or the other, however, has an impact on another variable that is a supplementary essential and therefore not a subject of this summary: heat input.

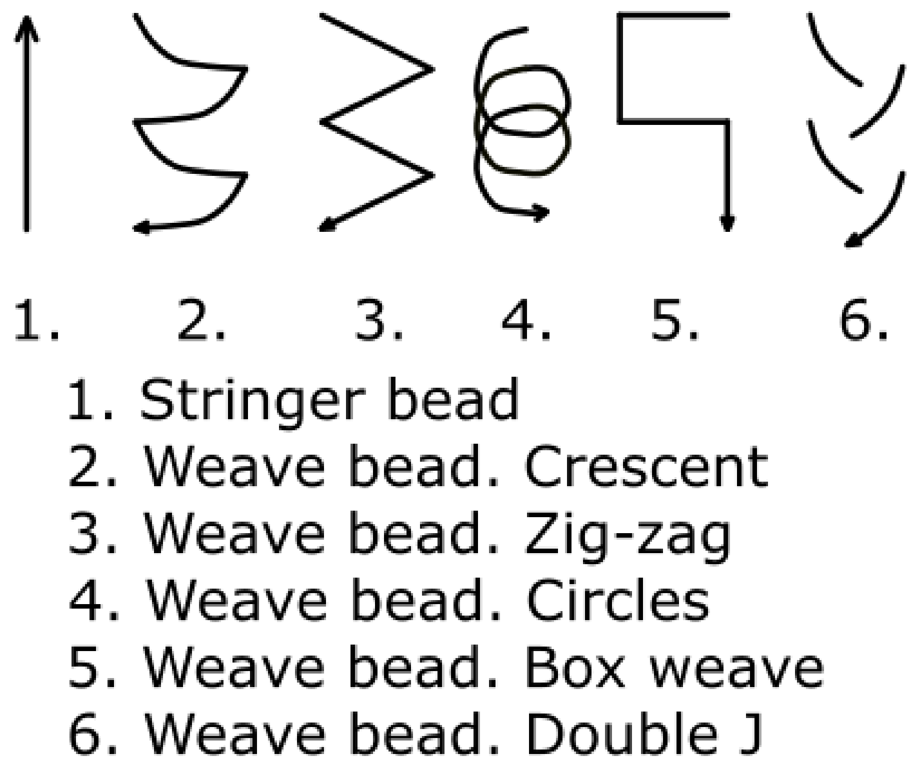

FIGURE 21 WELDING TECHNIQUES

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

Interpass cleaning is essential to ensure complete slag removal as well as fusion between the weld beads. Turning up the amperage to “burn away the slag” is not the way to make a cleaning. Welders need to take steps to properly clean between weld passes, even grinding the profiles if needed to improve fusion and bead placement. It can be done by using a needle descaler or a hand chipping hammer and a power brush. Not an essential variable.

23. QW-410.6 A change in the method of back gouging.
Back gouging is the removal of weld metal and base metal from the weld root side of a welded joint to facilitate complete fusion and complete joint penetration upon subsequent welding from that side. It does so by providing a better surface for the new weld and eliminating any edges of the weld metal that may have survived the root pass. Back gouging can be done using air grinders, electric grinders, or thermal processes for removing the material, like Manual Metal Arc gouging, Air Carbon Arc Gouging, Plasma Arc Gouging or Oxyfuel Gouging. Thermal processes can be up to 4 times faster and quieter than cold chipping operations.

24. 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.
The big difference between single pass to multipass per side is heat input.

The process of solution annealing consists of heating the material up to a temperature above 1950°F and holding it long enough for the carbon to go into solution. After this, the material is quickly cooled to prevent the carbon from coming out of solution and achieve an evenly distributed solution of carbon and austenite in the metallurgical structure of the material. It improves corrosion resistance and ductility in both the weld and the HAZ. Properties • Reduction of stresses • Improved material structure • Improved magnetic properties • Reduction of hardness possible • Improved welding properties • Improved corrosion resistance • Good dimensional and shape accuracy • Clean process, parts remain bright

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

Semiautomatic and automatic welding have less defects than manual welding. However, a change of it won´t affect mechanical properties by definition

26. QW-410.26 The addition or deletion of peening.

According to the ASME IX definition, peening is the mechanical working of metals using impact blows. Peening is a method of adding residual compressive stress to the component by bombarding the surface with high quality spherical media in a controlled operation. The media can be steel, ceramic, or glass and each piece acts like a tiny peening hammer producing a small indentation on the surface.

The application locally yields the material, inducing beneficial compressive stress, the characteristics of which are dependent on the base material and component design. At the same time, unwanted tensile stresses are removed. Peening shows a beneficial effect on both the life and strength of a component, making the surface more resistant to fatigue, cracking, stress corrosion, and cavitation erosion, given than cracks will not grow in a compressive environment. If you wish to have your production weld peened, the WPS should include peening too. And why the addition of peening changes mechanical properties? it is demonstrated that an excess of peening will reduce fatigue life of a component. However, it is not an essential variable.

27. QW-410.64 For vessels or parts of vessels constructed with P-No. 11A and P-No. 11B base metals, weld grooves for thickness less than 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.

I am not going to go deep in this point, given its complexity. P numbers 11A and 11B group various high strength low alloy steels that you can find in appendix P of the ASME IX. If you can look for the specifications of these metals in the internet, you will notice that most them require some kind of heat treatment during manufacturing. For these steels, use of thermal processes during part welding obliges the manufacturer to prepare a WPS using those thermal processes. So it becomes an essential variable.

POINTS TO REMEMBER

Regardless if it is an essential or a nonessential variable, you should make certain that an appropriate value for each variable is recorded on the WPS, that the WPS covers the ranges for the welding application for each variable listed for each process, as specified in QW-250 and that every variable range on the WPS is being followed during fabrication or repairs. Also, when qualifying the WPS, the final PQR should be signed.

Q&A Annex 1

What is the root face limitation as listed on the attached WPS and PQR?

a. 3/32”

b. 1/8”

c. No limit

d. Not designated

If the supporting PQR is used, are the P-no’s correct on the attached WPS?

a. Yes

b. No

c. Could be if properly preheated

d. Not enough information

Is the thickness range on the WPS supported by the PQR?

a. Yes

b. No

c. Requalification is required by API 570

d. Requalification is required by ASME V

Is the attached PQR properly qualified?

a. No, because RT is not allowed during PQR qualification

b. No

c. No, because peening is allowed by B31.3

d. Yes

What should have been the correct number and type of guided bends on the PQR?

a. 2 side bends

b. 2 face and 2 root bends

c. 1 side, 1 face and 1 root bend

d. 2 face, 2 root and 4 side bends