

# Welding Procedure Specification (WPS)

Welding procedure specification(WPS) for tank based on the requirement of ASME Code Section IX. The code defines it as "A WPS is a written qualified welding procedure prepared to provide direction for making production welds to Code requirements".

The WPS may be used to provide direction to the welder or welding operator to meet the code requirement. The WPS should include all essential, nonessential and supplementary essential variables i.e. joint design, base material, filler metal, position, preheat and post weld heat treatment, gas composition, electrical characteristic, etc.. These variables have been provided in the article II QW-250 thru QW-280 of ASME Code Section IX.

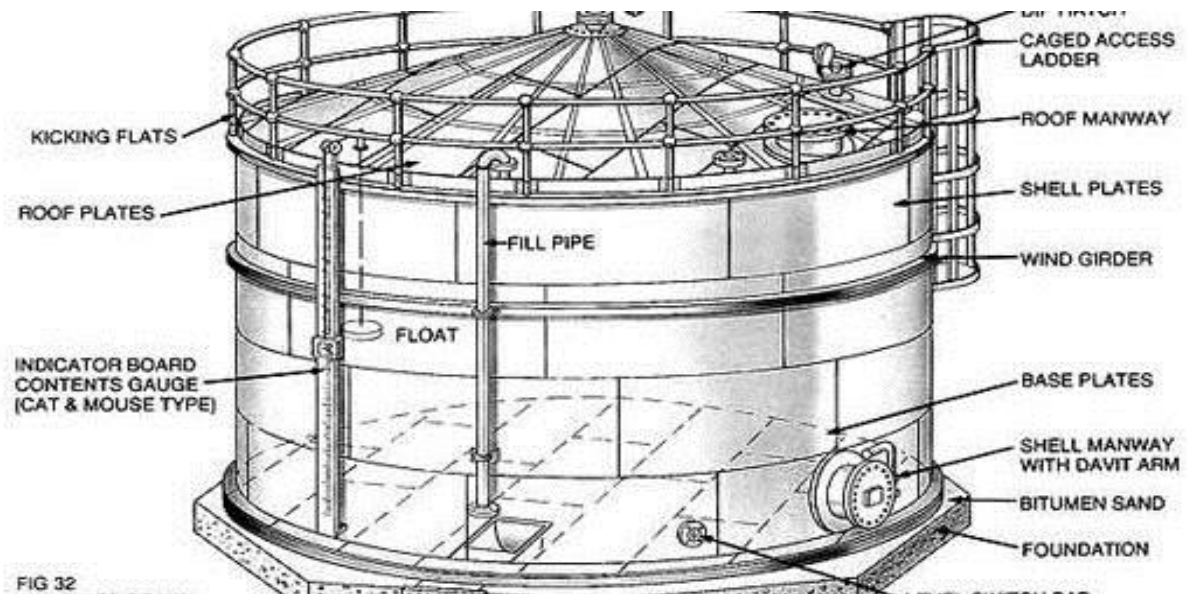


There is the standard form for the WPS in ASME Code Section IX (Form QW-482). This form can be copied and used. The welding engineer may use different sources such as welding handbook etc. Each field in this form must be completed. This WPS is written with the knowledgeable persons but still we need to proof the written WPS produce a weld with desired mechanical property.

The written welding procedure specification must be qualified by mechanical testing that is called procedure qualification record (PQR).

The WPS specifies ranges, and when you need to use related WPS out of the specified ranges, you need to revise your WPS and re-qualify it.

There are many grouping systems in ASME Code Section IX in purpose to reduce the number of WPS's and PQR's. These groupings are P numbers, A numbers, F numbers. These numberings are grouping similar material or filler metal with specific characteristics and cause to reduce the number of WPS's. This grouping reduces the costs.



The ranges indicated in the article IV ASME Code Section IX. The article IV should not be read directly; you should refer to specified paragraph when referred in the QW-250 thru 280 for the ranges. The article IV in ASME Code Section IX formed from hundreds of paragraphs which are not related to each other and each paragraph numbered and must be read when referred from other places in the code.

## Welding tank Map

The welding map is the equipment sketch which identifies the welding seams and indicates what welding procedure specification (WPS) shall be used for that particular welding seam.

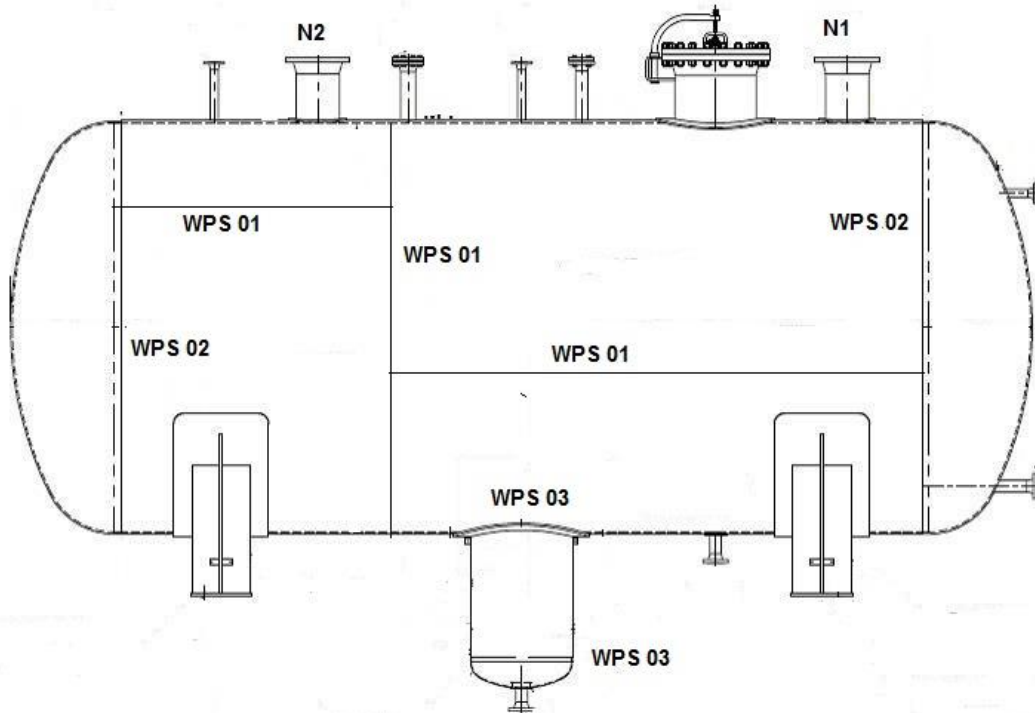
The welding procedure specifications (WPS's) are provided by the manufacturer to the customer for approval. The weld procedures provided to customer alongside vessel or equipment drawings and design calculation.

The customer welding SME (subject matter expert) reviews the welding procedures and comment or approve them.

A particular vessel or equipment might have several welding procedures for different locations. The welding map assists the project team, i.e., customer inspector, welding engineer, supplier quality control team, etc. to identify related weld procedure and correspondent weld seam.

## Welding Map Example

The following sketch illustrates a typical pressure vessel weld map and indicates 4 WPS's are going to be used for manufacturing of this pressure vessel.



The WPS 01 will be used for longitudinal and circumferential joints.

The WPS 02 will be used for head to shell joints. In this vessel, the heads are torispherical, and the thickness of the heads are 1.7 times of the shell and WPS 01 can not be applied here since thickness range limitation.

The WPS 03 will be used for boot welds. The shell and head materials are carbon steel, and boot material is stainless steel so the WPS 01 and 02 can not be utilized for boot section since it has different P number.

Depends on the equipment design it might have several WPS's, and we need a map to show them in the drawing. The map also can be displayed in tabulated format. There is no standard form for weld map, and each manufacturer has own way to illustrate applied WPS's in the vessel/equipment drawing.

## **Welding Procedure Qualification Record (PQR)**

Procedure qualification record (PQR) based on requirements of ASME Code Section IX. The purpose of qualifying a WPS is that to indicate joining process proposed for production welding has required mechanical property.

The WPS is written by knowledgeable person but needs to be tested to ensure the produced weld based on WPS has required mechanical property. When the WPS provided, then a test sample must be prepared and welded. All welding variable must be recorded during the welding. Please note in WPS you have the range but you will not have a range in the PQR, and you need to record a single value for each specified variable.

For example, your WPS indicates preheat temperature as 100 to 160 degree Fahrenheit. You are starting the preheat process on your test specimen and measuring base metal temperature with a pyrometer and after few minutes you record the joint temperature as 140 degree Fahrenheit, and then you stop preheating and asking your welder to start welding. Your preheat temperature in the PQR form will be 140 degree Fahrenheit. This applies to all other variables such as joint design, filler wire diameter, PWHT condition, material thickness, material grade and type, voltage, amperage, inert gas flow rate and type, etc. You should indicate a single value for each field, and the range will not be acceptable.

## **Welding Procedure Qualification Records in ASME Code Section IX**

The test specimen size and dimension must be based on identified values in ASME Code Section IX. After completion of welding and heat treatment (if needed), you need to send the test specimen to the metallurgical lab for mechanical testing. For any PQR, normally two tension tests, two root face bend test and two face bend test is required.



The acceptance criteria have been provided in the ASME Code Section IX. The QW-451 table provides you the information about number and type of tests. For example, if your test specimen is greater than the  $\frac{3}{4}$  inch you cannot perform root and face bend test and instead you need to run 4 side bend tests.

The acceptance criteria for tension test have been provided in QW-153.1. The test specimen should not be broken below the minimum specified tensile strength of base metal, but if it



breaks in out of weld area or out of weld interface then would be acceptable if it is not more than 5% below the minimum specified tensile strength. For instance, if you material is SA 516 Gr 70, and it breaks out of weld area on 67 ksi then the test would be acceptable.

The acceptance criteria for bend test have been provided in QW- 163. Normally after bend test there should be any crack more than 1/8 inch on the side that was placed on the stress.

The PQR documents what occurred during welding of the test coupon and the result of the test coupon. The PQR gives suitability of weld for required mechanical properties e.g. strength and ductility. The tension test indicates the strength and the bend tests indicate ductility.

Please note the procedure qualification record cannot be revised otherwise the case for revising being typing error or misspelling. The PQR must include all essential variable (such as P number, F number, A number, PWHT) and supplementary essential variables (such as Group Number). The nonessential variables are not code requirements for PQR.

When construction code like ASME Code Section VIII Div I requires impact testing, the impact testing must be included in Welding Procedure Qualification Record technical testing. Normally you need to conduct two set of impact testing, one set in weld metal and one set in heat affected zone.

.