

# Welding Procedure & Welder Qualification Review

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## Overview

- What is the purpose of Welding Procedure and Welder Qualification
- Explanation of Terminology
- What are the different Codes and Standards
- How do I use these documents to compile and qualify my procedures
- How Lloyd's Register can help



# Weld Procedures

## Question

What is the main reason for carrying out a Welding Procedure Qualification Test ?

## Answer

To show that following a given set of parameters will produce a welded joint that has the properties that satisfy the design requirements

# Welder Qualification

## Question

What is the main reason for carrying out a Welder Qualification Test?

## Answer

To test the ability of a welder to follow verbal or written instructions and verification that the weld produced meets the required standard

## Why We Need Weld Procedure Testing



# Terminology

- **WPS - Weld Procedure Specification:**
  - Qualified instructions on how to complete the weld
- **PQR - Procedure Qualification Record (ASME) & WPAR - Weld Procedure Approval Record:**
  - Record of the welding parameters and test results
- **Welders Qualification Test Certificate & Welders Performance Qualification (ASME)**
  - Record of Welder test results and ranges of approval

# Terminology

- **Essential Variable:**
  - A parameter that when changed outside its permitted range requires requalification
- **Non Essential Variable**
  - A parameter that when changed does not require requalification
- **Supplementary Essential Variable**
  - Is an essential variable only when impact testing is required

# Ranges in approval

## Weld Procedures

- Range of approval is limited to materials with similar chemical composition and mechanical properties to that used in the PQR. Welding is within a strict range of parameters for the essential variables recorded during the PQR test.

## Welder Qualifications

- Range of approval is not as restrictive as Procedure testing with fewer essential variables. One welder performance qualification can cover many WPS's.



# Components of a welding procedure

## Parent material

- Type (Grouping)
- Thickness
- Diameter (Pipes)
- Surface condition)

## Welding process

- Type of process (MMA, MAG, TIG, SAW etc)
- Equipment parameters
- Amps, Volts, Travel speed

## Welding Consumables

- Type of consumable/diameter of consumable
- Brand/classification
- Heat treatments/ storage

# Components of a welding procedure

## Joint design

- Edge preparation
- Root gap, root face
- Jigging and tacking
- Type of baking

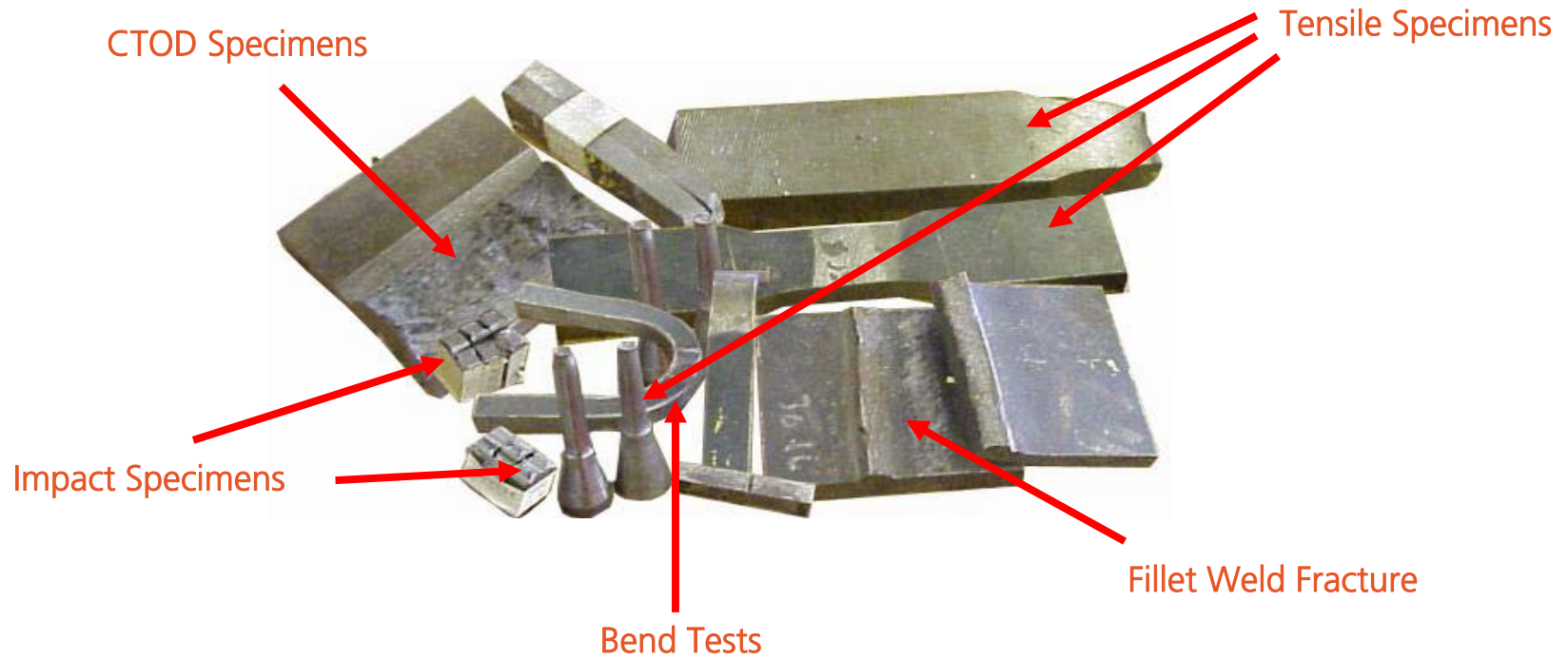
## Welding Position

- Location, shop or site
- Welding position e.g. 1G,2G, 3G etc
- Any weather precaution

## Thermal heat treatments

- Preheat, temps
- Post weld heat treatments e.g. stress relieving

# Testing



Non Destructive Exam  
Visual- DPI- MPI- RT- UT

# Mechanical Properties

The amount of deformation which metal can withstand under different modes of force application

- Malleability → Ability of a material to withstand deformation under static compressive loading without rupture
- Ductility → Ability of a material undergo plastic deformation under static tensile loading without rupture. Measurable elongation and reduction in cross section area
- Toughness → Ability of a material to withstand bending or the application of shear stresses by impact loading without fracture.
- Hardness → Measurement of a materials surface resistance to indentation from another material by static load
- Tensile Strength → Measurement of the maximum force required to fracture a materials bar of unit cross-sectional area in tension

# Testing

## Tests for required properties

- Tensile tests (Transverse Welded Joint, All Weld Metal)
- Toughness testing (Charpy, Izod)
- Hardness tests (Brinell, Rockwell, Vickers)
- Bend testing
- CTOD (Crack Tip Opening Displacement)
- Corrosion tests, HIC & SOHIC Tests

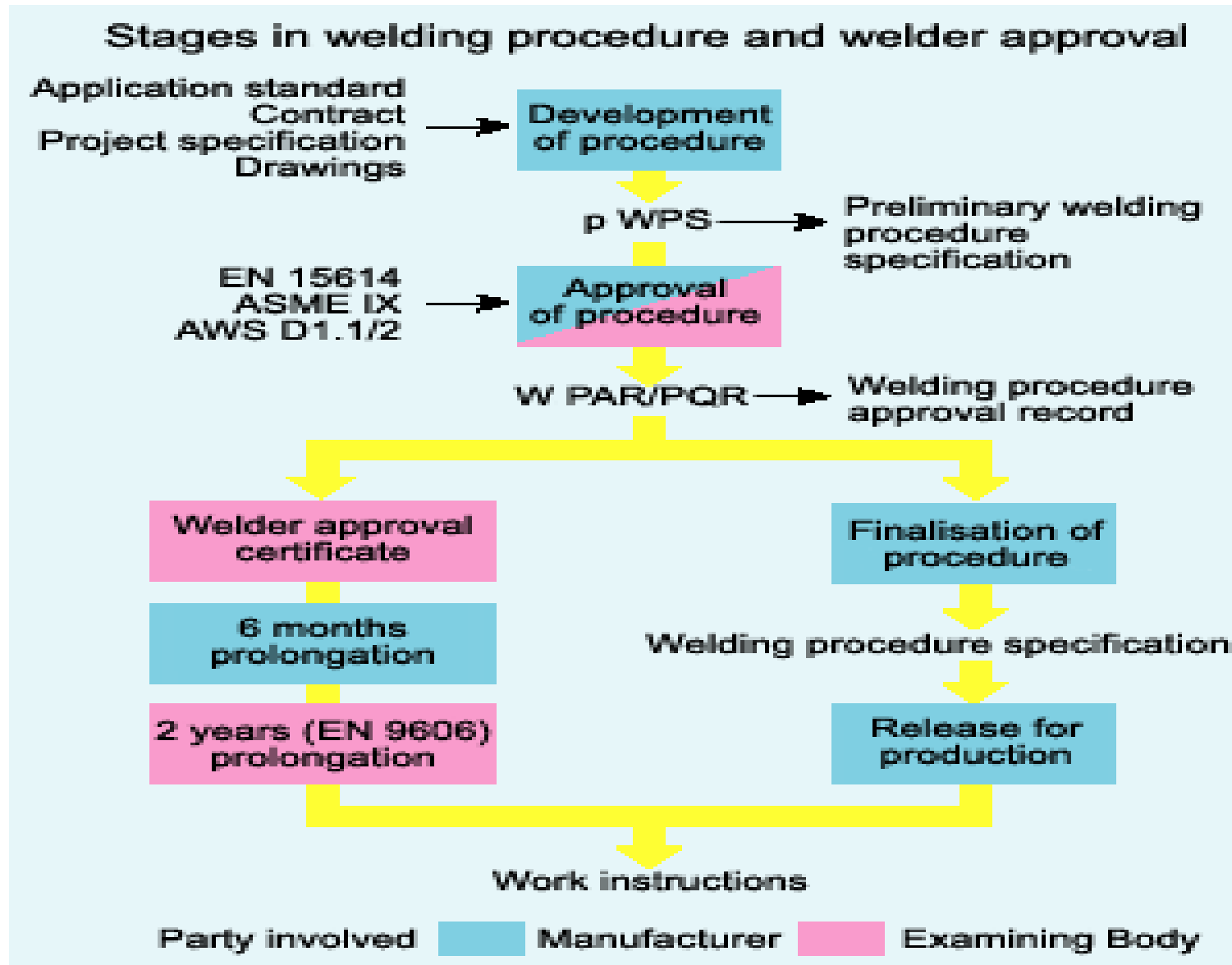
## Tests for weld quality

- Macro testing
- Fillet weld fracture testing
- Butt weld nick-break testing
- NDE ( VT,PT,MT,RT,UT)

## Codes & Standards

<b>APPLICATION</b>	<b>APPLICATION CODE</b>	<b>WELD PROCEDURE APPROVAL</b>	<b>WELDER APPROVAL</b>
<b>Pressure Vessels</b>	PD 5500 BS EN 13445 series  ASME B&PV Section III-NB (Nuclear) ASME B&PV Section VIII	BS EN ISO 15614  ASME B&PV Section IX	BS EN 287 BS EN ISO 9606 ASME B&PV Section IX
<b>Process Pipework</b>	BS 2633 BS 4677 BS 2971  ANSI/ASME B31.1 ANSI/ASME B31.3	BS EN ISO 15614 BS EN ISO 15614 BS EN ISO 15614-1 (if required) ASME IX ASME IX BS EN ISO 15614-1 (if required)	BS EN 287 BS EN ISO 9606  ASME B&PV Section IX
<b>Structural Fabrication</b>	AWS D1.1 AWS D1.2 AWS D1.6 BS EN 1011 BS 8118	AWS D1.1 AWS D1.2 AWS D1.6 BS EN ISO 15614-1 BS EN ISO 15614-2	AWS D1.1 AWS D1.2 AWS D1.6 BS EN 287 BS EN ISO 9606 BS 4872
<b>Storage Tanks</b>	BS EN 14015 BS EN 12285  API 620/650	BS EN ISO 15614-1, -2 BS EN ISO 15614-1, -2 ASME IX	BS EN 287 BS EN ISO 9606-2 BS 4872 ASME IX

# BS EN1011



# Organisation, Content and Structure of Section IX of the ASME B & PV Code

- Section IX is structured into 2 Parts: **Welding (QW)** and **Brazing (QB)**
- Each part is subdivided into four articles, namely;
  - General requirements
  - Procedure qualifications
  - Performance qualifications
  - Welding resp. brazing data
- Additionally
  - QW contains one article relating to “Standard Welding Procedure Specifications” (SWPS’s)
  - Appendices detail all the mandatory and non-mandatory requirements



# Article IV - Welding Data

## QW-400 to QW-416 Variables

- This Section covers all aspects concerning of welding processes
  - Joints, base and filler metal, positions, preheat, post weld heat treatment, gas, electrical characteristics and technique

*However, do **NOT** read individual paragraphs on their own but in conjunction with procedure or personnel qualification requirements only*

2010 SECTION IX

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	± Retainers			X
QW-403 Base Metals	.5	ϕ Group Number		X	
	.6	7 Limits impact		X	
	.8	ϕ 7 Qualified	X		
	.9	t Pass > 1/2 in. (13 mm)	X		
	.11	ϕ P-No. qualified	X		
QW-404 Filler	.4	ϕ F-Number	X		
	.5	ϕ A-Number	X		
	.6	ϕ Diameter			X
	.7	ϕ Diameter > 1/4 in. (6 mm)		X	

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).

## Article IV - Welding Data

### QW-420 to QW 424 Material groupings

- Base metals are assigned P-Numbers in table QW / QB – 422
  - P-Number: Ferrous / Nonferrous material according to base metal spec
- In order to reduce the number of procedure qualifications, each individual P- Number potentially covers a wide variety of materials

### QW-430 to QW-433 F – Numbers

- Grouping of electrodes and other welding consumables
- Usability characteristics
- Principal based on grouping similar to P numbers
- Table QW-432 shows F, ASME (SFA....) and AWS (E....)

## Article II - Welding Procedure Specifications - WPS

- A WPS is a written (qualified) welding procedure prepared to provide direction for the making of production welds
- The completed WPS shall describe all of the essential, nonessential, and, when required, supplementary essential variables
- Variables are defined for each process in QW-250 through QW-280
  - Each variable shall be addressed with facts, e.g. yes, no, none or any other meaningful definition – not applicable is not acceptable
- Changes to WPS's are allowed, however:
  - Changes in essential and supplementary essential variables require requalification and (therefore) a new WPS
  - Changes in nonessential variables can be made without requalification, but do need to be documented and the WPS must be revised

## Article II - Procedure Qualification Record - PQR

- A PQR is a record of welding data used to weld a test coupon
- It is a record of actual variables recorded during the welding of the test coupons
- PQR shall document all essential and, when required, all supplementary essential variables for each welding process
- Nonessential variables may be recorded (optional)
- All variables are actual values used during welding of the test coupon
- Changes to a PQR are not permitted as it is a record of what happened during a particular welding test, except for editorial corrections and addenda
- All changes except editorial and those invoked by an Addenda, require re-qualification and recertification of the PQR

## Article III - Welding Performance Qualification

- Article lists the welding processes with the essential variables that apply to welder and welding operator performance qualifications
- Welder qualification is limited by essential variables given for each process
- Variables are listed in QW-350 / QW-360 and defined in Article IV
- Welder may be qualified by mechanical tests or by radiography of a test coupon or of his initial production welding
- Manufacturer is responsible for conducting tests to qualify the performance of a welder in accordance with a qualified WPS.

# European Standards

Unlike ASME Section IX, WPS qualification to BS EN ISO15607 in the EN series is not contained in a single document

- BS EN ISO 15614 Specification and qualification of welding procedures for metallic materials - Welding Procedure test
- Part 1: Arc welding of Steels and nickel alloys
- Part 2: Arc welding of aluminium and its alloys
- Part 3: Fusion and pressure welding of non-alloyed and low-alloyed cast irons
- Part 4: Finishing welding of aluminium castings
- Part 5: Arc welding of titanium, zirconium and their alloys
- Part 6: Arc and gas welding of copper and its alloys
- Part 7: Overlay welding
- Part 8: Welding of tubes to tube-plate joints
- Part 9: Underwater hyperbaric wet welding
- Part 10: Hyperbaric dry welding
- Part 11: Electron and laser beam welding
- Part 12: Spot, seam and projection welding
- Part 13: Resistance butt and flash welding

## European Standards cont.

- BS EN ISO 15612: 2004: Specification and qualification of welding procedures for metallic materials - Qualification by adoption of a standard welding procedure
- BS EN ISO 15610: 2003 Specification and qualification of welding procedures for metallic materials - Qualification based on tested welding consumables
- BS EN ISO 15611: 2003: Specification and qualification of welding procedures for metallic materials - Qualification based on previous welding experience

Again , unlike ASME Section IX, Welder qualification in the EN series is not contained in a single document

- BS EN 287-1:2011 Qualification test of welders - fusion welding - Part 1: steels
- BS EN ISO 9606-2: 2004: Qualification test of welders - fusion welding.
  - Part 2: Aluminium and Aluminium alloys
  - Part 3: Copper and Copper alloys
  - Part 4: Nickel and Nickel alloys
  - Part 5: Titanium and Titanium alloys
- BS EN 1418 : 1998 Welding personnel - Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanised and automatic welding of metallic materials



# Material Grouping

As with ASME , materials are grouped together in ISO15608 to reduce the number of procedures required. Steel Groups are:

- Group 1 C-Mn Steels
- Group 2 Fine Grain/TMCP Steels
- Group 3 QT or PH (except stainless steels)
- Group 4 Low Vanadium Cr-Mo Steels
- Group 5 Vanadium Free Cr -Mo Steels
- Group 6 High Vanadium Cr-Mo Steels
- Group 7 Ferritic, Martensitic and PH Stainless
- Group 8 Austenitic Stainless
- Group 9 Ni Alloy Steel
- Group 10 Duplex Stainless
- Group 11 HSLA Steels

# BS EN ISO 15614-1 Main ranges of qualification

## Section 8 Range of Qualification:

- 8.1: General
  - 8.2 Related to manufacturer
  - 8.3: Related to Parent Material
  - 8.4 Common to all Welding Procedures
  - 8.5 Specific to Processes
- 
- Validity is restricted to workshops and sites under the same technical and quality control.
  - Parent Material : Tables 3 & 4.
  - Thickness: Tables 5 & 6.
  - Diameter: Table 7
  - Position: All positions (except vertical down) when there are no hardness/ impact test requirements

# BS EN 287-1 Qualification test of welders - fusion welding - Part 1: steels

Covers:

- Essential variables and range of qualification
- Test piece form and size
- Welding conditions
- NDE/mechanical tests
- Acceptance requirements
- Period of validity and prolongation requirements
- Retest requirements in case of failure

Any questions



## How Lloyd's Register can help

- Qualified and experienced Professionals in the field
- Use of "Expert" programmes to ensure code compliance (TWI C-Spec)
- LR Weld Certification Service: Offers a fixed fee "one stop shop" from witnessing the welding, collecting the samples, NDE & mechanical testing, certification and certification management

For more information, please contact:

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