Section 6

WPS/Welder Qualifications

General

When structures and pressurised items are fabricated by welding, it is essential that all the welded joints are sound and have suitable properties for their application.

Control of welding is achieved by means of Welding Procedure Specifications (WPSs) that give detailed written instructions about the welding conditions that must be used to ensure that welded joints have the required properties.

Although WPSs are shop floor documents to instruct welders, welding inspectors need to be familiar with them because they will need to refer to WPSs when they are checking that welders are working in accordance with the specified requirements.

Welders need to be able to understand WPSs have the skill to make welds that are not defective and demonstrate these abilities before being allowed to make production welds.

1 Qualified Welding Procedure Specifications

It is industry practice to use **qualified WPSs** for most applications.

A welding procedure is **usually qualified** by making a test weld to demonstrate that the properties of the joint satisfy the requirements specified by the application standard and the client/end user.

Demonstrating the mechanical properties of the joint is the principal purpose of qualification tests, but showing that a defect-free weld can be produced is also very important.

Production welds made in accordance with welding conditions similar to those used for a test weld should have similar properties and therefore be fit for their intended purpose.

Figure 1 is an example of a typical WPS written in accordance with the European Welding Standard format giving details of all the welding conditions that need to be specified.

1.1 Welding standards for procedure qualification

European and American Standards have been developed to give comprehensive details about:

- How a welded test piece must be made to demonstrate joint properties.
- How the test piece must be tested.
- What welding details need to be included in a WPS.
- The range of production welding allowed by a particular qualification test weld.

The principal **European Standards** that specify these requirements are:

EN ISO 15614 Specification and qualification of welding procedures for metallic materials – Welding procedure test

Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys
Part 2: Arc welding of aluminium and its alloys

The principal **American Standards** for procedure qualification are:

ASME Section IX Pressurised systems (vessels and pipework)

AWS D1.1 Structural welding of steels

AWS D1.2 Structural welding of aluminium

1.2 The qualification process for welding procedures

Although qualified WPSs are usually based on test welds that have been made to demonstrate weld joint properties; welding standards also allow qualified WPSs to be written based on other data (for some applications).

Some alternative ways that can be used for writing qualified WPSs for some applications are:

- **Qualification by adoption of a standard welding procedure –** test welds previously qualified and documented by other manufacturers.
- **Qualification based on previous welding experience –** weld joints that have been repeatedly made and proved to have suitable properties by their service record.

Procedure qualification to European Standards by means of a test weld (and similar in ASME Section IX and AWS) requires a sequence of actions that is typified by those shown by **Table 1**.

A successful procedure qualification test is completed by the production of a Welding Procedure Qualification Record (WPQR), an example of which is shown by **Figure 2**.

1.3 Relationship between a WPQR and a WPS

Once a WPQR has been produced, the welding engineer is able to write **qualified WPSs** for the various production weld joints that need to be made.

The welding conditions that are allowed to be written on a qualified WPS are referred to as the **qualification range** and this range depends on the welding conditions used for the test piece (the as-run details) and form part of the WPQR.

Welding conditions are referred to as **welding variables** by European and American Welding Standards and are classified as either **essential** or **non-essential variables**.

These variables can be defined as follows:

- **Essential variable:** A variable that has an effect on the mechanical properties of the weldment (and if changed beyond the limits specified by the standard will require the WPS to be re-qualified).
- **Non-essential variable:** A variable that must be specified on a WPS but does not have a significant effect on the mechanical properties of the weldment (and can be changed **without need for re-qualification** but will require a new WPS to be written).

It is because essential variables can have a significant effect on mechanical properties that they are the controlling variables that govern the qualification range and determine what can be written in a WPS.

If a welder makes a production weld using conditions outside the qualification range given on a particular WPS, there is danger that the welded joint will not have the required properties and there are then two options:

1 Make another test weld using similar welding conditions to those used for the affected weld and subject this to the same tests used for the relevant WPQR to demonstrate that the properties still satisfy specified requirements.

2 Remove the affected weld and re-weld the joint strictly in accordance with the designated WPS.

Most of the welding variables that are classed as essential are the same in both the European and American Welding Standards but their qualification ranges may differ.

Some application standards specify their own essential variables and it is necessary to ensure these are taken into consideration when procedures are qualified and WPSs written.

Examples of essential variables (according to European Welding Standards) are given in Table 2.

2 Welder Qualification

The use of qualified WPSs is the accepted method for controlling production welding but this will only be successful if the welders are able to understand and work in accordance with them.

Welders also need to have the skill to consistently produce sound welds (free from defects).

Welding Standards have been developed to give guidance on what particular test welds are required in order to show that welders have the required skills to make particular types of production welds in particular materials.

2.1 Welding standards for welder qualification

The principal **European Standards** that specify requirements are:

EN 287-1	Qualification test of welders – Fusion welding **Part 1**: Steels
EN ISO 9606-2	Qualification test of welders – Fusion welding **Part 2**: Aluminium and aluminium alloys
EN 1418	Welding personnel – Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanised and automatic welding of metallic materials

The principal **American Standards** that specify requirements for welder qualification are:

ASME Section IX	Pressurised systems (vessels & pipework)
AWS D1.1	Structural welding of steels
AWS D1.2	Structural welding of aluminium

2.2 The qualification process for welders

Qualification testing of welders to European Standards requires test welds to be made and subjected to specified tests to demonstrate that the welder is able to understand the WPS and to produce a sound weld.

For manual and semi-automatic welding the emphasis of the tests is to demonstrate the ability to manipulate the electrode or welding torch.

For mechanised and automatic welding the emphasis is on demonstrating that welding operators have the ability to control particular types of welding equipment.

American Standards allow welders to demonstrate that they can produce sound welds by subjecting their first production weld to NDT.

Table 3 shows the steps required for qualifying welders in accordance with European Standards.

Figure 3 shows a typical Welder Qualification Certificate in accordance with European Standards.

2.3 Welder qualification and production welding allowed

The welder is allowed to make production welds within the range of qualification recorded on his Welder Qualification Certificate.

The range of qualification is based on the limits specified by the Welding Standard for **welder qualification essential variables** – defined as:

A variable that if changed beyond the limits specified by the Welding Standard may require greater skill than has been demonstrated by the test weld.

Some welding variables that are classed as essential for welder qualification are the **same types** as those classified as essential for welding procedure qualification, but the range of qualification may be significantly wider.

Some essential variables are specific to welder qualification.

Examples of welder qualification essential variables are given in Table 4.

2.4 Period validity for a welder qualification certificate

A welder's qualification begins from the date of welding of the test piece.

The European Standard allows a qualification certificate to remain valid for a period of two years, provided that:

- The welding co-ordinator, or other responsible person, can confirm that **the welder has been working within the initial range of qualification.**
- Working within the initial qualification range is confirmed every six months.

2.5 Prolongation of welder qualification

A welder's qualification certificate can be prolonged every two years by an examiner/examining body but before prolongation is allowed certain conditions need to be satisfied:

- Records/evidence are available that can be traced to the welder and the WPSs used for production welding.
- Supporting evidence must relate to volumetric examination of the welder's production welds (RT or UT) on two welds made during the six months prior to the prolongation date.
- Supporting evidence welds must satisfy the acceptance levels for imperfections specified by the European welding standard and have been made under the same conditions as the original test weld.

Table 1 Typical sequence for welding procedure qualification by means of a test weld

The welding engineer writes a **preliminary** Welding Procedure Specification (pWPS) for each test coupon to be welded.

- A welder makes the test coupon in accordance with the pWPS
- A welding inspector records all the welding conditions used to make the test coupon (called the **as-run conditions**).

*An independent examiner/examining body/third party inspector **may be** requested to monitor the procedure qualification.*

The test coupon is subjected to **NDT** in accordance with the methods specified by the Standard – visual inspection, MT **or** PT and RT **or** UT.

- The test coupon is **destructively tested** (tensile, bend, macro tests).
- The code/application standard client may require additional tests such as hardness, impact or corrosion tests – depending on material and application.

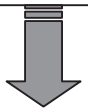
- **A Welding Procedure Qualification Record (WPQR) is prepared by the welding engineer giving details of:**
  – As-run welding conditions
  – Results of the NDT
  – Results of the destructive tests
  – Welding conditions allowed for production welding
- **If a third party inspector is involved he will be requested to sign the WPQR as a true record of the test.**

Table 2 Typical examples of WPS essential variables according to European Welding Standards

Variable	Range for procedure qualification
Welding process	No range – process qualified must be used in production.
PWHT	Joints tested after PWHT and only qualify PWHT production joints. Joints tested as-welded only qualify as-welded production joints.
Parent material type	Parent materials of similar composition and mechanical properties are allocated the same Material Group No; qualification only allows production welding of materials with the same Group No.
Welding consumables	Consumables for production welding must have the same European designation – as a general rule.
Material thickness	A thickness range is allowed – below and above the test coupon thickness.
Type of current	AC only qualifies for AC; DC polarity (+ve or -ve) cannot be changed; pulsed current only qualifies for pulsed current production welding.
Preheat temperature	The preheat temperature used for the test is the minimum that must be applied.
Interpass temperature	The highest interpass temperature reached in the test is the maximum allowed.
Heat input (HI)	When impact requirements apply maximum HI allowed is 25% above test HI. When hardness requirements apply minimum HI allowed is 25% below test HI.

Table 3 The stages for qualification of a welder

The welding engineer writes a WPS for welder qualification test piece.



- The welder makes the test weld in accordance with the WPS
- A welding inspector monitors the welding to ensure that the welder is working in accordance with the WPS.

An independent examiner/ examining body/third party inspector **may be** requested to monitor the test.

- The test coupon is subjected to **NDT** in accordance with the methods specified by the Standard (visual inspection, MT **or** PT and RT **or** UT)
- For certain materials, and welding processes, some destructive testing may be required (bends or macros).

- A welder's Qualification Certificate is prepared showing the welding conditions used for the test piece and the range of qualification allowed by the Standard for production welding.
- If a third party is involved, the Qualification Certificate would be endorsed as a true record of the test.

Table 4 Typical examples of welder qualification essential variables according to European Welding Standards

Variable	Range for welder qualification
Welding process	No range – process qualified is process that a welder can use in production.
Type of weld	Butt welds cover any type of joint except branch welds. Fillet welds only qualify fillets.
Parent material type	Parent materials of similar composition and mechanical properties are allocated the same Material Group No; qualification only allows production welding of materials with the same Group No. but the Groups allow much wider composition ranges than the procedure Groups.
Filler material	Electrodes and filler wires for production welding must be of the same form as the test (solid wire, flux-cored etc); for MMA coating type is essential.
Material thickness	A thickness range is allowed; for test pieces above 12mm allow ≥ 5mm.
Pipe diameter	Essential and very restricted for small diameters: Test pieces above 25mm allow ≥ 0.5 x diameter used (minimum 25mm).
Welding positions	Position of welding very important; H-L045 allows all positions (except PG).

Weldspec

WPS record number	WPS - 031 Revision 0	Qualified to	EN 15614-1: 2004
Date	12/04/2006	Company name	TWI Ltd
Supporting PQR(s) Reference docs.	PQR-031 - Rev 0		

MATERIAL/JOINTS QUALIFIED

Joint type	Butt plate ss mb nb, bs gg ng : T-Butt ss bs : Fillet plate : Butt pipe ss mb nb : Fillet pipe
Parent metal(s)	Groups 8-8
Notes	

WELD/TEST CONDITIONS

Without PWHT

TEST PIECE MATERIAL SPECIFICATION

Type	ASTM A213 TP316L	Grp-no. 8.1
Welded to	ASTM A213 TP316L	Grp-no. 8.1
Backing	ASTM A213 TP316L	Grp-no. 8.1

MATERIAL SIZE QUALFIED

		Minimum	Maximum
Material thickness fillet	(mm)	3.0	7.2
Material thickness butt	(mm)	3.0	12.0
Outside diameter	(mm)	57.2	no max.
Throat thickness	(mm)	No Min	No Max

WELDING PROCESSES

Welding process	TIG
Type	Manual

FILLER METALS

Filler metal manufacturer, trade name		METRODE 316S92
Filler metal designation type		Chemical
Filler metal designation		EN 12072 19 12 3 L
Filler metal size	(mm)	2.4
Deposited thickness	(mm)	3.0 - 12.0

POSITION

Position of groove	All positions

PREHEAT

Preheat temperature	(°C)	4
Maximum interpass temperature	(°C)	150

GAS

Shielding gas Type		EN 439 - I1
Flow rate	(l/min)	10 to 12
Manufacturer, Trade name		n/a
Backing gas: Type		EN 439 - I1
Flow rate	(l/min)	4
Manufacturer, Trade name		n/a

ELECTRICAL

Filler metal size	(mm)	2.4
Amperes		80 to 140
Volts		10 to 12
Travel speed	(mm/min)	30 to 60
Maximum heat input	(kJ/mm)	2.0
Tungsten size	(mm)	2.4
Tungsten type		WT 20 (2% Thoria)
Current/polarity		DC -VE
DC pulsing current		None

TECHNIQUE

String or weave		Stringer
Maximum width of run	(mm)	n/a
Orifice/gas cup size		12
Multi/Single pass per side		Multi-pass only
Closed or out-of-chamber		Not applicable
Surface preparation		degreased before welding
Initial/interpass cleaning		Brushing
Back gouging method		None

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Figure 1 *Example of a Welding Procedure Specification (WPS) to EN 15614 format.*

Weldspec

PQR record number	WIS 5-002	Revision 0	pWPS record number	WIS 5 - p002	Revision 0
Date	27/03/2006				

Examiner/examining body	Third Party Ltd	Manufacturer	TWI Ltd
Reference number	TPL/TWI/WIS5-002	Address	
Code/Testing standard	EN 15614-1: 2004		

EXTENT OF APPROVAL (JOINT/WELDING CONDITIONS)

Joint type		Butt plate ss mb nb, bs gg ng : T-Butt ss bs : Fillet plate : Fillet pipe
Parent metal(s)		Groups 1-1
Coupon thickness	(mm)	17.5 - 70.0
Coupon outside diameter	(mm)	Greater than 500.0
Fillet throat thickness	(mm)	No Restriction
Branch angle	(deg.)	n/a
Preheat	(°C)	50
Interpass temperature	(°C)	200
PWHT and/or ageing		-

EXTENT OF APPROVAL (PROCESS)

Welding process		111: MMA
Welding process type		Manual
Welded thickness	(mm)	17.5 - 70.0
Welded outside diameter	(mm)	Greater than 500.0
Filler metal type		en 499 e 46 6 mn1ni b12 h5
Shielding gas/flux		none
Welding positions		PA,PC,PE,PF
Preheat temperature	(°C)	50
Interpass temperature	(°C)	200
Current/polarity		DC +VE
Multi/Single pass per side		Multi-pass only
Heat input	(kJ/mm)	Max 3.2
Metal transfer mode		n/a
Backing gas		n/a

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Figure 2.1 *Example of WPQR (Qualification Range) to EN 15614 format.*

Weldspec

PQR record number	WIS 5-002	Revision 0	pWPS record number	WIS 5 - p002	Revision 0
Date	27/03/2006				

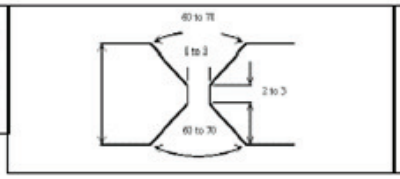
TEST PIECE MATERIAL SPECIFICATION

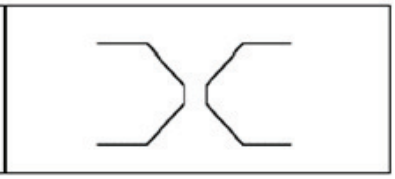
	Product form	Specification (type or grade)	Grp-no.	Size	Sch.	Thick. (mm)	Dia.(mm)
	Plate	BS 10025	1.1	-	-	35	-
Welded to:	Plate	BS 10025	1.1	-	-	35	-

and tested:	Without PWHT, With Impacts
Notes	

TEST PIECE JOINT SPECIFICATION

Joint design		Butt-plate bs gg
Backing:		gg: gouging or grinding
Retainers		
Groove angle	(deg.)	60
Root opening	(mm)	2.5
Root face	(mm)	2





WELDING PROCESSES

Welding process	111: MMA
Type	Manual

FILLER METALS

Filler metal manufacturer, trade name		ESAB OK 53.08 Hytuf 1NI
Filler metal designation type		Yield strength
Filler metal designation		EN 499 E 46 6 Mn1NI B12 H5
Filler metal size	(mm)	3.25 & 4.0
Deposited thickness	(mm)	35
MMA Electrode coating		B basic

POSITION

Position of groove	PF

PREHEAT

Preheat temperature	(°C)	50
Maximum interpass temperature	(°C)	200

ELECTRICAL

Filler metal size	(mm)	3.25 & 4.0
Amperes		3.25mm = 110; 4.0mm = 130
Volts		23 to 25
Electrode run out length	(mm)	3.25mm=75min.; 4.0mm=125min.
Travel speed	(mm/min)	60 to 70
Maximum heat input	(kJ/mm)	2.6
Current/polarity		DC +ve

TECHNIQUE

String or weave		Stringer and Weave
Maximum width of run	(mm)	8
Multi/Single pass per side		Multi-pass
Surface preparation		ground
Initial/interpass cleaning		Brushing and Grinding
Back gouging method		arc-air

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Figure 2.2 *Example of a WPQR document (test weld details) to EN 15614 format.*

Weldspec

PQR record number	WIS 5-002	Revision 0	pWPS record number	WIS 5 - p002	Revision 0
Date	27/03/2006				

TENSILE TESTS

Type/Number	Re (N/mm²)	Rm (N/mm²)	A% on	Z%	Fracture location	Remarks
transverse	480	610	32	35	Ductile-Base Metal	
transverse	473	598	33	35	Ductile-Base Metal	

Comments: 2 Transverse tensile tests according to EN 895

GUIDED BEND TESTS

Type/Number	Bend angle	Elongation°	Results
4 Side bend tests as per 7.4.3 and EN 910	EN 25817		Acceptable

Comments:

TOUGHNESS TESTS

Notch location/direction	Temperature (°C)	Values (J)	(J)	(J)	Average (J)	Remarks
weld metal (surface)	-46	157	146	149	150.67	
weld metal (root)	-46	127	136	132	131.67	
FL (surface)	-46	67	78	63	69.33	
FL + 2 (surface)	-46	105	113	143	120.33	
FL + 5 (surface)	-46	216	203	215	211.33	

Comments:

CERTIFICATION

Welder's name	ID Number	Stamp number		
R.A.T. Catcher			Mechanical testing by	The Test House
			Laboratory test number	TTH - 1341-2006
			Test file number	1341-2006
			Tests conducted by	I. A. M. Tougher

Certified that test welds were performed, welded and tested satisfactorily in accordance with the requirements of the code/testing standard indicated above.

Examiner or examining body

Name	Signature
Date	

Manufacturer

Name	Signature
Date	

Signature 3

Name	Signature
Date	

Signature 4

Name	Signature
Date	

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Figure 2.3 *Example of WPQR document (details of weld test) to EN 15614 format.*

TWI

Welderqual

EN DESIGNATION

Designation	EN287-1, 111, T, BW, 1.1, B, t14.27, D168.28, H-L045, ss, nb

Welder's name	A. Weaver		Test date	06/07/2005	
ID Number	AW-3463		WPQ record number	3463-001	
Date of birth	12.3.79		Standard test number	n/a	Rev. 0
Stamp number	3463		pWPS record number	WPS - 013	Rev. 0
Company name	XYZ Fabrications		Qualification code	EN 287-1: 2004	
Division	North East		Examining body	Third Party Ltd	
Job knowledge	Not tested		Reference no.	TPL/XYZ/3463-1	
			Expiry date	05/07/2007	

BASE METALS

	Product form	Specification (type or grade)	Grp-no.	Size	Sch.	Thick(mm)	Dia(mm)
	Pipe	BS 10025 (50-B)	1.1	152.40	120	14.27	168.28
Welded to:	Pipe	BS 10025 (50-B)	1.1	152.40	120	14.27	168.28
Joint type	Butt						

VARIABLES	Actual values	RANGE QUALIFIED
Type of weld joint	Pipe - Butt	Butt, Fillet welds and Branch welds where angle >= 60°
Base metal	1.1 to 1.1	1.1, 1.2, 1.4

BASE METAL THICKNESS		Actual values Butt	Actual values Fillet	RANGE QUALIFIED Butt	RANGE QUALIFIED Fillet
Plate thickness	(mm)	14.27	-	5.00 min	5.00 min
Pipe/tube thickness	(mm)	14.27	-	5.00 min	5.00 min
Pipe diameter	(mm)	168.28	-	84.14 and above	84.14 and above

VARIABLES	Actual values	RANGE QUALIFIED
Welding process	111: MMA	111: MMA
Type	Manual	Manual
Backing	nb: without backing	ss nb, ss mb, bs
Filler metal type/designation	EN 499 E 46 6 Mn Ni B	Any Similar
Filler metal group	n/a	Any Similar
Covered electrode type	B basic	B,A,RA,RB,RC,RR,R
Weld deposit thickness (mm)	12.70	5.00 min
Weld position (Actual position tested)	H-L045	
Butt-Plate		PA,PC,PF,PE
Fillet-Plate		PA,PB,PF,PD
Butt-Pipe		PA,PF,PC,H-L045
Fillet-Pipe		PA,PB,PF,PD
Butt-Pipe Diameter (see en287 6.3 a,c)		-

TESTS

Type of test	Acceptance criteria	Result	Comments
Visual examination per Table 10 and EN 970	EN ISO 5817	Acceptable	see - EN ISO 5817
Radiographic examination per Table 10 and EN 1435	EN ISO 5817	Acceptable	see - EN ISO 5817

Notes	branch set-on; angle at smallest required

CERTIFICATION

Tests conducted by		Laboratory test number	
Mechanical tests by		Test file number	

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of EN 287.

Signature 1 (defined using Tools-Options-Default Settings)		Signature 2 (also user defined)	
Name	Signature	Name	Signature
Date		Date	

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Figure 3 *Example of a Welder Qualification Test Certificate (WPQ) to EN 287 format.*