Education and Culture

Leonardo da Vinci

Course: 141 - TIG WELDING OF STAINLESS STEEL

Module 4

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MODULE 4

Welding procedures and instructions.

The Manufacturer shall prepare the Welding Procedure Specification(s) (WPS) and shall ensure that these are used correctly in production.

The welding procedures applied during production shall be as specific as possible, in order to clearly identify actions and parameters to be used for the required joint. However, if the relevant WPS contains data too detailed and not useful for the welder, dedicated work instructions may be used directly derived from such a WPS containing only the necessary data. These instructions have to refer directly to the welding procedure specification they derived from, e.g. by referring to the relevant WPS number.

Considering that welding is a special process and that the quality of the welded joint cannot be properly controlled only by final tests, the welding procedures significant for the final product quality shall be qualified precisely prior to production. As a consequence, those Welding Procedure Specifications should be prepared in accordance with a Welding Procedure Qualification Record (WPQR). Normative references to the specification and to the qualification of welding procedures are given in the table.

Welding process	Standard	Material	Scope	Field of application
All fusion welding processes	ISO 15607	All	WPS, WPQR	General Rules
	ISO 15610		WPQR	Qualification based on tested welding consumables
	ISO 15611			Qualification based on previous welding experience
	ISO 15612			
	ISO 15613			Qualification by adoption of a standard welding procedure
				Qualification based on pre-production welding test
Gas Welding	ISO 15609-2	Steels	WPS	Compiling
	ISO 15614 - 1		WPQR	Qualification based on welding procedure test – Steels

Arc welding	ISO 15609-1	All	WPS	Compiling
	ISO 15614 - 1	Steels and Nickel alloys	WPQR	Qualification based on welding procedure test
	ISO 15614 - 2	Aluminium, Magnesium	WPQR	Qualification based on welding procedure test
	ISO 15614 - 3	Steel castings	WPQR	Qualification based on welding procedure test
	ISO 15614 - 4	Aluminium castings	WPQR	Qualification based on welding procedure test
	ISO 15614 - 5	Titanium and zirconium	WPQR	Qualification based on welding procedure test
	ISO 15614 - 6	Copper	WPQR	Qualification based on welding procedure test
	ISO 15614 – 7	All applicable	WPQR	Qualification based on welding procedure test – corrosion resistance overlay, cladding restore and hardfacing
	ISO 15614 – 8	All applicable	WPQR	Qualification based on welding procedure test - Welding of tubes to tube-plate joints
Electron beam welding	ISO 15609 – 3	All	WPS	Compiling
	ISO 15614 – 11	All applicable	WPQR	Qualification based on welding procedure test
Laser Welding	ISO 15609 – 4	All	WPS	Compiling
	ISO 15614 – 11	All applicable	WPQR	Qualification based on welding procedure test
Underwater Arc Welding – Wet Hyperbaric	ISO 15614 – 9	All applicable	WPQR	Qualification based on welding procedure test
Underwater Arc Welding – Dry Hyperbaric	ISO 15614 – 10	All applicable	WPQR	Qualification based on welding procedure test

Standards for the qualification of welding procedures

Different methods for the qualification of welding procedures are available:

- *welding procedure test* **–** this method consists in welding a standardised test piece on which destructive and non-destructive tests are carried out in order to verify the achievement of required properties;
- *use of approved welding consumables* **-** this method of approval may be used if the welding consumables and the base material are not particularly affecting the welding quality, provided that heat inputs are kept within specified limits;
- *previous welding experience* - a welding procedure may be qualified by referring to previous experiences in welding if the Manufacturer is able to prove, by appropriate authentic documentation of an independent nature, that he has previously satisfactorily welded the same joint with reliable results;
- *use of a standard welding procedure* – a procedure is qualified if it is issued as a specification in the format of a WPS or WPQR based on appropriate qualification (e.g based on the relevant part of EN ISO 15614), not related to the Manufacturer and qualified by an examiner or examining body;
- *Pre production Test* - this method is the only reliable method of qualification for those welding procedures in which the resulting properties of the weld strongly depend on certain conditions such as: components, special restraint conditions, heat sinks etc., which cannot be reproduced

by standardised test pieces; it is mostly used when the shape and dimensions of standardised pieces do not adequately represent the joint to be welded.

Even if different qualification methods are considered, the most commonly used are qualification by welding procedure test and pre-production test; however the applicable method of qualification is generally specified in either manufacturing codes, standards or contracts.

In order to demonstrate the achieved quality of the welded product, all the welding related documents (e.g. WPS, WPQR, Welder's Qualification record, etc) shall be properly controlled.

This involves the preparation and maintenance of a procedure for the management of such documents, in order to identify issuance responsibilities, distribution methods, availability, and method for withdrawing obsolete documents. Even if it is not a normative requirement, a commonly adopted method to control documentation is the production of a written procedure, produced or approved by the welding coordinator, to be kept by the Manufacturer quality assurance department or directly by the welding coordinator himself.

In the next page a typical WPS form is reported, produced according to EN ISO15609-1.

COMPANY NAME OR LOGO	**WELDING PROCEDURE SPECIFICATION (WPS)**	**WPS n°** _____ **Rev** . ___ **Supp. WPQR** **Date**

Welding process(es)	a)	b)	c)
Type(s)	a)	b)	c)

JOINTS –

Joint Type

Backing

Backing material

Weld preparation

Method of preparation & Cleaning

PARENT METAL

Group n° To group n°

Spec. Type & grade

To Spec. Type & grade

Thickness

Outside Diameter

Other

Joint drawiing

WELDING CONSUMABLE

	a)	b)	c)
Specification n°			
Designation			
Size			
Trade name			
Manufacturer			
Flux design. EN			
Flux Trade name			
Weld deposit			

Other

GAS(ES)

	Gas(es)	Mixture	Flow Rate
Plasma			l/min
Shielding a)			l/min
Shielding b)			l/min
Trailing			l/min
Backing			l/min

Other

ELECTRICAL CHARACTERISTIC -

Current

Polarity

Mode of Metal Transfer

Tungsten Electrode Type & size

Electrode wire feed speed range

Other

WELDING POSITION

Position

Welding Progression

Other

PREHEAT

Preheat Temperature

Interpass Temperature

Preheat maintenance

Other

TECHNIQUE

String or weave beads

Orifice or gas cup size

Initial & interpass cleaning

Method of back gouging

Oscillation _____ Amplitude Freq.

Distance contact tube – work piece

Multiple, single pass (for side)

Single or multiple electrodes

Torch angle direction of welding

Other

PWHT and/or AGEING

Temperature Range

Time Range (hour)

Heating rate

Cooling rate

Other

Run(s) or Layer(s)	*Welding process*	Filler metal		Current		Voltage V	Travel Speed mm/min	Heat input KJ/mm	Other
		EN designation or trade name .	Size (mm)	Type & polarity	Amperage A				

MANUFACTURER	APPROVED BY

Welding Procedure Specification

Methods for joint preparations in stainless steel (PSS2)

Most stainless steels are considered to have good weldability and may be welded by several welding processes including the arc welding processes, resistance welding, electron and laser beam welding, friction welding and brazing. For any of these processes, joint surfaces and filler metal must be clean.

Since the coefficient of thermal expansion for austenitic stainless steels is relatively high, the control of distortion must be considered in designing weldments of these alloys.

The volume of metal in joints must be limited to the smallest size which will provide the necessary properties. In thick plate, a “U” groove, which gives a smaller volume that a “V” groove, should be used.

If it is possible to weld from both sides of a joint, a double “U” or “V” groove joint preparation should be used. This not only reduces the volume of weld metal required but also helps to balance the shrinkage stresses.

Accurate joint fit up and careful joint preparation, which are necessary for high quality welds also, help minimize.

Joint location and weld sequence should be considered to minimize distortion. Strong tooling and fixturing should be employed to hold parts in place and resist tendencies for components to move during welding.

When any of the gas-shielded processes are used, the tooling should also provide an inert gas backup to the root of the weld to prevent oxidation when the root pass is being made. This is particularly important when 141 - TIG welding pipe with insert rings to allow the weld metal to wet and flow together at the root of the joint.

In welding pipe, insert rings, of the same composition as the filler metal should be used for the root pass and be welded by the 141 - TIG process. If copper chills are to be used near a weld area, they should be nickel plated to prevent copper pickup. If copper is in contact with the high temperature region of the heat-affected zone, it can melt and penetrate the grain boundaries of austenitic stainless steel causing embrittlement.

The principal basic types of joints used in arc welding are the butt, lap, corner, edge and T configurations. Selection of the proper design for a particular application will depend primarily on the following factors:

- the mechanical properties desired in the weld
- the type of grade being welded
- the size, shape and appearance of the assembly to be welded
- the cost of preparing the joint and making the weld

No matter what type of joint is used, proper cleaning of the workpieces prior to welding is essential if welds of good appearance and mechanical properties are to be obtained. On small assemblies, manual cleaning with a stainless steel wire brush, stainless steel wool or a chemical solvent is usually sufficient. For large assemblies or for cleaning on a production basis, vapor degreasing or tank cleaning may be more economical. In any case, it is necessary to completely remove all oxide, oil, grease, dirt and other foreign matter from the workpiece surfaces.