Course: 141 - TIG WELDING OF STAINLESS STEEL

Module 4
List of content

MODULE 4 ........................................................................................................................................3
  Welding procedures and instructions.........................................................................................3
  Methods for joint preparations in stainless steel (PSS2)........................................................7
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.

<table>
<thead>
<tr>
<th>Welding process</th>
<th>Standard</th>
<th>Material</th>
<th>Scope</th>
<th>Field of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>All fusion welding</td>
<td>ISO 15607</td>
<td>All</td>
<td>WPS, WPQR</td>
<td>General Rules</td>
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<td>processes</td>
<td>ISO 15610</td>
<td></td>
<td>WPQR</td>
<td>Qualification based on tested welding consumables</td>
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<td>ISO 15611</td>
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<td>Qualification based on previous welding experience</td>
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<td>ISO 15612</td>
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<td>Qualification by adoption of a standard welding procedure</td>
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<td></td>
<td>ISO 15613</td>
<td></td>
<td></td>
<td>Qualification based on pre-production welding test</td>
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<tr>
<td>Gas Welding</td>
<td>ISO 15609-2</td>
<td>Steels</td>
<td>WPS</td>
<td>Compiling</td>
</tr>
<tr>
<td></td>
<td>ISO 15614 - 1</td>
<td></td>
<td>WPQR</td>
<td>Qualification based on welding procedure test – Steels</td>
</tr>
<tr>
<td>Arc welding</td>
<td>ISO 15609-1</td>
<td>All</td>
<td>WPS</td>
<td>Compiling</td>
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</tr>
<tr>
<td></td>
<td>ISO 15614-2</td>
<td>All</td>
<td>WPS</td>
<td>Compiling</td>
</tr>
<tr>
<td></td>
<td>ISO 15614-3</td>
<td>All</td>
<td>WPS</td>
<td>Compiling</td>
</tr>
<tr>
<td></td>
<td>ISO 15614-4</td>
<td>All</td>
<td>WPS</td>
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<tr>
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<td>ISO 15614-5</td>
<td>All</td>
<td>WPS</td>
<td>Compiling</td>
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<td>Laser Welding</td>
<td>ISO 15609-3</td>
<td>All</td>
<td>WPS</td>
<td>Compiling</td>
</tr>
<tr>
<td>Underwater Arc Welding – Wet Hyperbaric</td>
<td>ISO 15614-4</td>
<td>All</td>
<td>WPS</td>
<td>Compiling</td>
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<tr>
<td>Underwater Arc Welding – Dry Hyperbaric</td>
<td>ISO 15614-9</td>
<td>All</td>
<td>WPS</td>
<td>Compiling</td>
</tr>
<tr>
<td></td>
<td>ISO 15614-10</td>
<td>All</td>
<td>WPS</td>
<td>Compiling</td>
</tr>
</tbody>
</table>

**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.
<table>
<thead>
<tr>
<th>COMPANY NAME OR LOGO</th>
<th>WELDING PROCEDURE SPECIFICATION (WPS)</th>
<th>WPS n°</th>
<th>Rev</th>
<th>Supp. WPQR</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding process(es)</td>
<td>a)</td>
<td>b)</td>
<td>c)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type(s)</td>
<td>a)</td>
<td>b)</td>
<td>c)</td>
<td></td>
<td></td>
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</tbody>
</table>

**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

**WELDING CONSUMABLES**
- Specification n°
- Designation
- Size
- Trade name
- Manufacturer
- Flux design. EN
- Flux Trade name
- Weld deposit
- Other

**GAS(ES)**
- Gas(es)
- Mixture
- Flow Rate

**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

**PWHT and/or AGEING**
- Temperature Range
- Time Range (hour)
- Heating rate
- Cooling rate
- Other

<table>
<thead>
<tr>
<th>Run(s) or Layer(s)</th>
<th>Filler metal</th>
<th>Current</th>
<th>Heat Input</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding process</td>
<td>EN designation or trade name</td>
<td>Size (mm)</td>
<td>Type &amp; polarity</td>
<td>Amperage A</td>
</tr>
</tbody>
</table>
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.