
	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB <i>Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)</i>	INDUS Ref No II-HVD69SL-v1.1
---	--	--

Contents

1. Scope	3
2. Reference Standard	3
3. The Purpose of welding procedure qualification	3
4. Documents to be established	3
5. Welding Procedure Specification (WPS)	4
6. Welding Procedure Qualification Record (WPQR)	10
7. Test Piece for WPQ	11
8. Extent of Approval for WPQR / Range of Qualification	14
9. Non –Destructive Examination	24
10. Destructive Tests	27
11. Retesting procedures	35
12. Validity of the qualification	35
13. WPQR for Repair by welding of the production welds	35
14. WPQR Reports	35
15. WPQR Format	37

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

1. Scope

This section specifies how a preliminary welding procedure specification is qualified by welding procedure tests.

This section is applicable for the qualification of production welding, repair welding and build-up welding.

This section defines the conditions for the execution of welding procedure tests and the range of qualification for welding procedures for all practical operations within the qualification of this document.

This section sets out the requirements relating to the qualification testing of welding procedures as specified in standards **NF EN ISO 15607 and NF EN 15609-1**, applicable for DNB Vessel and HNB3 Vessel.

Arc welding procedure qualification tests shall be performed in accordance with the full requirements of this section (which includes the requirement of **NF EN ISO 15614-1:2017- Level 2, ITER Vacuum handbook attachment-1 and RCC-MR Section 4**).

2. Reference Standard

RCC-MR 2007; Section 4 Welding; RS 3000 Welding Procedure Qualification

ITER Vacuum Handbook: Attachment 1 Welding_2FMM4B_v1_5

ISO 15607: Specification and qualification of welding procedures for metallic materials — General rules

ISO 15609-1: Specification and qualification of welding procedures for metallic materials —Welding procedure specification — Part 1: Arc welding


EN 15614-1: 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

3. The Purpose of welding procedure qualification

The primary purpose of the welding procedure qualification is to demonstrate that the joining process proposed for the construction is capable of producing joints having the required mechanical properties for the intended application.

4. Documents to be established

Every welding procedure qualification shall be carried out in accordance with the provisions set out in this section, must comply with the requirements of the relevant paragraphs and which shall comprise at least the following:

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--

- The p-WPS (preliminary Welding Procedure Specification), prepared in accordance with **ISO 15609-1 or ISO 15609-2**. The p-WPS shall be included in the welding data package
- The range of approval of the qualification
- The tests to be carried out and the associated criteria in relation to the qualification level
- The basic sketch for the removal of test specimens
- Bead distribution and the welding process used for each bead
- unwinding speed (where applicable)

5. Welding Procedure Specification (WPS)

5.1 The Welding Procedure Specification (WPS) is a document which details all the variables which must be defined to produce a weld of acceptable quality. The qualification of the WPS shall be performed in accordance with this section.

5.2 Each WPS shall detail each type of weld and shall include, but not be limited to, the following in accordance with **ISO 15609**:

5.2.1 Related to the manufacturer

- Identification of the manufacturer;
- Identification of the WPS / WPS number
- Reference to the Welding Procedure Qualification Record (WPQR) or other documents as required (**see EN ISO 15607:2003, Annex C**).
- Identification of equipment manufacturer

5.2.2 Related to the parent material


- Parent material type
 - Designation of the material(s), and reference standard(s);
 - Number(s) of the group(s) as given in **ISO 15608**.
 - Defining which joint element is comprised of a given material

A WPS may cover a group of materials.

- Material dimensions
 - Thickness ranges of the joint;
 - Outside diameter ranges for pipes.

5.2.3 Welding process (in accordance with ISO 4063)

5.2.4 Joint design

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

- A sketch of the joint design/configuration and dimensions or reference to standards / drawing which provide such information.
- Weld run sequence given on the sketch

5.2.5 Welding position

- Applicable welding positions in accordance with EN ISO 6947.

5.2.6 Joint / edge / groove preparation

- Joint preparation methods, cleaning, degreasing, including methods to be used;
- Jigging, fixtures and tack welding.

5.2.7 Range of qualified thicknesses and/or diameters

5.2.8 Welding technique

- Weaving if applicable
 - For manual welding maximum width of the run.
 - For mechanized and automatic welding maximum weaving or amplitude, frequency and dwell time of oscillation.
- Torch, electrode and/or wire angle.
- Single, multipass etc

5.2.9 Back gouging

- The method to be used.
- Depth and shape.

5.2.10 Backing

- The method and type of backing, backing material and dimensions.
- For gas backing, gas in accordance with EN 439.


5.2.11 Welding consumables

- Classification / Designation, make (manufacturer and trade name).
- Dimensions (size).
- Handling (baking, exposure to atmosphere, re-drying, etc.).

5.2.12 Electrical parameters

- Type of current (alternating current (AC) or direct current (DC)) and polarity.
- Pulse welding details (machine settings, programme selection) if applicable.
- Current range.
- Voltage range

If the equipment does not permit control of one of either variable, the machine settings shall be specified instead. The range of application for the WPS shall then be limited to equipment of that particular type.

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB <i>Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)</i>	INDUS Ref No II-HVD69SL-v1.1
---	--	--

5.2.13 Mechanized and automatic welding

- Travel speed range.
- Wire/strip feed speed range.

If the equipment does not permit control of one of either variable, the machine settings shall be specified instead. The range of application for the WPS shall then be limited to equipment of that particular type.

5.2.14 Preheat temperature

- The minimum temperature applied at the start of welding and during welding.
- If pre-heating is not required the lowest work piece temperature prior to welding.
- **EN ISO 13916** for guidance on the measurement of preheating temperature,

5.2.15 Interpass temperature

- Maximum and if necessary minimum interpass temperature.
- **EN ISO 13916** for guidance on the measurement of interpass temperature

5.2.16 Preheat maintenance temperature

- The minimum temperature in the weld zone which shall be maintained if welding is interrupted.
- **EN ISO 13916** for guidance on the measurement preheat maintenance temperature

5.2.17 Post-heating for hydrogen release

- Temperature range.
- Minimum holding time.

5.2.18 Post-weld heat-treatment

- The minimum time and temperature range for post-weld heat treatment or ageing shall be specified


5.2.19 Shielding gas and baking gas

- Designation in accordance with **EN 439** and, where applicable, the composition, manufacturer and trade name.
- Flow rates
- Compositions

5.2.20 Heat input

- Range of heat input (if specified).

5.2.21 Specific to Process 111 (Manual metal arc welding)

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB <i>Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)</i>	INDUS Ref No II-HVD69SL-v1.1
---	---	--

- The run-out length of electrode consumed or travel speed
- Drying and preservation temperatures for covered electrodes

5.2.22 Specific to Process 12 (Submerged arc welding)

- For multiple electrode systems the number and configuration of wire electrodes and polarity.
- Distance contact tube/work piece: The distance from contact tip nozzle to the surface of the work piece.
- Flux: Designation, manufacturer and trade name.
- Additional filler material.
- Arc voltage range.

5.2.23 Specific to Process 13 (Gas-shielded metal arc welding)

- Shielding gas flow rate and nozzle diameter.
- Number of wire electrodes.
- Additional filler material.
- The distance from the contact tip/contact tube to the surface of the workpiece.
- Arc voltage range.
- Mode of metal transfer.


5.2.24 Specific to Process 14 (Gas-shielded welding with non-consumable electrode)

- Tungsten electrode: the diameter, and codification in accordance with EN 26848.
- Shielding gas flow rate and nozzle diameter.
- Additional filler materials.

5.2.25 Process 15 (Plasma arc welding)

- Plasma gas parameters, e.g. composition, nozzle diameter, flow rate.
- Shielding gas flow rate and nozzle diameter.
- Type of torch.
- Distance contact tube/work piece: the distance from the nozzle to the surface of the work piece.
- Tungsten electrode: the diameter, and codification in accordance with EN 26848.


5.2.26 Additional Parameters for automatic welding may include:

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB <i>Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)</i>	INDUS Ref No II-HVD69SL-v1.1
---	---	--

- Welding equipment specification
- Tool and programme numbers (where applicable)
- Travel speed range
- Wire feed speed range
- Arc Voltage Control parameters

5.2.27 Equipment calibration records

5.2.28 Examiner or test body

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

5.3 WPS Format

Following format may be used for preparation of the pWPS and WPS. Note that the format does not contain the exhaustive list of all the variables. Manufacturer has to expand it so as to cover all the applicable parameters defined in the **clause 5.2** above.

ISO 15609-1:2004(E)

Annex A (informative)

Welding Procedure Specification (WPS)

Welding Procedure Specification:

WPQR No. :

Manufacturer :

Mode of metal transfer :

Joint Type and Weld Type:

Weld Preparation Details (Sketch)*

Method of Preparation and Cleaning :

Parent Material Designation :

Material thickness (mm) :

Outside Diameter (mm) :

Welding Position :

Joint Design	Welding Sequences

Welding Details

Run	Welding Process	Size of Filler Material	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed	Run out length/Travel Speed*	Heat input*

Filler material designation and make:

Any Special Baking or Drying :

Designation Gas/Flux : - Shielding :

- Backing :

Gas Flow Rate - Shielding :

- Backing :

Tungsten Electrode Type/Size :

Details of Back Gouging/Backing :

Preheat Temperature :

Interpass Temperature :

Post-heating:

Pre-heat maintenance temperature :

Post-Weld Heat treatment and/or Ageing :

(Time, Temperature, Method :

Heating and Cooling Rates*):

Other information*, e.g.:

Weaving (maximum width of run) :

Oscillation : amplitude, frequency, dwell time :

Pulse welding details :

Distance contact tube/work piece :


Plasma welding details :

Torch angle :

.....
Manufacturer


(name, signature, date)

* If required

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--

6. Welding Procedure Qualification Record (WPQR)

- 6.1 The Welding Procedure Qualification Record (WPQR) is used to record all the relevant data from the welding of test pieces in the qualification of the WPS.
- 6.1.1 The qualification of the WPS provides proof that the defined welding process, will achieve a weld of acceptable quality. The welding and testing of this must be witnessed by ITER-India or ITER recognised Independent Inspection Authority.
- 6.2 All welding data and results from the required non-destructive and destructive testing shall be documented using a Welding Procedure Qualification Record (WPQR). It can also be called Welding Procedure Approval Record (WPAR).
- 6.3 Qualification of the Welding Procedure Specification
- 6.3.1 An existing Welding Procedure Qualification Record (WPQR or WPAR) is acceptable if the following conditions are met:
- The test must have been performed in the same environment as proposed for production, using the same welding technique, process, joint configuration and welding equipment (for mechanised welds)
 - The allowable ranges are the same with regard to essential variables.
 - The related Preliminary Welding Procedure Specification (pWPS) has been qualified in accordance with **ISO 15614**
 - The test must have been witnessed by an ITER recognized Independent Inspection Authority. Regarding components to be manufactured with RCC-MR code, the witnessing Independent Inspection Authority is defined at the Register Third Party Inspector Organization (RTPIO) according the RCC-MR.
- 6.3.2 The welder or welding operator who (1) undertakes the welding procedure test satisfactorily in accordance with this section and (2) the relevant testing requirements of this section are met, is considered to be qualified for performing the production welds within the range of approval.
- 6.3.3 The supplier must also demonstrate that the welding equipment and plant use for qualification is properly maintained and calibrated in accordance with the relevant operation and maintenance schedules.
- 6.3.4 The welding and testing of test pieces shall be in accordance with Clauses **7 to 10 below.**

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

7. Test Piece for WPQ

7.1 General

The welded joint to which the welding procedure will relate in production shall be represented by making a standard test piece or pieces, as specified in clauses 7.3 to 7.5 below.

The direction of plate rolling shall be marked on the test piece when impact tests are required to be taken in the Heat Affected Zone (HAZ) and shall be mentioned in the impact test report.

Where the joint requirements and/or dimension of the test piece are not covered by the standard test pieces as shown in this section, the use of **ISO 15613** shall be required.

7.2 Number and type of test pieces

The number of test pieces shall be sufficient to allow all required tests to be carried out. Additional test pieces may be prepared in order to allow for extra testing and/or for re -testing specimens **(clause 11)**.

The number and type of test pieces for welding procedure approval and the tests to be carried out depend on the welding operation to be performed and are determined by:

- the essential variables governing the range of approval of the qualifications
- the working conditions: where access is difficult, this fact must be taken into account in the performance of the welding procedure test and in the conditions applied to the non-destructive examination of the qualification test piece.


7.3 Dimensions

The length of test pieces shall be sufficient to allow all required tests to be carried out. Longer test pieces may be prepared in order to allow for extra testing and/or for re -testing specimens **(clause 11)** .

For all test pieces except branch connections **(see Figure 4)** and T-joints (T-butt weld or fillet weld; see **Figure 3**), the material thickness, t , and the diameter, D , shall be the same for both plates and pipes on the required length of the test piece to be welded.

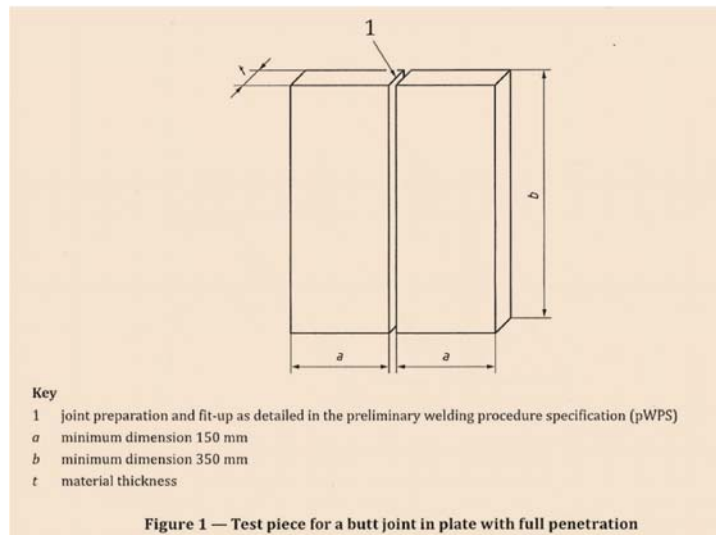
The thickness and/or pipe outside diameter of the test pieces shall be selected in accordance with **clause 8.5**

The dimensions of the qualification coupon shall be determined in accordance with:

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--

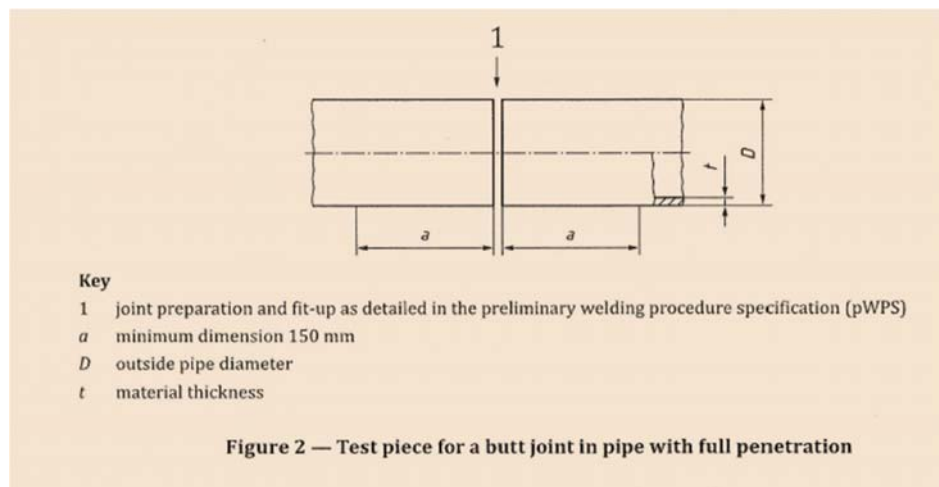
- The welding process
- The plan for the removal of specimens for tests and retests
- The non-destructive examinations to be performed
- If necessary, the qualification of a welding procedure for repairs
- In any event, the width of each part (or of each section of tube) to be welded must not be less than 150 mm or $2t$ (where t is the thickness of the test coupon), whichever is higher.


7.3.1 Butt joint in plate with full penetration



7.3.2 Butt joint in pipe with full penetration

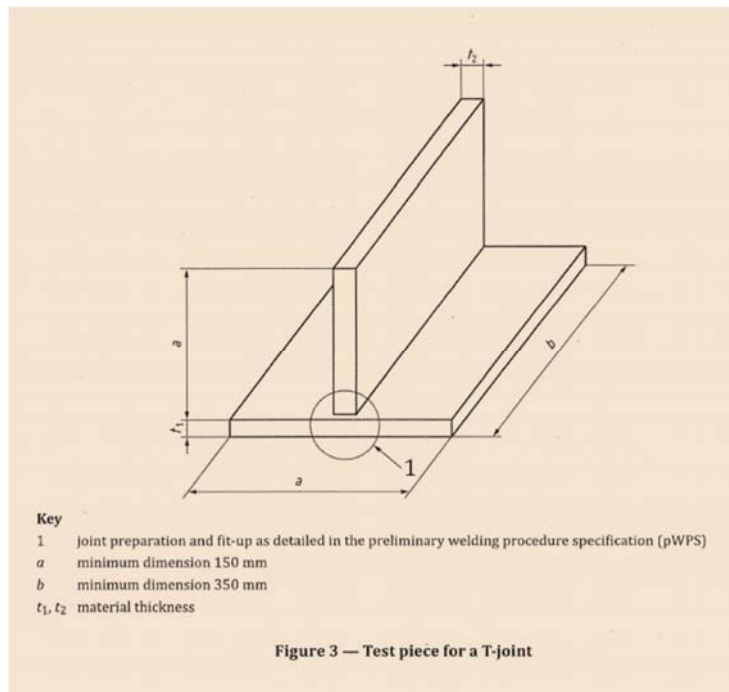
(The word "pipe", alone or in combination, is used to mean "pipe", "tube" or "hollow section" except square or rectangular hollow section.)



	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--

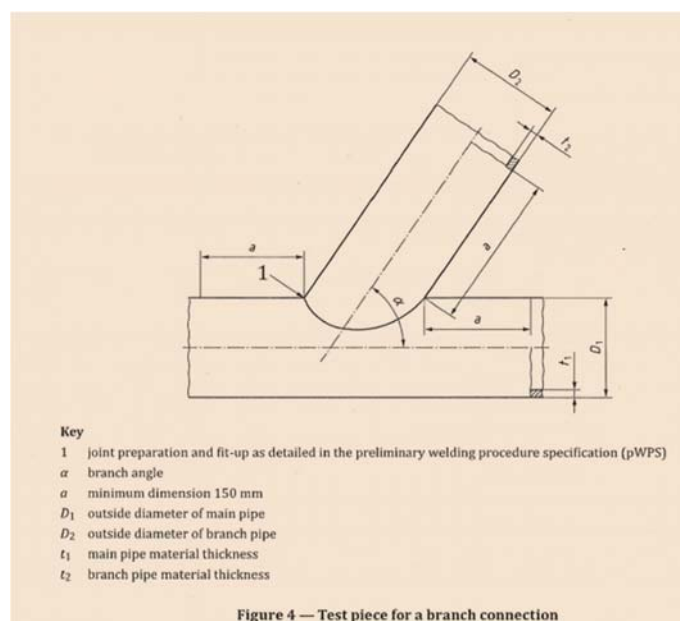
7.3.3 T-joint


(This test piece applies to fully penetrated butt welds or fillet welds).



7.3.4 Branch Connection

(The angle α is the minimum one used in production. This test piece applies to fully penetrated joints (set-on, set-in or set-through joint) and for fillet welds.)



	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB <i>Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)</i>	INDUS Ref No II-HVD69SL-v1.1
---	---	--

7.4 Type of groove

Grooves shall be machined, gouged or ground by the same processes as those used in production (thermal, mechanical, etc.). Where production grooves are to be prepared by oxygen cutting, the requirements of **Annexure-5: Fabrication** shall be met.

The groove shape shall correspond to one of the joints used in fabrication. At the request of the Contractor or Prime Contractor, special alignment methods may be stipulated: the relevant procedure shall be agreed between the parties concerned.

Grooves shall be subjected to the same examinations and tests prior to welding as those required in fabrication (**Annexure-5: Fabrication**). The test piece shall be prepared with clearances and fit-up corresponding to the limit tolerances required in fabrication / Manufacturing drawing.

8. Extent of Approval for WPQR / Range of Qualification

8.1 General

Changes outside of the ranges specified shall require a new welding procedure test.

8.2 Related to manufacturer

The qualification tests shall be performed in the same workshop as the production welds, subject to the provisions of **Annexure 6: Section-4: Technical qualification of production workshops**

8.3 Material Groups

For differing grades of stainless steel (304, 304L, 316, 316L and 316LN-IG), cross qualification can be accepted for manual welds when 316L filler is used. Cross qualification is not acceptable for automatic welds.


8.4 Base Materials

8.4.1 Qualification on production metal type and grade is mandatory. There is no requirement for the use of material from the production heat number for qualification of the WPS.

The base metal shall have undergone an acceptance test to establish the characteristics necessary for the application of this section. The acceptance test reports relating to base materials must be available before the start of welding operations on the test piece. These documents shall be submitted to the inspector at his request.

8.5 Thickness Range

8.5.1 General

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

Limits of qualification of both the parent material and deposited metal shall be as shown in Table 1 and Table 2. The deposited metal limits qualified shall not be exceeded in production welds except that the fillet weld thickness shall not be considered.

Both parts of the parent material to be welded shall be within the limits of thickness qualified, except that for dissimilar thickness parent materials there is no limit on the thickest part provided the qualification was performed on parent material of 30 mm or greater.

For multi-process qualification, the recorded thickness of the deposited metal of each process shall be used as a basis for the range of qualification for the individual welding process.

It is not intended that deposited metal thickness or base metal thickness or outside pipe diameters should be measured precisely, but rather the general philosophy behind the values given in **Table 1, Table 2 and Table 3** should be applied.


8.5.2 Thickness Range for Welds Excluding Fillet and Branch

The qualification of a welding procedure test on thickness 't' shall include qualification for thickness in the ranges given in the following **Table 1:**

Table-1: Thickness range of welds (excluding fillet and branch)

Thickness of test piece 't' (mm) (where 't' is the thickness of the thinner material)	Range of Approval ^{1,2} (Dimensions in mm)		
	Parent material thickness		Deposited weld metal thickness for each process 's'
	For single run or single run from both sides	Multi-run	
$t \leq 3$	0.5 t to 2 t		Max. 2 s
$3 < t \leq 12$	0.5 t (3 min) to 1.3 t	3 to 2 t	Max. 2 s
$12 < t \leq 20$	0.5 t to 1.1 t	0.5 t to 2 t	Max. 2 s
$20 < t \leq 40$	0.5 t to 1.1 t	0.5 t to 2 t	Max. 2 s when $s < 20$ Max. 2 t when $s \geq 20$
$40 < t \leq 100$		0.5 t to 2 t	Max. 2 s when $s < 20$ Max. 200 when $s \geq 20$
$100 < t \leq 150$		50 to 2 t	Max. 2 s when $s < 20$ Max. 300 when $s \geq 20$
$t > 150$		50 to 2 t	Max. 2 s when $s < 20$ Max. 1.33 t when $s \geq 20$
1 - When impact requirements are specified but impact tests have not been performed, the maximum thickness of qualification is limited to 12 mm. 2 - The range of approval may have to be reduced in order to avoid hydrogen cracking.			

Table 6-2 Range of Approval for material thickness and weld deposit thickness– all welds

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--

8.5.3 Thickness Range for Fillet Welds

The qualification of a welding procedure test on thickness t shall include qualification for thickness in the ranges given in the following **Table-2**.

Table-2: Thickness Range for Filler Welds

Thickness of test piece 't' (mm)	Range of approval (Dimensions in mm)		
	Material thickness	Throat thickness	
		Single run	Multi-run
$t \leq 3$	0.7t to 2 t	0.75 a to 1.5 a	No restriction
$3 < t < 30$	3 to 2 t	0.75 a to 1.5 a	No restriction
$t \geq 30$	≥ 5	†	No restriction

Note 1: a is the throat thickness of the test piece
Note 2: Fillet welds cannot be qualified by Butt welds
† For special applications only. Each throat thickness has to be proofed separately by a welding procedure test

Table 6-3 Range of qualification for material thickness and throat thickness of fillet welds

The extension of the range of approval (mentioned in above table) for weld throat thicknesses greater than 10 mm is not authorized for welding of Austenitic Stainless steel.

In case of different material thicknesses, the range of qualification of both thicknesses of the test pieces shall be calculated separately.

8.5.4 Thickness Range for Branch Pipes (Diameter Range)

The qualification of a welding procedure test on diameter D shall include qualification for diameters in the following ranges give in following **Table-3**.

Table-3: Thickness Range for Branch Pipes (Diameter Range)

Diameter of test piece $D^{1,2}$ (in mm)	Range of approval
$D \leq 25$	0.5 D to 2 D
$D > 25$	$\geq 0.5 D$ up to plates (25 mm min)


1) D is the outside diameter of the pipe or the outside diameter of the set-on branch pipe
2) Approval given for plates also covers pipes when outside diameter is > 500 mm

Table 6-4 Range of approval for pipe and branch connections

8.5.5 Angle of Branch connection

A welding procedure test shall be carried out on a branch connection with angle α (see **Figure 4**).

A test piece made with a branch angle, α between 60° and 90° in the procedure test qualifies the angle $60^\circ \leq \alpha < 90^\circ$.

	<p>Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB</p> <p>Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)</p>	<p>INDUS Ref No II-HVD69SL-v1.1</p>
---	--	--

An angle $\alpha < 60^\circ$ requires a separate test piece and qualifies for angles from α up to 90° .

8.6 Range of Approval for type of joint

Table-4: Range of Approval of Welded Joints

Type of Joint in Approval Test Piece			Range of Approval												
			Butt welds on plate				T Butt welds on plate		Fillet weld on plate	Butt welds on pipe		Fillet weld on pipe	Branch welds on pipe		
			Welded from one side		Welded from both sides		Welded from one side	Welded from both sides		Welded from one side			Set on	Set through	
			With backing	No backing	With gouging	No gouging				With backing	No backing				
Butt weld on plate	Welded from one side	With Backing	✓	✗	Δ	Δ	✗	✗	✗	✗	✗	✗	✗	✗	✗
		No Backing	Δ	✓	Δ	Δ	✗	✗	✗	✗	✗	✗	✗	✗	
	Welded from both sides	With gouging	✗	✗	✓	Δ	✗	✗	✗	✗	✗	✗	✗	✗	✗
		No gouging	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗
Butt weld on pipe	Welded from one side	With backing	Δ	✗	Δ	Δ	✗	Δ	✗	✓	✗	✗	✗	✗	✗
		No backing	Δ	Δ	Δ	Δ	Δ	Δ	✗	Δ	✓	✗	✗	✗	✗
T Butt weld on plate	Welded from one side		✗	✗	✗	✗	Δ	Δ	✗	✗	✗	✗	✗	✗	✗
	Welded from both sides		✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗
Fillet weld	Plate		✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗
	Pipe		✗	✗	✗	✗	✗	✗	Δ	✗	✗	✓	✗	✗	✗
Branch weld in pipe	Set on		✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗
	Set through		✗	✗	✗	✗	✗	✗	✗	✗	✗	✗		✓	✗
Key: ✓ Indicates the weld for which the WPS is approved in the approval test Δ Indicates those welds for which the WPS is also approved ✗ Indicates those welds for which the WPS is not approved															

Key:
 ✓ Indicates the weld for which the WPS is approved in the approval test
 Δ Indicates those welds for which the WPS is also approved
 ✗ Indicates those welds for which the WPS is not approved

Table 6-5 Range of approval for type of joint

8.7 Range of Approval Welding Consumables

8.7.1 Related to qualification and acceptance tests for welding consumable

The filler metal used for the qualification test piece shall comply with the procurement specifications for products intended for the production welds covered by the qualification.


The filler material shall have undergone an acceptance test to establish the characteristics necessary for the application of this section.

The acceptance test reports and qualification data sheet issued by the product Supplier relating to these materials (base metal and filler materials) must be available before the start of welding operations on the test piece. The same applies to the welding filler material qualification data sheet issued by the product Supplier. These documents shall be submitted to the Inspector at his request.

8.7.2 Related to chemical composition and batch

All consumables shall be certified to a standard acceptable to the ITER IO (e.g. ISO 14344) and Annexure 6: Section 1: Acceptance of Filler material,

In the case of manual welding processes, the approval range of filler materials covers other filler metals as long as they are in the same range and chemical composition.

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--

In the case of automatic and semi-automatic welding processes the welding consumables used for qualification shall be the same batch as those used for production welds. Following any change during production, weld samples shall be welded and examined prior to the continuation of production with the new batch of consumables.

8.7.3 Related to type of welding

Qualification using filler does not qualify autogenous (fusion welding without filler material) welds or vice versa.

8.7.4 Related to Grade

It shall have the same geometric properties and be of the same grade (as specified in the acceptance specification).

The welding procedure is only approved for the use of covered electrodes, flux or flux cored wires of the same coding, and for filler metal (wire, rod, etc) of the same grade (i.e. procurement specification) as that used for the qualification test piece.

However, a new qualification is not required where use is made of another filler material with the same symbol (all types of flux, flux-core for wires or electrode covering) and conforming to the same procurement specification, provided that this has been qualified in accordance with the provisions of **RS 5000**.

8.7.5 Related to trade name of manufacturer


The range of validity is restricted to the manufacturer trade name of the filler material used in the procedure test.

8.7.6 Related to geometrical characteristics

The welding procedure is only approved for the use of filler materials with exactly the same geometrical characteristics as the materials used for the qualification test piece. However, this rule does not apply to processes 111 (manual shielded metal arc welding) and 114 (self-protecting flux cored wire welding) for which the qualification is made for the filler material of diameter immediately lower or greater, for each pass, except for the root pass performed without backing strip in one sided welded joint, for which no change in diameter is allowed. Furthermore, these processes 111 and 114 are subject to the special requirements in clause 8.18.

8.8 Welding Processes

In all cases, any change in the welding process will require a requalification of the process. In addition, in the case of automatic welding any change to the welding equipment will require requalification.

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--

Qualification of a multi-pass welding procedure does not qualify the single-pass welding procedure and vice-versa.

Each degree of mechanization shall be qualified independently (manual, partly mechanized, fully mechanized and automatic).

When the test piece is welded with more than one welding process, the procedure is valid only for the sequence of processes used on the test piece. Test specimens shall include deposited material from each welding process used.

8.9 Welding Position

Welds for qualification shall be done in local conditions similar to the local conditions where the production weld will be made. Local access to the test piece (in terms of welder access) and the orientation of the test piece (relative to the welder) shall be similar to those for the production weld for which they qualify.

The basic welding positions are defined in standard **NF EN ISO 6947**.

8.10 Welding conditions and type of current

The welding qualification is limited to the following:

- The ranges of the electrical parameters: I (amp) in all cases, U (volts) automatic welding only
- The range of welding speeds, v (automatic welding only) defined in the p-WPS (preliminary Welding Procedure Description).

The current generators used must be of the same type (DC, AC, or pulsed arc) as those used in production and have similar static characteristics (inclined, vertical, horizontal etc).

Polarity must be same as that of production.

Where automatic welding machines are used, the same trademark and type of machines as used during manufacture shall be used.


In the course of the qualification test, periodic measurements shall be made of:

- parameters V, I and v (v = speed) for automatic processes only,
- parameter I for semi-automatic or manual processes.

Where an automatic welding machine is used, V and I shall be measured continuously.

It should be noted that the Inspector or Surveillance agent for the qualification test may stipulate the values of these parameters for the execution of the coupon within the limits stated in the documents describing the welding procedure and in accordance with the position of the weld to be used for the qualification.

8.11 Heat input (arc energy)

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--

Arc energy and heat input are measures of the heat generated by the arc. The heat input can be replaced by arc energy (J/mm). The arc energy shall be calculated in accordance with **ISO/TR 18491**. When using the calculation for the heat input, the k-factor according to **ISO/TR 17671-1** shall be considered. The kind of calculation, either heat input or arc energy, shall be documented.

Range of heat input is +/- 25% of that used in the test piece. If welding procedure test has been performed at both a high and a low heat input level, then all intermediate heat input levels are also qualified. It is not necessary to calculate every run.

For covered electrode, the heat input average shall be calculated for each used diameter in order to define the qualified heat input.

For process 111, the heat input may also be measured by the run out length per unit length of electrode.

When the welding time is too short and when the length of the weld is not significant (e.g. for small repair, for tack welds), the heat input need not to be verified; only the adjustable parameters should be checked like amperage and/or voltage.

8.12 Preheating temperature

Throughout the qualification, the preheating temperature on each pass must be maintained atleast equal to the specified minimum value as per p-WPS (preliminary Welding Procedure Specification).

Decrease of preheat temperature from the recorded preheating temperature on the WPQR requires a re-qualification.

Where a gas shield is used, the introduction of preheating at above 50°C into a welding procedure for which it was not specified is prohibited.

8.13 Interpass temperature


Throughout the qualification, the maximum interpass temperature must be equal to value as per p-WPS.

Increase of interpass temperature from the interpass temperature reached on the WPQR shall require re-qualification.

This limitation does not apply when a WPS qualified when an austenitic material is solution annealed after welding.

8.14 Postheating

After completing half the joint, a welding sequence at a higher temperature may be performed, in order to reach and measure the nominal interpass temperature.

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

The postheating temperature shall be as specified in the p-WPS. Any reduction of the specified minimum duration or temperature of postheating treatment is prohibited.

8.15 Post weld heat treatment

Addition or deletion of post-weld heat-treatment is not permitted.

The tests piece shall be subjected to the same thermal cycles as those corresponding to the heat treatments performed on production joints.

Qualification of the welding procedure is invalidated if there is any modification of the temperature cycles for heat treatment performed after welding.

8.16 Welding technique

Changes invalidating approval of the welding procedure:

- Change from a narrow-run to a wide-run deposit (oscillation more than 3 times the diameter of the core wire),
- Change from a spray, droplet or pulsed arc to a short-circuit arc, or vice-versa,
- Modification of the width, frequency or dwell time of oscillation,
- Change in the trade designation of the welding automation equipment,
- Reduction, during manufacture, by 10% or more of the front shield gas flow in relation to the minimum specified value,
- Change in the root shield: method used (global or local),
- Change from a single-electrode to a multiple-electrode process and vice-versa.

8.17 Baking Gas

A butt weld procedure test made without backing gas qualifies a welding procedure with group I, N1, N2 and N3 backing gas according to **ISO 14175**, but not vice versa.

Main group of backing gas covers all sub-groups of the same main group (classification according to **ISO 14175**).


A change between group I, N and R backing gas does not require re-qualification.

8.18 Process specific additional rules:

8.18.1 Processes 111 (manual shielded metal arc welding) and 114 (self-protecting flux cored wire welding)

The equivalence covered by **Clause 8.7** above is only permissible if the current ranges used in production are those defined in the qualification certificate or the qualification technical data sheet as required by **RS 5000**.

Where these ranges are not complied with for a diameter, the welding procedure qualification shall include this diameter and no equivalence shall be considered.

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

8.18.2 Process 15 (plasma arc welding)

The welding procedure is qualified only for the ranges specified in the p-WPS (preliminary Welding Procedure Specification) for the distance between the edges to be welded.

Qualification of the welding procedure is restricted to the nominal composition of plasma gas used in the welding procedure test.

The qualification is restricted to nominal composition of the shielding gas used in the procedure test.

Welding with filler material does not qualify for welding without filler material or vice versa.

A change in the type of joint preparation (groove) requires a re-qualification.

8.18.3 Process 12 (Submerged arc welding)

Each variant of process 12 (121 to 126) shall be qualified independently. Any change in the number of electrodes requires re-qualification. Any addition or deletion of wires (cold wire or hot wire) shall require re-qualification. Also, a change of more than ± 10 % of the ratio of the supplementary filler material to the electrode requires re-qualification.

The qualification of the welding procedure test is restricted to manufacturer, trade name and designation of the flux used in the test.

When flux from re-crushed slag is used, each batch or blend requires a new qualification test.

8.18.4 Process 13 (Gas shielded metal arc welding)

- Shielding gases:


The qualification is restricted to nominal composition of the shielding gas used in the procedure test. The designation of **ISO 14175** may be used to specify the shielding gas composition, e.g. **ISO 14175:2008-M21-ArC-18**.

A deviation of max. ± 20 % (relative) of the nominal composition of the CO₂ content is allowed.

However, an intentional addition or deletion of maximum 0,1 % of any gas component does not require a new welding procedure test.

- Process variants:

The qualification given is restricted to the wire system used in the welding procedure test (e.g. single-wire or multiple-wire system).

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--

- Transfer mode
 - General

For solid and metal cored wires, the qualification using short circuiting transfer qualifies only short circuiting transfer.

Qualification using spray, pulse or globular transfer qualifies spray, pulse and globular transfer.
 - Waveform controlled welding

When a power source with waveform control (see ISO/TR 18491) is used, the power source manufacturer and waveform control mode shall be recorded on the WPQR including all other pertinent information.

Change from one manufacturer to another manufacturer of the power source or a change in the waveform control mode requires a new qualification test.
 - Welding with pulsed mode (without waveform control)

When a power source with pulsed mode is used, the identification of the power source manufacturer shall be recorded on the WPQR including all pertinent information.

Change from one manufacturer to another manufacturer of the power source does not require a new qualification test.
 - Welding without pulsed-mode and without waveform control

When the power source used to qualify a WPQR has been used without waveform control, an identification of the power source manufacturer is required.

Change from one manufacturer to another manufacturer of the power source does not require a new qualification test.


8.18.5 Process 14 (Gas-shielded arc welding with non-consumable electrode)

- Shielding gases

The qualification is restricted to nominal composition of the shielding gas used in the procedure test. The designation of ISO 14175 may be used to specify the shielding gas composition, e.g. ISO 14175:2008-13- . ArHe-30.

A deviation of max. ± 10 % (relative) of the nominal composition of the helium content is allowed.

However, an intentional addition or deletion of maximum 0,1 % of any gas component does not require a new welding procedure test.

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

- Filler material

Welding with filler material does not qualify for welding without filler material or vice versa.

9. Non –Destructive Examination

9.1 The qualification coupon shall be subjected to all the non-destructive examinations specified for the manufacture of the joints qualified by it and the coupon shall also comply with the specification requirements.

9.2 All non-destructive testing in accordance with following clauses of the section shall be carried out and accepted on the test pieces prior to cutting of the test specimens. The discard (see Figure 5 and Figure 7) shall not be considered for NDE. Any post-weld heat treatment (PWHT) that is specified shall be completed prior to nondestructive testing.


9.3 Supplier's inspectors shall be competent in accordance with ISO 9712.

9.4 Examination

9.4.1 After post weld heat treatment (if applicable) and prior to destructive testing, test pieces shall be examined by the following Table-5:

Table-5: Type and extent of NDE

Test Piece	Type of Test	Extent of Testing	Applicable standard
1. Butt Joint with full penetration (Pipe and Plate)	Visual Examination	100%	ISO 17637
	Surface Crack Detection on the accessible weld surfaces (Penetrant testing*) Refer Clause 4 of Annexure 5 for the requirements related to LDP.	100%	ISO 3452
2. T-Joint with full penetration			
3. Branch connection with full penetration	Radiographic examination	100%	ISO 17636
	OR Ultrasonic examination		ISO 17640 and ISO 22825
4. T-joint Fillet weld	Visual Examination	100%	ISO 17637
5. Branch connection Fillet weld	Surface Crack Detection on the accessible weld surfaces (Penetrant testing*)	100%	ISO 3452
*Inspection using Photothermal camera is permitted in the case where the manufacturer has qualified the method/acceptance criteria prior to the weld qualification			

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB <i>Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)</i>	INDUS Ref No II-HVD69SL-v1.1
---	---	--

9.4.2 For a pipe or plate of 2 mm (or less) wall thickness, the method of examination shall be agreed prior to examination.

9.5 Acceptance Criteria

Defects which are detected by the relevant non-destructive examination method shall be assessed in accordance with ISO 5817 level B. In particular acceptance criteria are detailed in **Table 6 below. Table 6** is in accordance with **ISO 5817** however contains additional requirements for production vacuum boundary welds.



	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

Table-6: Requirements for the acceptance criteria for NDE

	Defect Type	Permitted maximum
Planar Defects	Cracks or lamellar tears Lack of root fusion Lack of side fusion Lack of inter-run fusion Lack of root penetration	Not permitted
	Slag inclusions - individual	20% of t or 2 mm, which ever is smaller
	Slag inclusions - Group	Aggregate length not to exceed t in a length of 12 t, except when the distance between successive indications exceeds 6L where L is the longest indication in the group
	Inclusions – Tungsten or Copper	Not permitted
	Isolated pores - round	Diameter <20% t or 2 mm, whichever is smaller
Cavities	Gas pore uniformly distributed porosity	1% for single layer (2% for multi-layer) by area where the area of the radiograph to be considered is the length of the weld affected by the porosity times the maximum thickness of the weld
	Elongated pores - wormholes	Not permitted
	Linear Porosity	Not permitted
	Under cut	Some intermittent undercut permitted. Depth not to exceed 0.5 mm for t > 3 mm or 10% for t < 3 mm. Under cut to blend smoothly with the parent material.
Profile defects	Incompletely filled groove, sagging. Root concavity, shrinkage groove	0.05 t or 0.5 mm, which ever is smaller. Weld thickness shall not be less than the parent plate thickness
	Excess penetration - pipe	Not greater than 5% of the pipe internal diameter up to 2 mm max.
	Excess penetration – plate	t = 0.5 to 3 mm: , h ≤ 1 mm+10% b t > 3mm: h ≤ 1 mm+20% b max 3mm.
		h=height of excess penetration on backside of plate and b the width
	Excess weld material	Not greater than 10% weld width
	Misalignment	Not greater than 10% of the parent material thickness
	Fillet leg length (asymmetry)	Unequal leg length should not exceed 20% of the fillet throat thickness
	Burn through	Not permitted
Other	Root oxidation	Not permitted where a backing purge gas is specified in the WPS

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--


- 9.6 Anti-counterfeit measures to be put in place following NF A09-283 “Non-destructive testing - Traceability and securing of radiographic testing” to ensure full reliability of controls. Refer: Template_Traceability of radiographic control _Supervision_Observation_Report
- 9.7 The results from all these tests shall be included in Manufacturer’s Construction Records. All Radiographic testing records shall be digitalized with a quality allowing full exploitation of the test result as the original (e.g. standard NF_EN_14096-1, Non-destructive testing - Qualification of the radiographic films digitalization systems)

10. Destructive Tests

10.1 Tests to be carried out

Table-7: Destructive Tests

Test Piece	Type of Test	No. of tests	Applicable standard
1. Butt Joint with full penetration (Pipe and Plate)	Longitudinal Tensile test (if applicable)	See Clause 10.3 below	
	Transverse Tensile test	See Clause 10.4 below	
	Transverse bend test	See Clause 10.5 below	
	Impact Test	See Clause 10.6 below	
	Hardness test	1	
	Macroscopic Examination	1	10.8
	Microscopic examination	1	10.8
	Ferrite contents	1	10.10
2. T-Joint with full penetration	Hardness test	2	10.9
	Macroscopic Examination with photos	4	10.8
3. Branch connection with full penetration	Microscopic Examination at 200X with photos	2	10.8
4. T-joint Fillet weld	Hardness test	2	10.9
5. Branch connection Fillet weld	Macroscopic Examination with photos	4	10.8
	Microscopic Examination at 200X with photos	2	10.8
	Fracture test	1	
*Inspection using Photothermal camera is permitted in the case where the manufacturer has qualified the method/acceptance criteria prior to the weld qualification			

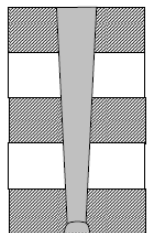
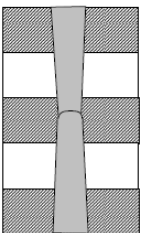
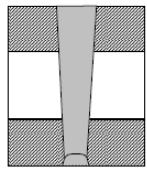
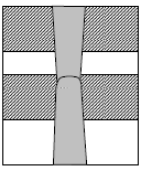
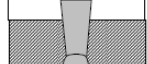
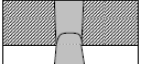
	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

10.2 Location and taking of test specimen

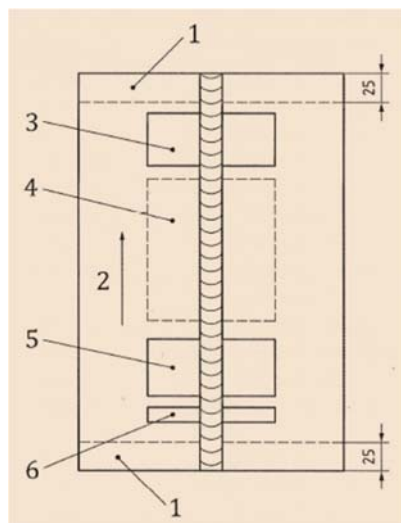
10.2.1 Test specimen sampling areas and positioning in the thickness for butt welds of plate and pipe shall be as per Table 8 below.

Table-8: Location of taking of test specimen

Table RS3231.21c : test specimen sampling areas, positioning in the thickness

Welding of one side only	Sampling area		Welding of both sides
$t > 100 \text{ mm}$ 	P R	P R A	$t > 200 \text{ mm}$ 
$30 < t \leq 100 \text{ mm}$ 	P R	P R	$30 < t \leq 200 \text{ mm}$ 
$t \leq 30 \text{ mm}$ 	P	P	$t \leq 30 \text{ mm}$ 
t : thickness of qualification test piece the sampling areas (P on the skin, R at the root, A additional) are not localized in the same section and shall be distributed to comply with positioning specified in figures 5 and 6 of standard NF EN ISO 15614-1			


The sampling areas (P on the skin, R at the root, A additional) are not localized in the same section and shall be distributed as follows (Figure 5 for plate and Figure 6 for pipe):



Key

- 1 discard 25 mm
 - 2 welding direction
 - 3 area for:
 - 1 tensile test specimen
 - bend test specimens
 - 4 area for:
 - impact and additional test specimens if required
 - 5 area for:
 - 1 tensile test specimen
 - bend test specimens
 - 6 area for:
 - 1 macro test specimen
 - 1 hardness test specimen
- NOTE: Not to scale.

Figure-5: Location of test specimen for a butt joint in plate

	<p>Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB</p> <p>Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)</p>	<p>INDUS Ref No II-HVD69SL-v1.1</p>
---	--	--

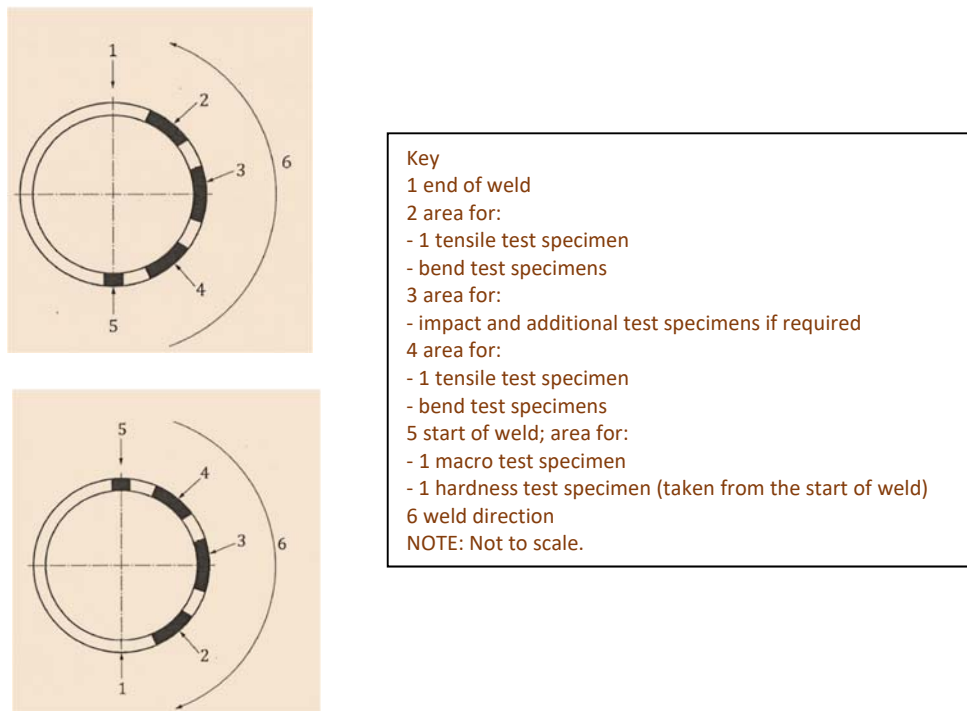


Figure-6: Location of test specimen for a butt joint in pipe

10.2.2 Location of test specimens in a T-joint

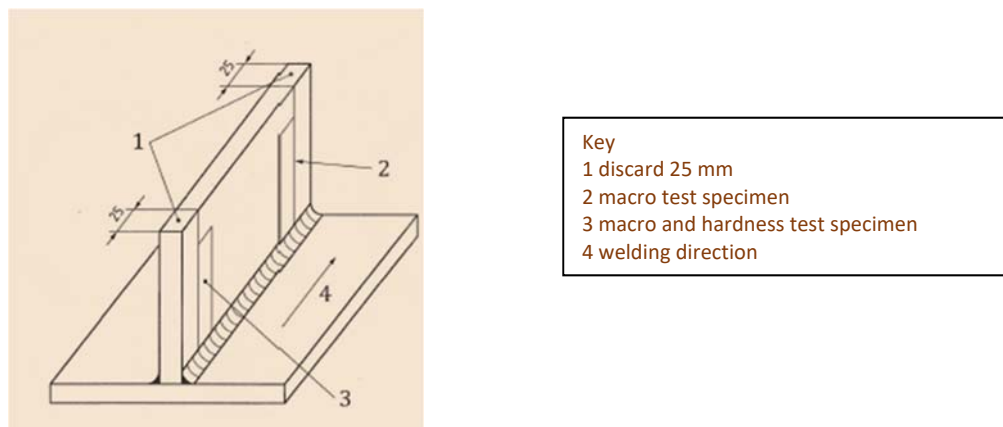



Figure-7: Location of test specimens in T-joint

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--

10.2.3 Location of test specimens for a branch connection on pipe

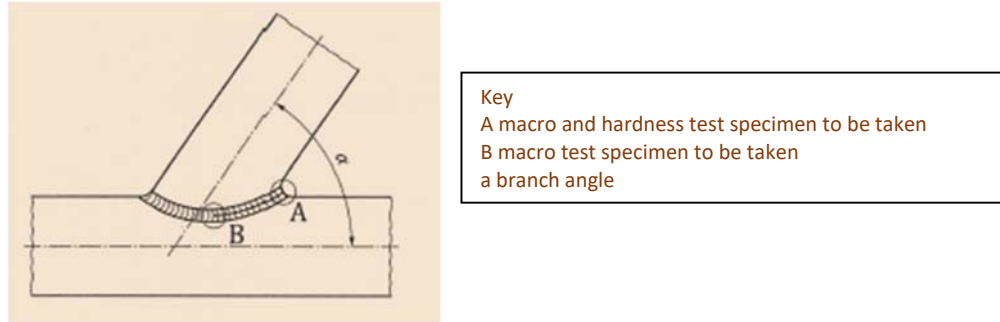



Figure-5: Location of test specimen for a branch connection on pipe

10.2.3 It is acceptable to take the test specimens from locations avoiding areas which have imperfections within the acceptance limits for the NDT method(s) used.

10.3 Longitudinal Tensile Test (if $t \geq 15\text{mm}$) on Deposited weld metal

Temperature	Room			200 Deg C
Procedure	RS1.0120			RS1.0120
Measurement	Rm, Rp0.2, A%, Z			Rp0.2 and for information Rm, A%, Z
Sampling conditions	RS1.0121			RS1.0121
Area (Table 8)	P*	R*	A*	P*
Number of test	1	1	1	1
Acceptance criteria	The tensile strength and the yield strength shall be at least equal to those specified for the base metal. Where base metals are joined for which different minimum values are specified for these two characteristics, the values to be guaranteed shall be the lower of the two for each of the characteristics.			
	The tensile strength of the deposited metal shall not exceed 800 MPa. Elongation shall be at least 25% and the reduction in area shall be recorded for information. If in the case of tubular butt-welded qualification coupons the fracture occurs outside the middle third with an unsatisfactory value, a retest may be performed at the 12 o'clock position on a test specimen prepared in accordance with the requirements of annex E of standard NF EN 10002-1. This retest shall give a value greater than or equal to 25%.			


	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

*The sampling areas (P, R, A) are not localized in the same section and shall be distributed to comply with positioning specified in figures 5 and 6.

10.4 Transverse Tensile test


Temperature	Room	200		
Procedure	RS 1.0110			
Measurement	Rm + Location of the break			
Sampling conditions	RS 1.0111 ISO 4136			
Area (Table 8)	P	R	P	R
Number of test	1#	1	1	1
Acceptance Criteria	<p>The tensile strength and the yield strength shall be at least equal to those specified for the base metal, unless otherwise specified prior to the testing.</p> <p>Where base metals are joined for which different minimum values are specified for these two characteristics, the values to be guaranteed shall be the lower of the two for each of the characteristics.</p>			
Additional Note	<p>The test shall represent the whole thickness except as necessary to obtain parallel sides on the specimens.</p> <p>Tensile testing shall ensure all welding processes used and the associated essential variables are tested.</p> <p>It is not essential to overlap the specimens as identified in ISO 4136.--> to be checked.</p> <p>For pipes >50 mm outside diameter, the excess weld metal shall be removed on both faces to give the test specimen a thickness equal to the wall thickness of the pipe.</p> <p>For pipes ≤50 mm outside diameter, for which the transverse tensile test is performed on the full pipe, the excess weld metal may be left undressed on the inside surface of the pipe.</p>			

#for thickness less than 30 mm, 2 test specimens shall be sampled, each covering the entire thickness

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

10.5 Bend Test

	Root Bend	Face Bend	Side Bend (if thickness >20mm)
Temperature	Room		
Procedure	RS 1.0220 ISO 5173:2002		RS 1.0220 ISO 5173:2002
Measurement	Ductility (Qualitative assessment)		Ductility (Qualitative assessment)
Sampling conditions	RS 1.0211		RS 1.0213
Area (Table 8)	Internal Skin	External Skin	Through Thickness
Number of test	2	2	2
Bend angle and Former diameter	The bend angle shall be 180° round a former of diameter 2t, where t is the thickness of the specimen.		
Acceptance Criteria	<p>The bend test specimen shall have no open defects exceeding 2 mm measured in any direction on the convex surface after bending.</p> <p>Defects located in the angles of the test specimen shall be taken into consideration.</p> <p>If localized decohesions occur, the method described in RS1.0240 shall be used to identify its origin. If the results obtained using this method demonstrate that the metal's deformation capacity has been exceeded in a localized area, these results shall be deemed acceptable.</p> <p>Imperfections appearing at the corners of a test specimen during testing shall be ignored in the evaluation.</p>		


	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	---	--

10.6 KV Impact Test (if $t \geq 12\text{mm}$)

	Weld			HAZ		Base Metal	
Temperature	Room			Room		Room	
Procedure	RS 1.0310 ISO 9016			RS 1.0320		???	
Measurement	Energy			Energy		Energy	
Sampling conditions	RS 1.0310			RS 1.0320 (notch on the fusion line)		???	
Area (Table 8)	P	R	A	P	A	P	A
Number of test	3	R	A	3	3	3	3
Acceptance Criteria	The results of each series of tests (3 test specimens) in the weld metal and the HAZ shall satisfy the following requirements at room temperature: KV: 60 J minimum individual value, this value can be reduced to 50 J for welding steels in group 8 subjected to stress relieving heat treatment.						
Additional Note	<p>The striker radius of 2 mm according to ISO 148-1 shall be used, unless otherwise specified.</p> <p>For weld metal, test specimen type VWT (V: Charpy V-notch - W: notch in weld metal - T: notch through the thickness)</p> <p>For HAZ specimen type VHT (V: Charpy V-notch - H: notch in heat affected zone - T: notch through the thickness) shall be used.</p> <p>Specimens shall be sampled from a maximum of 2 mm below the upper surface of the parent metal and transverse to the weld.</p> <p>In the HAZ, the mid-point of the notch shall be at 1 mm to 2 mm from the fusion line. In the weld metal, the mid-point of the notch shall be at the weld centreline.</p> <p>For butt joints where the material thickness is $t > 50\text{ mm}$, two additional sets of specimens shall be taken from the root area, one set taken in the weld and one set taken from the HAZ.</p> <p>Where more than one welding process or type of covering and fluxes are qualified in a single test piece, additional impact test specimens shall be taken from the weld metal and HAZ that include each process and type of covering and fluxes.</p>						

10.7 Chemical analysis

A sample for chemical analysis shall be taken in a zone outside the dilution area. In addition, chemical analysis shall be performed for each process used in combination, except for TIG root passes.

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

If the thickness of the test piece makes it impossible to perform analysis in a zone outside the dilution area, the analysis shall be performed on the surface of a separate deposit of sufficient thickness.

Where a longitudinal tensile test is required the sample shall be taken from the end extension of a tensile specimen chosen so as not to lie within the dilution zone.

The quantities of all elements analyzed during acceptance tests of filler materials shall be determined.

The required results are those defined in the acceptance specification (RS 2120).

10.8 Metallographic examination

These are performed in accordance with Annex RSI 400 on a complete transverse section of the weld.

In the case of pipe welds, the section examined shall preferably lie in the overlap zone.

In addition, the micrographic and macrographic criteria specified in RSI 400 shall be satisfied.

The test specimen shall be prepared and etched in accordance with ISO 17639 on one side to clearly reveal the fusion line, the HAZ and the build-up of the runs.

The test specimen shall include unaffected parent metal and shall be recorded by at least one photograph of macro cross-section per procedure test.

The acceptance levels shall be in accordance with Table-6.

10.9 hardness measurement

Vickers hardness testing with a load of HV 10 shall be performed in accordance with ISO 9015-1.


Hardness measurements shall be taken in the weld, the heat affected zones and the parent metal in order to evaluate the range of hardness values across the welded joint.

For double sided welds, one additional row of indentations shall be made through the root area.

Examples of typical indentation patterns are given in ISO 9015-1.

Where more than one welding process is used, each welding process has to be measured by at least one row of indentation.

For each row of indentation at least three individual indentations shall be made in each of the following areas:

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

- The weld
- Both heat affected zones
- Both parent metals

For the HAZ, the first indentation shall be placed as close to the fusion line as possible.

The results from the hardness test shall be reported for information.

10.10 Determination of the delta ferrite content

The delta ferrite content of the deposited metal, as determined using Delong ou Mc Kay's modified Schaeffler diagram (**Clause 5 of Section 1 of Annexure 6**), shall lie between 5% and 15% (preferably not exceeding 12% max.)

In case of doubt, an additional test may be performed by a magnetic saturation method or direct magnetic measurement (the apparatus having been calibrated beforehand).

11. Retesting procedures

Where an unsatisfactory result is due to the poor execution of the test the relevant result must be disregarded and the test shall be repeated.

12. Validity of the qualification

The welding procedure qualification is valid for an unlimited time on condition that it is not invalidated by the requirements of Clause 9 and 12 of Section 5 of Annexure 6.


However, for welds that are thought to be particularly difficult to perform or that are of major importance, ITER-India / IO may stipulate that the skill level demonstration to be provided in accordance with the requirements defined in Section 4 of Annexure 6 should refer to comparable production weld procedures that are not more than three years old.

13. WPQR for Repair by welding of the production welds

- 13.1 The welding procedures used for repairs shall be qualified in accordance with **Clause 10.**
- 13.2 The weld repairs must be simulated on the welding procedure qualification test piece.
- 13.3 Qualification shall be required for each procedure in making the repair.
- 13.4 Full series of tests required for original welding qualification shall be performed for the repair weld procedure qualification.

14. WPQR Reports

The WPQR is a statement of the results of assessing each test piece including re-tests.


	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB <i>Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)</i>	INDUS Ref No II-HVD69SL-v1.1
---	--	--

The relevant items listed for the WPS in the relevant part of **ISO 15609** shall be included, together with details of any features that would be rejectable by the requirements of this section. If no rejectable features or unacceptable test results are found, a WPQR detailing the welding procedure test piece results is qualified and shall be signed and dated by the examiner or the examining body.

The results of welding procedure qualification tests shall be made available to the Inspector and shall be submitted to him at his request. The results shall be contained in a report which shall describe:

- The essential conditions (both specified and actual) governing the execution of weld on the test piece
- The non-destructive examinations performed and the results obtained
- The destructive tests carried out, together with the required values and the results obtained
- The base metal and filler materials material certificates / acceptance reports
- The report must contain the conclusions of the workshop Inspector / examiner.

A WPQR format **(Clause 15 of this section)** shall be used to record details, range of qualification and level for the welding procedure and the test results, in order to facilitate uniform presentation and assessment of the data.

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB <i>Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)</i>	INDUS Ref No II-HVD69SL-v1.1
---	---	--

15. WPQR Format

ISO 15614-1:2017(E)

Annex B (informative)

Welding procedure qualification record form (WPQR)

Welding procedure qualification — Test certificate

Manufacturer's WPQR no.:

Examiner or examining body:

Manufacturer:


Reference no.:

Address:

Code/testing standard:

Level:

Date of welding:

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

ISO 15614-1:2017(E)**Test piece****Range of qualification**

Product form:

Welding process(es):

	Welding processes used		
	No. 1	No. 2	No. 3
Process			
Deposited metal thickness (mm):			

Type of joint and weld:

Parent material group(s) and sub-group(s):

Parent material thickness (mm):

Throat thickness (mm):

Single layer/multi-run:

Outside pipe diameter (mm):

Filler material designation:

Filler material make:

Filler material size:

Designation of shielding gas/flux:

Designation of backing gas:

Type of welding current and polarity:

Transfer mode:

Heat input:

Welding positions:

Preheat temperature:

Interpass temperature:

Post-heating:

Post-weld heat-treatment:

Other information (see also 8.5):


We confirm that the statements in this record are correct and that the test pieces were prepared, welded, tested and have fulfilled the requirements in accordance with ISO 15614-1.

Location

Date of issue

Examiner or examining body

Name, date and signature

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

ISO 15614-1:2017(E)

Record of weld test

Location:	Examiner or examining body:
Manufacturer's pWPS no.:	Method of preparation and cleaning:
Manufacturer's WPQR no.:	Parent material specification:
Manufacturer:	Material thickness (mm):
Welder's/operator's name:	Outside pipe diameter (mm):
Joint type and weld:	Welding position:

Weld preparation details (sketch)*:

Joint design	Welding sequences

Welding details

Run	Welding process	Size of filler material	Current A	Voltage V	Type of current/ polarity	Wire feed speed	Travel speed*	Heat input*	Metal transfer

Filler material designation and make:

Any special baking or drying:

Gas/flux — shielding:

Backing:

Gas flow rate — shielding:

Backing:

Tungsten electrode type/size:

Details of back gouging/backing:

Preheat temperature:

Interpass temperature:

Post-heating:

Post-weld heat treatment (PWHT):

(Time, temperature, method:

heating and cooling rates*):

Other information*, e.g.:

Weaving (maximum width of run):

Oscillation: amplitude, frequency, dwell time

Pulse welding details:

Distance contact tube/workpiece:

Plasma welding details:

Torch angle:


Manufacturer

Name, date and signature

* If required

Examiner or examining body

Name, date and signature

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)	INDUS Ref No II-HVD69SL-v1.1
---	--	--

ISO 15614-1:2017(E)

Test results

Manufacturer's WPQR no.:

Examiner or examining body:

Visual:

Reference no.:

Penetrant/magnetic particle testing*:

Radiographic testing*:

Ultrasonic testing*:

Temperature:

Tensile tests

Type/no.	R _e MPa	R _m MPa	A % on	Z %	Fracture location	Remarks
Requirement						

Bend tests**Former diameter**

Type/no.	Bend angle	Elongation*	Results

Macroscopic examination
(add photograph/image)

Impact test***Type****Size****Requirement**

Notch location/direction	Temp. °C	Values			Average	Remarks
		1	2	3		


Hardness Test* (type/load)

Location of measurements (Sketch*)

Parent metal:

HAZ:

Weld metal:

	Manufacturing, testing and supply of vacuum vessels for HNB3 (Beam Line Vessel and Beam Source Vessel) and DNB <i>Annexure 6B: Welding_ Welding Procedure Specification (WPS) and Welding Procedure Qualification (WPQ)</i>	INDUS Ref No II-HVD69SL-v1.1
---	---	--

ISO 15614-1:2017(E)

Other tests:

Remarks:

Tests carried out in accordance with the
 requirements of:

Laboratory report reference no.:

Test results were acceptable/not acceptable:

(Delete as appropriate)

Test carried out in the presence of:

* If required

.....

Examiner or examining body