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1 Purpose

With the control of the welding process, the corrosion and mechanical quality requirements can be ensured also in the welded locations.

With welding documentation, the qualifications requirement fulfillment and the extent of welding excavations and executed [welding quality](#) can be presented for the customer.

This document covers repair welding of castings as well as fabrication welding. Section 6 and 7 provide more detailed instructions for welding repair of the casting and section 8 provides instructions for the manufacture of weld joint preparation for the products.

This specification applies to all welded fabrication and casting repairs for Sulzer Industry BU. This includes, but is not limited to, the welding of pump casings, piping, vessels, castings, wear rings and baseplates. These requirements apply to welding performed by contractors, fabricators, foundries, and their sub-suppliers. Responsibility for implementation at Sub-suppliers is laying within the Supplier who receive the Sulzer Purchase Order.

The supplier shall refer to supporting documentation such as e.g. (PS) Purchasing Specification, (PO) Purchaser order, (ITP) Inspection Test Plan, (SQS) Sulzer quality Standards and/ or others for additional requirements.

Job-specific requirements may take precedence over or add to the requirements of this document. In case that requirements appear to conflict, the more stringent requirements shall prevail any conflict or question shall be brought to the attention of Sulzer.

Any required deviation to this document shall be submitted to Sulzer for review and approval.

2 References

- Material specifications (typically ASTM, EN)
- ASME BPVC IX Welding and brazing qualifications
- EN ISO 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
- EN ISO 9606-1 to 4 Qualification testing of welders (Fusion welding)
- EN ISO 14731 Welding coordination. Tasks and responsibilities
- EN ISO 5817 - Welding Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections
- [EN ISO 3834-2 Quality requirements for fusion welding of metallic materials – Part 2: Comprehensive quality requirements](#)
- [ISO 17662 Welding — Calibration, verification and validation of equipment used for welding, including ancillary activities](#)

3 Responsibilities and qualifications

Each location performing casting repairing and/or fabrication [welding](#) shall have a Welding responsible person for local welding process.

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Welding responsible person at Sulzer factories and at subcontractor workshops (fabrication, foundries and machining) is responsible for controlling that welding is performed under controlled conditions and according to the given instructions.

All operators performing welding shall have a qualification (WPQ) according to international code (ASME IX or EN ISO 9606-1). If required in (PO) Purchaser order, (ITP) Inspection Test Plan, the qualification must be accordance to code to which they will be welding.

All welding activities including preparations like tack welding, fabrication and repair work shall be done by qualified welders only with the aid of a WPS. This also applies to tack welds which will be removed before the completion of the weld

It is **recommended** that the welder shall be retested every 3 years also according to ASME IX.

A written examination for welders on the theory, safety and processes for welding is recommended. The so called "job knowledge test" shall be done whenever a new welder qualification takes place or at least every third year.

If a job knowledge test program is not available at a supplier site, the current applied training content and frequency of trainings take place shall be presented to gain understanding and trust in the qualification and skill of the welders.

The welding responsible person confirms every six months with his signature on qualification record that the welder has been welding within the initial range of qualification.

Minor (cosmetic) welding can be performed by operators with sufficient occupational guidance with the approval of local Welding responsible person. If welder qualification not required in PO or ITP.

EN ISO 3834-2 is recommend as guideline for welding quality requirements.

4 Welding procedure specifications WPS/PQR

Weld processes are qualified by welding qualification tests. Qualification tests shall be done according to the standard EN ISO 15614-1 and/or ASME IX and possible additional requirements stated by Sulzer. The tests are done under the control of an independent 3rd party

The welding responsible person is responsible for preparing the qualification tests and documentation:

- WPS (Welding Procedure Specification)
- PQR (Procedure Qualification Record)

As a minimum the use of English language is required. Bilingual translations are preferred, local language and English.

The necessary WPS for the job must be present in the shop at the time of welding and understood in full by the welder and or welding operator.

At any time, a welding related document may be reviewed by Sulzer for compliance with specifications. If deviations are observed, the document can be rejected.

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The procedure qualification documents (WPS/PQR) and welder qualifications (WPQ) are given to customer when required.

5 Weld procedure qualification record (WPQR)

Test according to recognized standards and with mandatory soundness attained by ISO 17025 accreditation for all PQR testing. This requirement does not apply for production NDT (Nondestructive testing).

Minimum testing is according EN ISO 15614-1 and/or ASME IX standard and additional testing recommended for the qualification of WPQR shall be in accordance with Table 1 of this procedure.

Where testing per Table 1 does not meet or project specific requirements, then additional test shall be carried out.

Note1: Whenever a new PQR is performed the specimen shall be longer than needed for additional testing. It is best practice to do the WPQR with a test specimen of extended size in order to have enough material left for further tests. This PQR specimens shall be stored properly and stamped for easy identification as well as from 3rd party inspector if applicable.

Note 2: The requirements in Table 1 have recommendations for welding approval. A filler material supplier determines the process-specific approval limits for a filler material.

6 Definition: Major weld repair (ASTM) for the castings

In defining the extent of the weld repair, the ASTM definition is used:

- Leak in the hydrostatic testing or
- Depth of the cavity exceeds 20% of the actual thickness or 1" (25 mm), whichever is smaller or
- The extent of the cavity exceeds approximately 10 in² (65 cm²)

Hydrostatic leaking components shall be re-tested after the weld repair.

7 Weld instructions for the casting repairs

Key steps in welding operation:

- Removing of the defect area of casting with arc air, finishing the excavation with grinding
- Inspect the opening visually (VT), no cracks allowed. If specified in Order Quality Plan, other methods and/or criteria to be used, like PT
- Weld repairs according to WPS/PQR
- Finishing or the weld with grinding to follow the casting surface smoothly
- Inspection of welding surface visually (VT) to fulfill the internal casting acceptance criteria, defined in procedure N04620EN, Visual Inspection of Castings. If specified in Order Quality Plan, other methods and/or criteria to be used, like PT

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Local Welding responsible person shall create and distribute the necessary instructions for local production.

For Sulzer Industry BU factories, two levels of weld instructions exist:

- Detailed WPS/PQR instructions
- Material specific production weld instructions, in which the most important practical guidelines are presented for the welders (Sulzer internal instruction N31871EN Minor weld repairs of castings)

If there are not sufficient instructions available, complementary instructions must be defined **together** with Sulzer welding experts.

8 Weld joint preparation

Tack welds at the root of the joint shall be made with a filler metal equivalent to that which will be used in the root pass. Tack welds shall be made by qualified welders and shall be fused with the root pass or removed before welding. Cracked tack welds shall be removed by grinding, not welded over.

Surfaces to be welded and adjacent surfaces shall be dry, clean, and free of contamination (dirt, oil, grease, scale, paint, slag, chemicals, low melting point metals, etc.) before welding. The clean area shall extend at least 1 inch (25 mm) beyond the weld joint in all directions. Cleaning is required on both the inside and outside surfaces. For pipe, this includes both the OD and ID.

ASME SECTION IX Welding, Brazing, and Fusing Qualifications detail QW-420 BASE METAL GROUPINGS P Number 4, 5, 6, 8, 9, 10, and 4X. Recommended that if surfaces have been prepared using thermal cutting or gouging shall have at least 1/16" of material beyond the cut surface removed by grinding or machining.

Any deviation from the weld joint preparation as specified in the related WPS is only acceptable if the dimension is increasing. Any decrease of dimensions on the joint preparation is not permissible.

9 Post weld heat treatment (PWHT)

A post weld heat treatment must be done for the casting and the fabrication if it is required in the material standard / specification or by customer specification.

10 Filler metals and consumable

Suppliers shall have a written weld filler control procedure outlining the control and handling of weld filler. This procedure shall be submitted on request for approval as a condition of qualification. The procedure shall define clearly:

The method used to maintain identity of filler to prevent metal mixing.

The method of issuing filler to the welder.

Disposition of filler metal certs.

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The storage and handling of filler materials and its conditions. Furthermore, handling of flux and coated or cored filler materials with parameters for storage and re-drying.

11 Welding technique requirements

Arc strikes, and weld starts, and stops shall be confined to the weld joint. Arc strikes outside the weld joint shall be removed by grinding and examined for cracks using the inspection method required for that surface, VT at minimum. Grinding shall not reduce the wall thickness to less than the minimum design wall thickness. This rule applies independently of material.

GTAW "washing" without filler material is not allowed.

Crater cracks shall be removed by grinding. Crater cracks shall not be welded over.

The visual appearance of welds is very important to the confidence of the users of Sulzer's pumps. Suppliers shall make every reasonable effort to ensure that visible welds have a visually appealing appearance. As a minimum standard all welding seams must be cleaned as needed and brushed after welding, all spatter and or slag shall be removed. Also, all edges shall be deburred or chamfered.

12 Equipment

All welding and related auxiliary equipment must be regularly maintained and calibrated. A sticker shall indicate the expiry date on the equipment. A calibration certificate must be available on request. [Recommended guideline for calibration according ISO 17662](#)

13 NDT requirements

All NDT requirements are given in the respective mentioned in the ITP (Inspection and test plan) and the PO (Purchase Order).

14 Welding documentation

Sulzer Purchase Order defines for subcontractor (fabrication, foundry, machining) the required documentation to be provided, typically:

- Welders qualification (WPQ), EN or ASME
- WPS/PQR/WPQR documentation, EN or ASME
- Defect maps (Hold Point) weld repair for the castings. This might need customer approval or not, depending on the Order Quality Plan

The content of reports is defined in Order Quality Plan and in Purchase Order specifications (Quality Specification, QS).

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Table 1. Sulzer recommended WPQR testing requirements

	ASME IX / EN 15614 / Other recognized std.	Macro-examination	Micrographic-examination	Impact Tests	Hardness	ASTM G48 Corrosion Test Method A	Ferrite count	ASTM A262 Intergranular corrosion test
Carbon Steel Note 1	•	•	•	•	•			
Mart 12% and 13% Cr Steel Note 1	•	•	•	•	•			
Aus 304 / 304L	•	•	•	•	•			•
Aus 316 / 316L	•	•	•	•	•			•
Duplex Note 2, 3, 4, 5	•	•	•	•	•	•	•	
Super Duplex (PRE≥40) Note 2, 4, 5, 6	•	•	•	•	•	•	•	
NiCrMo	•	•	•	•				
Aus 6Mo	•	•	•	•				

ASME IX or EN 15614-1 Requirement	
Note 1	Impact testing at -30 °C Acceptance limit is minimum KV=27J (average of three samples)
Note 2	Hardness 28 HRC (Duplex) and 32 HRC (Super Duplex)
Note 3	ASTM G48 method A shall be at 25 °C for 24 hours. Accept: No pitting, 4.0 g/m ² (0.00082 lb/ft ²) max. weight loss
Note 4	Impact tests required at -46 °C. Accept 45J (single reading 35J) minimum
Note 5	Ferrite balance shall be in the range of 35-65 % for weld metal and HEZ heat effected zone
Note 6	ASTM G48 method A shall be at: 40 °C for 24 hours if in the as welded condition. 50 °C for 24 hours if PWHT is applied. Accept: No pitting, 4.0 g/m ² (0.00082 lb/ft ²) max. weight loss

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