

Test Procedure	Sulzer Pumps Technical Quality	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		

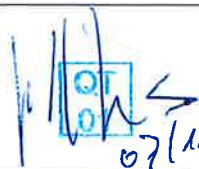
Document control sheet for the issuing of Test Procedures (NDE) by Level III
The signatures below indicate review and approval of this NDE procedure by NDE Level 3.

检测程序（无损检测）由NDE 3级 发布文件控制单
以下的签字表示本NDE程序已由NDE 3级人员审核及批准。

Dokumentkontrollblatt zur Erstellung von Testverfahren (ZfP) nach Level III
Die folgenden Unterschriften zeigen die Überprüfung und Genehmigung dieses ZfP-Verfahrens nach ZfP Level 3.

Hoja de control de documentos para la emisión de Procedimientos de prueba (ECM) por Nivel III
Las firmas a continuación indican la revisión y aprobación de este procedimiento de ECM por NDE Nivel 3.

Folha de controle de documentos para a emissão de Procedimentos de Teste (END) pelo Nível III
As assinaturas abaixo indicam a revisão e aprovação deste procedimento de END pelo Inspetor END Nível 3.

	Name (printed letters) 姓名（打印） Name (Druckbuchstaben) Name (Letra de molde) Nome (Letra de forma)	Function / Qualification 职务/资质 Funktion / Qualifikation Función / Calificación Função / Qualificação	Date & Signature 日期&签名 Datum & Unterschrift Fecha y Firma Data & Assinatura
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Approved 批准 Genehmigt Aprobado Aprovado	Marcel Willems, on behalf of Eurofins Qualitech AG.	NDT Expert (MT Level 3)	 07/10/24
Remarks / 备注 / Bemerkungen / Comentarios / Comentário:			

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 1 of 25

1 Scope

- 1.1 This generic procedure prescribes the magnetic particle examination for detecting discontinuities that are near or open to the surface.
- 1.2 It is applicable to:
 - 1.2.1 Ferromagnetic materials
 - 1.2.2 Different components as base materials, forgings, castings, welds and similar parts

2 Reference standards

- 2.1 The following documents are referenced in this specification. All documents shall be current issue unless specified otherwise. In case of any conflict between the current specification and the referred documents, the current document shall take precedence.

ASME BPVC Section V Article 7	Magnetic Particle Examination
Article 25, SE-709	Standard Guide for Magnetic Particle Testing
ASME BPVC Section VIII Div. 1	Pressure Vessels - Rules and Acceptance Standards
ISO 3059	Non-destructive testing - Penetrant testing and magnetic particle testing - Viewing conditions
ASME B31.1	Power Piping - Requirements and Acceptance Standards
ASME B31.3	Process Piping - Requirements and Acceptance Standards
API 610 / ISO 13709	Standard requirements for overhung, between-bearings and vertically suspended centrifugal pumps used in petroleum, petrochemical and gas industry process services
MSS SP-53	Quality Standard for Steel Castings and Forgings for Valves, Flanges, Fittings, and Other Piping
ASME B16.5	Pipe Flanges and Flanged Fittings - NPS 1/2 through NPS 24 metric/inch Standard
ASME B16.34	Valves-Flanged, Threaded, and Welding End
AWS D1.1	Structural Welding Code - Steel
ISO 17635	NDT of Welds – General rules for metallic materials
ISO 23278	NDT of Welds – MT – Acceptance levels
BS-EN 1369	Founding – Magnetic particle testing
BS-EN 10228-1	Steel Forgings – Part 1: Magnetic particle inspection
ASNT SNT-TC-1A	Personnel Qualification and Certification in Non-destructive Testing
ISO 9712	Non-destructive Testing; Qualification and Certification of NDT Personnel
Sulzer DT-0003	Magnetic Particle Test Report
- 2.2 Sulzer documents referenced may be downloaded from <https://www.sulzer.com/q-documents>

3 Qualification of testing personnel

- 3.1 The personnel performing [magnetic particle](#) examination required in the Project Quality Plan (Inspection & Test Plan) for NDE purposes shall be qualified and certified in accordance with the Company's Written Practice, which conforms to the Recommended Practice SNT-TC-1A, the ASNT Central Certification Program (ACCP), ISO 9712, ANSI/ASNT CP-189, ASNT 9712 or equivalent national standard (e.g. CAN/CGSB 48.9712) and must have a currently valid vision test.
- 3.2 An operator with MT-level I can perform an examination only under the supervision of personnel qualified and certified MT-level II or higher.

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
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Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 2 of 25

- 3.3 Interpretation and evaluation of results shall only be carried out by personnel qualified and certified MT-level II or higher, who is supervising the examination of MT-level I and evaluates the results. . If a MT level I participated in the examination, both the MT level I operator and supervising MT level II or higher shall sign the records.
- 3.4 All qualifications and certification must comply, in full, with at least one of the standards referenced in Paragraph 2.0 of this document and, where applicable, should be in full compliance with the Project Quality Plan (Inspection & Test Plan).

4 Examination conditions

4.1 Timing of examination

- 4.1.1 The examination shall be carried out in the manner defined in the project Quality Plan (Inspection & Test Plan), both in chronological order and material condition.

4.2 Extent of examination

- 4.2.1 The extent or scope of the examination shall be as defined in the project Quality Plan (Inspection & Test Plan). Where welds, or specific areas are being examined, then the examination shall include a minimum of 25 mm (1 inch) outside the area being tested and in the case of welds must include the entire "Heat Affected Zone (HAZ)" plus 25 mm (1 inch) of adjacent base metal on both sides of the weld.

4.3 Surface conditions and preparation

- 4.3.1 The surfaces can be examined in rough condition (as-welded, as-rolled, as-cast or as-forged). Surface roughness shall not exceed Ra 6.3µm (Rugotest N9) unless by prior agreement, and any discontinuities that may impair the test shall be removed by grinding or by other means.
Note: If magnetic particle testing is carried out on un-machined surfaces (e.g. castings), then a surface roughness up to a maximum of Ra 25µm (Rugotest N11) is permitted.
- 4.3.2 If magnetic particle testing is foreseen on an early production stage and on un-machined surfaces (e.g. castings) test may be done with a surface roughness up to Ra 25. But if magnetic particle testing is specified in later manufacturing stages, testing has to be done on machined surfaces and with the above defined surface roughness of max. Ra 6.3 µm (Rugotest N9).
- 4.3.3 The surfaces to be examined shall be free of all dirt, rust, scale, weld spatter, grease, oil or other contaminations that can reduces the sensitivity. Surface preparation by grinding or machining or other methods shall be necessary in these cases. Care shall be taken to ensure indications are not masked when grinding, machining, etc.
- 4.3.4 The surface to be examined and all adjacent areas within at least 25 mm (1 inch) shall be thoroughly degreased using a suitable solvent. The surface condition shall be adequate to allow accurate interpretation of indications commensurate with the acceptance criteria specified.
The surface shall be dry.
- 4.3.5 Where contrast and interpretation of magnetic particle indications is difficult, surface viewing shall be improved by the application of a thin (max. 50 µm / 2 µin.) non-ferromagnetic contrast paint. When contrast paint is used it shall be demonstrated that indications can be detected (ASME V T-741.2).

4.4 Coatings

- 4.4.1 Nonmagnetic coatings and paint with thickness ≤ 0.05 mm (0.002 in.) are allowed.
- 4.4.2 Coatings with a thickness > 0.05 mm (2 mil) as well as other coatings such as electrical conducting or magnetic coatings are only permitted, if it is demonstrated that such coatings do not mask any indications. The procedure for this demonstration shall be defined prior to the inspection with a corresponding specification.
- 4.4.3 Where it cannot be proven that the coating will not impede the inspection, then the coating shall be removed.

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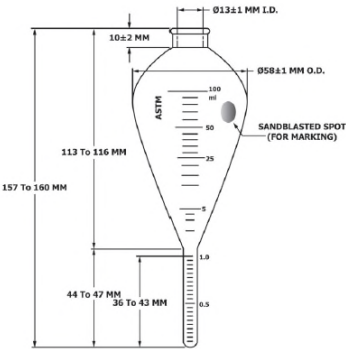
Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 3 of 25

4.5 Examination temperature

- 4.5.1 The temperature of the magnetic products and of the surface of the area to be examined shall be within the temperature range limitations set by the manufacturer of the consumables (*normally maximum approx. 50°C / 122°F, when using wet magnetic particles*).

4.6 Magnetic products / consumables

- 4.6.1 The magnetic particle examination may be performed with wet or dry magnetic particles. Other methods are permitted only by prior Sulzer Pump's agreement.
- 4.6.2 The use of wet (fluorescent) magnetic particles is preferred. If wet visible (colour contrast) magnetic particles are used, the flaw detectability can be improved by using contrast paint/colour contrast products (see point 4.3 above) as magnetic particles must contrast with the component background.
- 4.6.3 Magnetic particles in suspension shall comply with the requirements of ASME V T-765. The concentration shall be checked at regular intervals with the applicable pear shaped centrifuge tube for fluorescent or non-fluorescent particles. Allow the demagnetized suspension to settle for approx. 60 min with petroleum distillate suspensions or 30 min with water-based suspensions before reading.

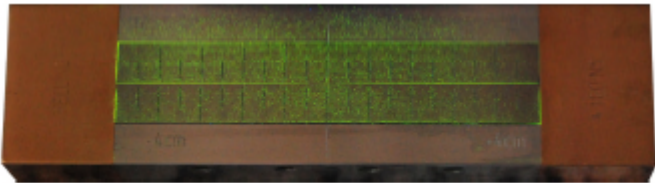


Centrifuge Tube

Settling Volumes:

- | | | |
|---|---------------------------|---------------|
| - | Fluorescent particles | 0.1 to 0.4 mL |
| - | Non-fluorescent particles | 1.2 to 2.4 mL |

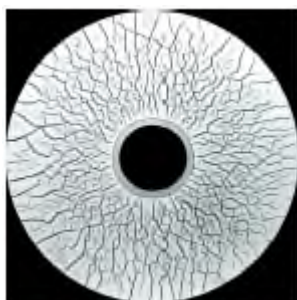
4.6.4 Devices for evaluation of magnetic particle examination materials:



- When using fluorescent particles

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
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Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 4 of 25



- When using non-fluorescent (black) particles, on a thin white contrast coating

4.6.5 Both fluorescent and non-fluorescent suspensions shall be checked periodically for contaminants such as dirt, scale, oil, lint, loose fluorescent pigment, water (in the case of oil suspensions), and particle agglomerates which can adversely affect the performance of the magnetic particle examination process. The test for contamination shall be performed at least once per week.

4.6.5.1 Carrier Contamination.

For fluorescent baths, the liquid directly above the precipitate should be examined with fluorescent excitation light. The liquid will have a little fluorescence. Its colour can be compared with a freshly made-up sample using the same materials or with an unused sample from the original bath that was retained for this purpose. If the “used” sample is noticeably more fluorescent than the comparison standard, the bath shall be replaced.

4.6.5.2 Particle Contamination.

The graduated portion of the tube shall be examined under fluorescent excitation light if the bath is fluorescent and under visible light (for both fluorescent and non-fluorescent particles) for striations or bands, differences in colour or appearance.

Bands or striations may indicate contamination. If the total volume of the contaminants, including bands or striations exceeds 30% of the volume magnetic particles, or if the liquid is noticeably fluorescent, the bath shall be replaced.

4.7 Application of (wet) Magnetic Particles

4.7.1 During application of the wet magnetic particles, it shall be allowed to flow on to the component with very little pressure, so that the particles are allowed to adhere to a flaw indication without being washed off. Care should be taken to ensure that excessive build-up of magnetic particles does not occur that could mask indications.

4.7.1.1 The wet magnetic particles shall be applied just before and during the magnetization.

4.7.1.2 The spraying of the surface shall be completed before the magnetization is switched off.

4.7.1.3 The formation of the indications shall be finished, before the object is moved or examined.

4.7.2 Magnetization shall be continuous and of a duration no shorter than 3 seconds

4.8 Application of dry powder

4.8.1 When the dry powder technique is used, a powder blower shall be utilized for powder application. Hand squeezed particle applicators shall only be used if a powder blower cannot be utilized due to the size of the part, the accessibility of the area to be tested. In this case, following precautions have to be taken:

4.8.1.1 It shall be that the area to be controlled is covered completely with the powder.

4.8.1.2 Avoid blowing away possible indications by exerting too high pressure with the applicator.

4.8.1.3 Powder colour shall be selected to ensure the greatest possible contrast with the surface being examined.

4.8.2 Size and colour of magnetic particles used with the dry powder technique are essential variables and have to be included in the test report.

4.8.3 The products have to be used according to the specification of the manufacturer. Health and safety requirements identified in the manufacturer’s Safety Data Sheets and/or risk assessment must be

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Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 5 of 25

followed. Used products have to be disposed according to the local legal requirements and/or the instruction of the manufacturer.

4.9 Equipment

- 4.9.1 All equipment such as horizontal units (test-bench), movable power units, yokes, and measuring devices such as gauss-meter, hall-effect probe, UV-A- and white light-meter shall be checked and calibrated at least once per year in accordance with ASME V Art. 7, T-760.

4.10 Type of current

- 4.10.1 The following types of current can be used:
- 4.10.1.1 Direct current, also as full wave or half wave rectified current
 - 4.10.1.2 Alternating current
- 4.10.2 If necessary, it should be demonstrated on the Ketos (Betz) Test Ring that sub-surface defects can be detected using rectified or with direct current prior to the examination taking place.
- 4.10.3 Part magnetization with alternating current is preferred for those applications where examination requirements call for the detection of discontinuities, such as fatigue cracks, that are open to the surface to which the magnetizing force is applied.

4.11 Magnetic Field

- 4.11.1 Magnetic field strength shall be $\geq 2.4 \text{ kA/m}$ ($\geq 30 \text{ Oe}$), but not so strong that it causes the masking of relevant indications by non-relevant accumulations of magnetic particles.
- 4.11.2 There are two approved methods to determine the actual magnetization for single directional magnetization:
- 4.11.2.1 by measuring the tangential magnetic field strength at the surface with a calibrated magnetic field strength meter (gauss-meter, hall effect probe).
 - 4.11.2.2 use of formulas as per T-753 in order to determine required magnetic field strength; see § 5.4 and § 5.5.
- 4.11.3 If the magnetization is too high and false indications appear, the field strength shall be reduced according to the given range.
- 4.11.4 The ASME pie-shaped magnetic field indicator (Pie Gage), or flaw shims (Castrol strips), which are put on the surface, shall be used for the proof of presence and the direction of the magnetization only but not for the verification of the field strength. To verify the field strength, a calibrated magnetometer (Gauss Meter), or Hall Effect probe shall be used.
- 4.11.5 Test benches which induces multidirectional magnetic fields will have each direction checked individually.
- 4.11.6 Where this is not possible, measurement of simultaneously multidirectional induced magnetic fields such as those created by a three phase, fully rectified current generator, the adequacy of the magnetic field shall demonstrate by the use of shim type indicators or the ASME Pie-shape Field indicators. Hall Effect probes shall not be used.

4.12 Magnetic Field Coverage

- 4.12.1 The magnetization has to be made in at least two different directions, which have to be as far as possible under a relative angle of 90° (perpendicular), but not less than 50° and not more than 130° .
- 4.12.2 All examinations shall be carried out with sufficient overlap of the examination's sectors to ensure 100% coverage of the area being inspected at the required sensitivity. For welds the area under test shall in all cases include the weld and heat-affected zone plus 25 mm (1") of adjacent base metal on both sides of the weld.
- 4.12.3 The prod / pole spacing shall be within the range of 150 mm to 200 mm (for detail see § 5.3 and 5.7). Where unfavourable geometry limits spacing, the minimum distance shall be 75 mm.

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Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 6 of 25

5 Types of magnetization

5.1 Magnetization shall be in accordance with one of the methods defined in § 5.3 to 5.7 of this Test Procedure (TP).

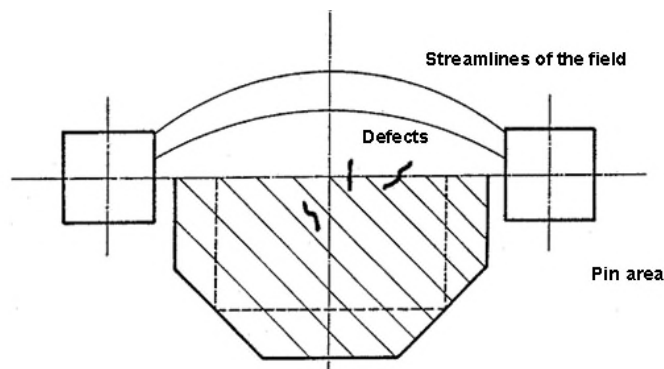
5.2 **Application:** Enclosure 7; Table showing the advantages and limits of the various ways of magnetizing a part.

Test equipment must be calibrated in accordance with § 4.9 of this procedure.

5.3 Yokes

5.3.1 Magnetic particle testing with yokes has to comply with following requirements:

- Magnetization: With magnetic field
- Type of current: Alternating current or direct current may be used . Permanent magnetic yokes shall not be used.
- Contact: The poles shall be in full contact with the surface.
- Defect orientation: Perpendicular to the connecting line between the poles
- Examined sector: The examined sector is an octagon with the pole distance as diameter, except the areas near to the poles. 25 mm equal to 1 inch around the poles are not testable.
- Overlap: At least 10 % of the examined sector



5.3.2 Prior to the inspection being carried out, it shall be demonstrated that the yoke is capable of lifting a steel test block of the following weights:

- alternating current yoke: lifting force ≥ 4.5 kg
- direct current yoke: lifting force ≥ 18.1 kg

5.3.3 Each weight shall be weighed with a scale from a reputable manufacturer and stenciled with the applicable nominal weight prior to first use. A weight need only be verified again if damaged in a manner that could have caused potential loss of material.



Yoke Method of Part Magnetization

Revision: 13	Date: 07/10/2024	Amendment: Visual Examination reference removed from 3.1, Enclosure 6 added
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Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 7 of 25

5.4 Direct contact or Central Conductor Technique

5.4.1 Magnetic particle testing with current magnetization has to comply with following requirements:

5.4.1.1 Magnetization: Circular magnetization possible with:

- axial current through the part. A good electrical connection between part and contact plates is necessary.
- a central conductor

5.4.1.2 Defect orientation: Parallel to the flow of the current

5.4.1.3 Type of current: Direct or rectified current.

5.4.2

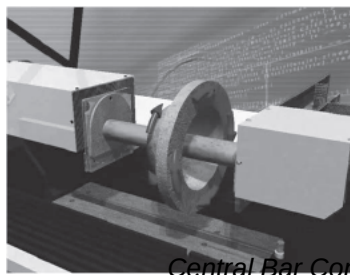
5.4.2.1 The current shall be 300 amp/in. (12 A/mm) to 800 amp/in. (31 A/mm) of outer diameter.

5.4.2.2 For parts with geometric shapes other than round, the greatest cross-sectional diagonal in a plane at right angles to the current flow shall be used in lieu of the outer diameter in (1) above.

5.4.2.3 If the current levels required for (1) cannot be obtained, the maximum current obtainable shall be used and the field adequacy shall be demonstrated; see §4.9.

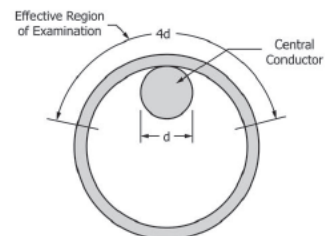


Direct Contact Shot



Central Bar Conductors

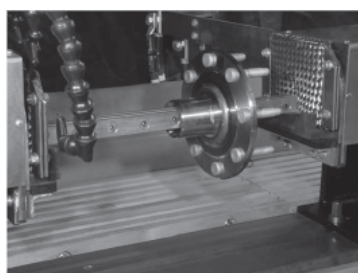
(circular magnetization)



5.5 Induced magnetic field,

5.5.1 i.e. the current is induced in a ring-shaped part, which works like the secondary winding of a transformer.

Note: this magnetization is only possible with alternating current.



Using Laminated Core

(longitudinal magnetization)

5.6 Coil or cable

5.6.1 A magnetic particle testing with coil or cable has to comply with following requirements:

5.6.1.1 Magnetization: Longitudinal magnetization

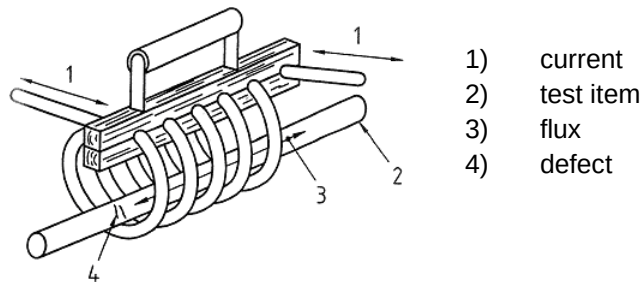
5.6.1.2 Defect orientation: Parallel to the plane of the coil

5.6.1.3 Type of current: Direct or rectified current

5.6.1.4 Examined sector: Long parts have to be examined in sectors ≤ 450 mm. If an area is more distant from the coil than 150 mm, the sufficient magnetic field strength has to be checked.

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Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 8 of 25



5.6.2 Parts With L/D Ratios Equal to or Greater Than 4.

The magnetizing current shall be within 10% of the ampere-turns' value determined as follows:

35,000

Ampere-turns = $(L/D) + 2$

For example, a part 10 in. (250 mm) long × 2 in. (50 mm) diameter has an L/D ratio of 5.

Therefore,

35,000

$(L/D + 2) = 5000 \text{ Ampere-turns}$

5.6.3 Parts With L/D Ratios Less Than 4 but Not Less Than 2.

The magnetizing ampere-turns shall be within 10% of the ampere-turns' value determined as follows:

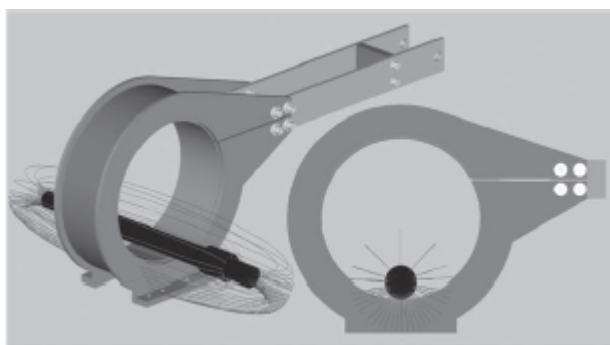
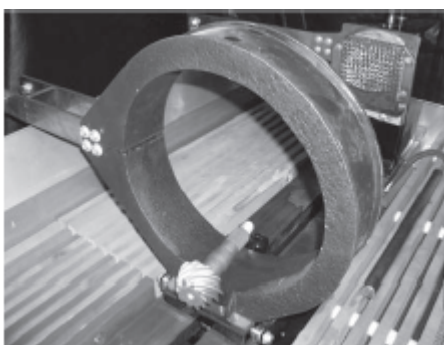
45,000

Ampere-turns = L/D

5.6.4 Parts With L/D Ratios Less Than 2. Coil magnetization technique cannot be used.

5.6.5 If the area to be magnetized extends beyond 9 in. (225 mm) on either side of the coil's center, field adequacy shall be demonstrated using a magnetic field indicator or artificial flaw shims per T-764.

5.6.6 For large parts due to size and shape, the magnetizing current shall be 1200 ampere-turns to 4500 ampere-turns. The field adequacy shall be demonstrated using artificial flaw shims or a pie-shaped magnetic field indicator in accordance with T-764. A Hall-Effect probe gaussmeter shall not be used with encircling coil magnetization techniques.



Bench Fixed Coil and Field Distribution

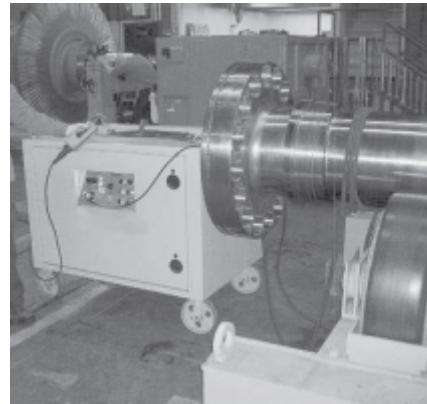
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Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 9 of 25



Cable Wrap Magnetization Example

(low fill factor)



(high fill factor)

- 5.6.7 Fill Factor: The Magnetization with a coil is depend upon the Fill Factor. The fill factor is the ratio of the cross-sectional area of the test piece to the cross-sectional area of the coil.

A high fill factor is where Cross-sectional area of the coil is less than twice the cross-sectional area of the part including hollow portions. In other words, the test piece takes up one half or more of the area of the coil. A High Fill-Factor is greater than 0.5

Low Fill Factor is where the cross-sectional area of the coil is equal or less than one-tenth of the cross-sectional area of the part being examined. In other words, Low Fill Factor is less than or equal to 0.1

5.7 Combined magnetization

A technique sketch shall be prepared for each different geometry examined. Parts with repetitive geometries but different dimensions may be examined using a single sketch when field strength is demonstrated to be adequate. Magnetic particle testing with combined magnetization shall comply with following requirements:

5.7.1 Application: Stationary unit for small and middle-sized parts, like axle, rings and similar parts

- 5.7.1.1 Magnetization: Two 90° (perpendicular) magnetizations occur.

Possible are:

- current flow through the part
- current flow through a central conductor or an auxiliary conductor
- coil
- magnetic flux flow

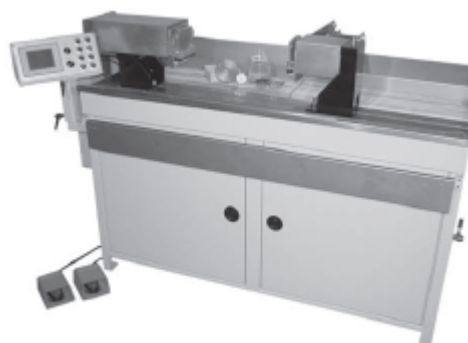
- 5.7.1.2 Defect orientation: In all the directions

- 5.7.1.3 Type of current: Only three phase, full-wave rectified current shall be used to magnetize the part. The initial magnetizing current requirements for each circuit shall be established using the guidelines (see T-753 and T-754).

- 5.7.1.4 Magnetic field: The magnetic field strength shall be measured separately for each single magnetization.

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Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 10 of 25



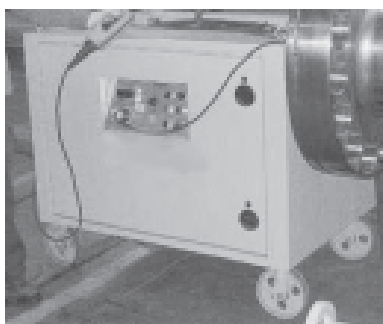
Multidirectional Magnetic Particle Units

5.7.2 Application: Stationary or portable Power Units for larger parts

Defect orientation and type of current as per § 5.7.1 above, however:

- 5.7.2.1 Magnetization: Depending on the dimensions of the part to be examined; all-over, or in sections
- 5.7.2.2 Magnetic field: Hall Effect probes shall not be used. Shim-type indicators are best used with wet particle procedures, the Pie-shaped magnetic particle field Indicator is best used at dry particle procedures.

Areas where adequate field strengths cannot be demonstrated, additional magnetic particle techniques shall be used to obtain the required two-directional coverage.



Typical transportable power unit



Direct contact magnetization through magnetic leech clamp of part



Spring loaded contact clamp

5.8 Prods

5.8.1 A magnetic particle testing with prods has to comply with following requirements:

- 5.8.1.1 Magnetization: Circular
- 5.8.1.2 As a guide current flow should be calculated at:
- 40/50 amps per cm of prod spacing for sections greater than 19 mm thickness
 - 36/44 amps per cm of prod spacing for sections less/equal than 19 mm thickness
- 5.8.1.3 Defect orientation: Parallel to the connecting line between the prods
- 5.8.1.4 Type of current: Direct current or rectified alternating current may be used
- 5.8.1.5 Prods' distance: The distance between the prods should be greater than 75 mm and less than 200 mm.
- 5.8.1.6 Examined sector: The width of the examined sector on both sides of the connecting line between both prods is $\frac{1}{4}$ of distance between the prods.
- 5.8.1.7 Overlap: At least 10 % of the examined sector

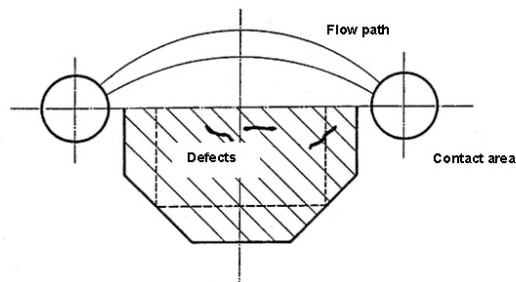
5.8.2 Equipment:

5.8.2.1 Prods shall be equipped with switches on the handles for activating the magnetising current.

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group					Doc No: TQ TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 11 of 25

- 5.8.2.2 Tips shall be either steel or aluminium and shall be clean to ensure good electrical contact. Zinc plated or galvanised prods shall not be used.
- 5.8.2.3 Prods shall have a minimum dimension of 10 mm and as large a contact area as possible. The contact faces of the prods shall be inspected prior to use and re-faced if burned or damaged.
- 5.8.3 Method:
- 5.8.3.1 Magnetization shall not be activated until adequate contact pressure between prods and part has been achieved. The magnetization shall be continuous, at least 3 sec. and the contact pressure shall not be released until the current is switched off.
- 5.8.3.2 Care should be taken to prevent local overheating, arcing or burning of the surface being inspected especially on high carbon or alloy steels. Arc strikes that inadvertently occur shall be removed by grinding and re-examined using the magnetic flow method (for example with a yoke).
- 5.8.4 Magnetic field:
To verify the direction of the magnetic field a Pie Type magnetic particle field indicator or shims shall be used.



Typical portable power pack for prods



Typical single prod set



Typical double prod set

6 Inspection and evaluation conditions

6.1 Inspection conditions with fluorescent magnetic particles

While using fluorescent magnetic particles, the inspection conditions are the following:

6.1.1 Room:

- 6.1.1.1 The inspection has to be made in a darkened room. The residual white light intensity on the surface to be examined shall be ≤ 21.5 lx.

6.1.2 UV-lamp:

- 6.1.2.1 UV-A light with wave length about 365 nm and in accordance ASME BPVC Section V, T-777.2.
- 6.1.2.2 Warm up of UV-lamp ≥ 10 minutes shall be allowed for the lamp to achieve the required intensity prior to inspection.
- 6.1.2.3 UV-light intensity ≥ 1000 μ Watt/cm² on the surface to be examined

6.1.3 Operator:

- 6.1.3.1 Adaptation time in the darkened area ≥ 5 minutes

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group					Doc No: TQ TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 12 of 25

6.1.3.2 Wearing of light sensitive or tinted glasses is not allowed.

6.2 Inspection conditions with visible (colour contrast) magnetic particles

While using visible (colour contrast) magnetic particles, the inspection conditions are the following:

6.2.1 Magnetic particles:

6.2.1.1 The colour of the magnetic particles shall be sufficiently different than the colour of the examination surface.

6.2.2 Light intensity:

6.2.2.1 The test surface shall be inspected under daylight or artificial light with a light intensity of $\geq 1'076$ lx.

6.2.2.2 The viewing conditions shall be such that glare and reflections are avoided on the surface to be examined.

The light intensity, natural or supplemental white light source, shall be measured with a white light meter prior to the evaluation of indications or a verified light source shall be used. Verification of light sources is required to be demonstrated only one time, documented, and maintained on file.

6.2.3 Surface:

Where contrast and interpretation of magnetic particle indications is difficult, surface viewing shall be improved by the application of a thin (max. 50 μm) non-ferromagnetic contrast paint.

6.3 Inspection and evaluation of indications

6.3.1 The examined surface has to be evaluated immediately after the flow off of the excessive product. The evaluation of the surface occurs during the magnetization.

6.3.2 False indications and broad areas of product which could mask indications of defects are unacceptable. Such areas shall be cleaned and re-examined. If the field strength is near to the upper limit (see paragraph 4.9), the field strength can be reduced but still respecting the specified limits in paragraph 4.9.

6.3.3 Where there is doubt as to the relevance of an indication, the surface in that area shall be cleaned and re-examined.

Alternatively other non-destructive testing methods can be applied, to determine if an indication is due to a defect. Such additional tests have to be reported to Sulzer Pumps.

7 Assessment of indications

7.1 Due to diversity of project requirements defect acceptance will be as specified in the project Quality Plan (Inspection & Test Plan). In the absence of a Quality Plan (Inspection & Test Plan) the Sulzer quality organisation responsible for the project will advise in writing the appropriate acceptance standard.

7.2 Acceptance Standards

7.2.1 ASME BPVC Section VIII Div. 1; see Enclosure 1

- Man. App. 6 (Welds and machined parts)
- Man. App. 7 (Castings)

7.2.2 ASME B31.1; see Enclosure 2

- § 136.4.3 (Welds)
- § 102.4.6 (Castings)

7.2.3 ASME B31.3; see Enclosure 3

- § 341.3.2 / § K341.3.2 (Welds)
- § 302.3.3 / § K302.3.3 (Castings and Forgings)

7.2.4 API Standard 610 / ISO 13709; see Enclosure 4

- § 8.2.2.5 (Welds and Castings)

7.2.5 EN ISO Standards see Enclosure 5

- BS-EN 23278 (Welds)
- BS-EN 1369 (Castings)
- BS-EN 10228-1 (Forgings)

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group					Doc No: TQ TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 13 of 25

7.2.6 AWS D1.1

[see Enclosure 6](#)

8 Repairs

- 8.1 All repair work that involves welding shall fulfil PO / ITP requirements. Any deviation requires an approved concession request prior to execution by Sulzer
- 8.2 All relevant indication shall be marked on the components themselves, or where this is not possible on an NDE defect map. All relevant indications shall be removed completely.
- 8.3 Whenever an imperfection is to be weld repaired, the excavation shall be examined by one of following method before welding to ensure complete removal of defect
 - 8.3.1 Visual inspection, if the imperfection was found by visual inspection.
 - 8.3.2 Penetrant testing, if the imperfection was found by PT,MT,UT or RT.
- 8.4 On completion of welding, repaired areas shall be blended into their surrounding surfaces to avoid any sharp contours and be examined by the same quality standards that are used to inspect the castings / welds. When subsequent heat treatment is required, examination shall be conducted after heat treatment.

9 Ground areas

- 9.1 Surface defects can be ground without a weld repair, unless the minimal thickness is under the allowed values of the drawings. The ground areas must blend into the nearby areas. Sharp edges, corners and notches are not allowed.
- 9.2 All ground areas shall be examined again with magnetic particle testing and documented in the test report.

10 Demagnetization

- 10.1 With the exception of structural fabrications (baseplates, stands, stools etc.), castings and pipework all items must be demagnetized after being tested.
- 10.2 The ease of demagnetization is dependent on the coercive force of the metal. High retentivity is not necessarily related to high coercive force in that the strength of the residual field is not always an indicator of ease of demagnetizing. In general, demagnetization is accomplished by subjecting the part to a field equal to or greater than that used to magnetize the part and in nearly the same direction, then continuously reversing the field direction while gradually decreasing it to zero.
- 10.3 Demagnetization Methods
 - 10.3.1 Withdrawal from Alternating Current Coil
 - 10.3.2 Decreasing Alternating Current
 - 10.3.3 Demagnetizing with Yokes
 - 10.3.4 Reversing Direct Current
- 10.4 After demagnetization, the residual field shall be ≤ 0.24 kA/m (≤ 3 Oe) unless otherwise agreed in writing.

11 Post examination cleaning

- 11.1 On completion of testing, and where residual NDE consumables may interfere with subsequent operations, then the component shall be cleaned and returned to its pre-inspection condition.
- 11.2 Where residual NDE consumables will not interfere with subsequent operations or will be removed by a subsequent operation, then removal is not necessary as long as the consumables used are not hygroscopic and will not damage the material corrosively.

12 Reporting

- 12.1 Checks of the products and of the equipment have to be recorded according to the internal specification.
- 12.2 For each examination and for each item tested shall be completed a report. This report has to include at least following information:

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group					Doc No: TQ TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 14 of 25

- 12.2.1 Name of the company performing the test
- 12.2.2 Identification of the object tested
- 12.2.3 Production stage respectively status of component at time of inspection (before or after the heat treatment)
- 12.2.4 Surface condition, material, thickness
- 12.2.5 Test procedure (identification and revision)
- 12.2.6 Extent of testing
- 12.2.7 Magnetic products (manufacturer, product denomination, batch number)
- 12.2.8 Colour of the magnetic particles used
- 12.2.9 Size of the magnetic particles used with the dry powder technique
- 12.2.10 Equipment used
- 12.2.11 Conditions of examination (magnetization, type of current, current intensity, magnetic field strength)
- 12.2.12 Inspection light conditions (UV-intensity, white residual light)
- 12.2.13 Residual magnetism (if required)
- 12.2.14 Acceptance criteria
- 12.2.15 Results (of the recording indications: type, position, length or diameter, distribution, eventually with drawing)
- 12.2.16 Date of examination
- 12.2.17 Date of recording
- 12.2.18 Operator's name, qualification and signature
- 12.2.19 Applied Standard (EN ISO or ASME)
- 12.3 Components shall be clearly identified as being either acceptable or rejectable. Non-conforming areas on components shall be marked on the components themselves, or where this is not possible on an NDE defect map.

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group					Doc No: TQ TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 15 of 25

Enclosure 1	ASME BPVC Section VIII Div. 1
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A) Welds and machined parts**Man App. 6**Relevant are indications ≥ 1.5 mm (1/16 in.)**All surfaces to be examined shall be free of:**

- (a) Relevant linear indications
- (b) Relevant rounded indications greater than 5 mm (3/16 in.)
- (c) Four or more relevant rounded indications in a line separated by 1.5 mm (1/16 in.) or less, edge to edge

B) Castings**Man App. 7**

Surface indications shall be compared with those indicated in ASTM E-125 Reference Photographs, and shall be removed if they exceed the following limits:

Type	Degree
I Linear discontinuities (hot tears and cracks)	All
II Shrinkage	2
III Inclusions	3
IV Chills and Chaplets	1
V Porosity	1

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group					Doc No: TQ TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 16 of 25

Enclosure 2	ASME B31.1
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A) Welds; §136.4.3

The following relevant indications ≥ 2.0 mm (1/16 in.) are unacceptable:

- (a) Any cracks or linear indications
- (b) Rounded indications with dimensions greater than 5.0 mm (3/16 in.)
- (c) Four or more rounded indications in a line separated by 2.0 mm (1/16 in.) or less, edge to edge
- (d) Ten or more rounded indications in any 3`870 mm² (6 in²) of surface with major dimensions of this area not to exceed 150 mm (6 in.) with the area taken in the most unfavourable location relative to the indications being evaluated

B) Castings; §102.4.6

Surface indications shall be compared with those indicated in ASTM E-125 Reference Photographs, and shall be removed if they exceed the following limits:

Type	Degree
I Linear discontinuities (hot tears and cracks)	1
II Shrinkage	2
III Inclusions	3
IV Chills and Chaplets	1
V Porosity	1

MSS SP-53 may be used for guidance; see ASME B31.3

Revision: 13	Date: 07/10/2024	Amendment: Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group		Doc No: TQ TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 17 of 25

Enclosure 3	ASME B31.3
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A) Welds;

§341.3.2

Indications whose major dimensions are greater than 1.5 mm (1/16 in.) shall be considered relevant.

The following relevant indications are unacceptable:

- (a) Cracks and linear indications, like lack of fusion, or undercutting
- (b) Surface porosity or exposed slag at nominal thickness ≤ 5 mm (3/16 in.)

B) Castings

§302.3.3

MSS SP-53 ASME B16.34

Maximum acceptable indications are as follows:

a) Linear indications

max. Size	For material thickness up to
≤ 8 mm (0.3 in.)	≤ 13 mm (0.5 in.)
≤ 13 mm (0.5 in.)	13 to 25 mm (0.5 to 1 in.)
≤ 18 mm (0.7 in.)	> 25 mm (1 in.)

For linear indications, the indications must be separated by a distance greater than the length of an acceptable indication.

b) Rounded indications

max. Size	For material thickness up to
≤ 8 mm (0.3 in.)	≤ 13 mm (0.5 in.)
≤ 13 mm (0.5 in.)	> 13 mm (0.5 in.)

Four or more rounded indications in a line separated by 2 mm (0.06 in.) or less edge to edge are unacceptable.

C) Forgings

§.....

MSS SP-53 ASME B16.34

Maximum acceptable indications are as follows:

a) Linear indications

max. Size	For material thickness up to
≤ 5 mm (0.2 in.)	≤ 13 mm (0.5 in.)
≤ 10 mm (0.4 in.)	13 to 25 mm (0.5 to 1 in.)
≤ 15 mm (0.6 in.)	> 25 mm (1 in.)

For linear indications, the indications must be separated by a distance greater than the length of an acceptable indication.

b) Rounded indications

max. Size	For material thickness up to
≤ 5 mm (0.2 in.)	≤ 13 mm (0.5 in.)
≤ 8 mm (0.3 in.)	> 13 mm (0.5 in.)

Four or more rounded indications in a line separated by 2 mm (0.06 in.) or less edge to edge are unacceptable.

Revision: 13	Date: 07/10/2024	Amendment: Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group		
Doc No:	TQ	TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 18 of 25

Enclosure 4	API Standard 610 / ISO 13709
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|------------------------|---------------------|--|
| a) Fabrications | §8.2.2.5 (Table 15) | acc. ASME BPVC Section VIII Div. 1 Man. App. 6 |
| b) Castings | §8.2.2.5 (Table 15) | acc. ASME BPVC Section VIII Div. 1 Man. App. 7 |
| c) Forgings | §..... | API 5L/ISO 3183 §9.10.4 |

Laminations or inclusions extending into the face or bevel of the pipe and having a visually determined length in the circumferential direction > 6,4 mm (0.250 in) shall be classified as defects. Pipes that contain such defects shall be rejected or cut back until no such lamination or inclusion is present at the pipe ends.

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group					Doc No: TQ TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 19 of 25

Enclosure 5 ISO 5817
MT Acceptance Standard for welds
ISO 17635 Non-destructive testing of welds – General rules for metallic materials

Quality Class according ISO 5817	Test technique and category acc. BS-EN 17638	Acceptance Criteria acc. ISO 23278
B	Test category not defined	2 X
C	Test category not defined	2 X
D	Test category not defined	3 X

ISO 23278 Non-destructive testing of welds – Magnetic particle inspection – Acceptance levels

The admissibility limits for linear indications shall be considered as relevant indications.

Type of indication	Acceptance Level ^a		
	1	2	3
Linear indication <i>l</i> = length of indication	$l \leq 1.5 \text{ mm}$	$l \leq 3 \text{ mm}$	$l \leq 6 \text{ mm}$
Non-linear indication <i>d</i> = major axle diameter	$d \leq 2 \text{ mm}$	$d \leq 3 \text{ mm}$	$d \leq 4 \text{ mm}$

^a Acceptance levels 2 and 3 may be specified with suffix "x" which denotes that all linear indications detected shall be evaluated to level 1.

However, the probability of detection of indications smaller than those denoted by the original acceptance level can be low. **Linear defect such like crack, lack of fusion and lack of penetration is NOT acceptable regardless of length.**
MT Acceptance Standard for steel castings

BS EN 1369:2015 Founding – Magnetic particle testing

PT Acceptance Standard for steel forgings

BS EN 10228-1:2011 Steel Forgings – Part 1: Magnetic particle inspection

Note: These two (British) European Standards are not included to this procedure.

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group					Doc No: TQ TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 20 of 25

Enclosure 6	AWS D1.1
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Welds (Table 8.1)

Discontinuity Category and Inspection Criteria	Statically Loaded Non Tubular Connections	Cyclically Loaded Non Tubular Connections								
(1) Crack Prohibition Any crack shall be unacceptable, regardless of size or location.	X	X								
(2) Weld/Base Metal Fusion Complete fusion shall exist between adjacent layers of weld metal and between weld metal and base metal.	X	X								
(3) Crater Cross Section All craters shall be filled to provide the specified weld size, except for the ends of intermittent fillet welds outside of their effective length.	X	X								
(4) Weld Profiles Weld profiles shall be in conformance with 7.23	X	X								
(5) Time of Inspection Visual inspection of welds in all steels may begin immediately after the completed welds have cooled to ambient temperature.	X	X								
(6) Undersized Welds The size of a fillet weld in any continuous weld may be less than the specified nominal size (L) without correction by the following amounts (U): <table><tr><td>L, specified nominal weld size, in [mm]</td><td>U, allowable decrease from L, in [mm]</td></tr><tr><td>≤ 3/16 [5]</td><td>≤ 1/16 [2]</td></tr><tr><td>1/4 [6]</td><td>≤ 3/32 [2.5]</td></tr><tr><td>≥ 5/16 [8]</td><td>≤ 1/8 [3]</td></tr></table> In all cases, the undersize portion of the weld shall not exceed 10% of the weld length. On web-to-flange welds on girders, underrun shall be prohibited at the ends for a length equal to twice the width of the flange.	L, specified nominal weld size, in [mm]	U, allowable decrease from L, in [mm]	≤ 3/16 [5]	≤ 1/16 [2]	1/4 [6]	≤ 3/32 [2.5]	≥ 5/16 [8]	≤ 1/8 [3]	X	X
L, specified nominal weld size, in [mm]	U, allowable decrease from L, in [mm]									
≤ 3/16 [5]	≤ 1/16 [2]									
1/4 [6]	≤ 3/32 [2.5]									
≥ 5/16 [8]	≤ 1/8 [3]									
(7) Undercut (A) For material less than 1 in [25 mm] thick, undercut shall not exceed 1/32 in [1 mm], with the following exception: undercut shall not exceed 1/16 in [2 mm] for any accumulated length up to 2 in [50 mm] in any 12 in [300 mm]. For material equal to or greater than 1 in [25 mm] thick, undercut shall not exceed 1/16 in [2 mm] for any length of weld. (B) In primary members, undercut shall be no more than 0.01 in [0.25 mm] deep when the weld is transverse to tensile stress under any design loading condition. Undercut shall be no more than 1/32 in [1 mm] deep for all other cases.	X									
(8) Porosity (A) CJP groove welds in butt joints transverse to the direction of computed tensile stress shall have no visible piping porosity. For all other groove welds and for fillet welds, the sum of the visible piping porosity 1/32 in [1 mm] or greater in diameter shall not exceed 3/8 in [10 mm] in any linear inch of weld and shall not exceed 3/4 in [20 mm] in any 12 in [300 mm] length of weld. (B) The frequency of piping porosity in fillet welds shall not exceed one in each 4 in [100mm] of weld length and the maximum diameter shall not exceed 3/32 in [2.5 mm]. Exception: for fillet welds connecting stiffeners to web, the sum of the diameters of piping porosity shall not exceed 3/8 in [10 mm] in any linear inch of weld and shall not exceed 3/4 in [20 mm] in any 12 in [300 mm] length of weld. (C) CJP groove welds in butt joints transverse to the direction of computed tensile stress shall have no piping porosity. For all other groove welds, the frequency of piping porosity shall not exceed one in 4 in [100 mm] of length and the maximum diameter shall not exceed 3/32 in [2.5 mm].	X	X								

Note: An "X" indicates applicability for the connection type; a shaded area indicates non-applicability.

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group					Doc No: TQ TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 21 of 25

Weld (Table 10.15)

Discontinuity Category and Inspection Criteria	Tubular Connections (All Loads)								
(1) Crack Prohibition Any crack shall be unacceptable, regardless of size or location.	X								
(2) Weld/Base Metal Fusion Complete fusion shall exist between adjacent layers of weld metal and between weld metal and base metal.	X								
(3) Crater Cross Section All craters shall be filled to provide the specified weld size, except for the ends of intermittent fillet welds outside of their effective length.	X								
(4) Weld Profiles Weld profiles shall be in conformance with 7.23	X								
(5) Time of Inspection Visual inspection of welds in all steels may begin immediately after the completed welds have cooled to ambient temperature.	X								
(6) Undersized Welds The size of a fillet weld in any continuous weld may be less than the specified nominal size (L) without correction by the following amounts (U): <table border="1"> <tr> <td>L, specified nominal weld size, in [mm]</td><td>U, allowable decrease from L, in [mm]</td></tr> <tr> <td>≤ 3/16 [5]</td><td>≤ 1/16 [2]</td></tr> <tr> <td>1/4 [6]</td><td>≤ 3/32 [2.5]</td></tr> <tr> <td>≥ 5/16 [8]</td><td>≤ 1/8 [3]</td></tr> </table> In all cases, the undersize portion of the weld shall not exceed 10% of the weld length. On web-to-flange welds on girders, underrun shall be prohibited at the ends for a length equal to twice the width of the flange.	L, specified nominal weld size, in [mm]	U, allowable decrease from L, in [mm]	≤ 3/16 [5]	≤ 1/16 [2]	1/4 [6]	≤ 3/32 [2.5]	≥ 5/16 [8]	≤ 1/8 [3]	X
L, specified nominal weld size, in [mm]	U, allowable decrease from L, in [mm]								
≤ 3/16 [5]	≤ 1/16 [2]								
1/4 [6]	≤ 3/32 [2.5]								
≥ 5/16 [8]	≤ 1/8 [3]								
(7) Undercut (A) For material less than 1 in [25 mm] thick, undercut shall not exceed 1/32 in [1 mm], with the following exception: undercut shall not exceed 1/16 in [2 mm] for any accumulated length up to 2 in [50 mm] in any 12 in [300 mm]. For material equal to or greater than 1 in [25 mm] thick, undercut shall not exceed 1/16 in [2 mm] for any length of weld.									
(B) In primary members, undercut shall be no more than 0.01 in [0.25 mm] deep when the weld is transverse to tensile stress under any design loading condition. Undercut shall be no more than 1/32 in [1 mm] deep for all other cases.	X								
(8) Porosity (A) CJP groove welds in butt joints transverse to the direction of computed tensile stress shall have no visible piping porosity. For all other groove welds and for fillet welds, the sum of the visible piping porosity 1/32 in [1 mm] or greater in diameter shall not exceed 3/8 in [10 mm] in any linear inch of weld and shall not exceed 3/4 in [20 mm] in any 12 in [300 mm] length of weld.									
(B) The frequency of piping porosity in fillet welds shall not exceed one in each 4 in [100mm] of weld length and the maximum diameter shall not exceed 3/32 in [2.5 mm]. Exception: for fillet welds connecting stiffeners to web, the sum of the diameters of piping porosity shall not exceed 3/8 in [10 mm] in any linear inch of weld and shall not exceed 3/4 in [20 mm] in any 12 in [300 mm] length of weld.	X								
(C) CJP groove welds in butt joints transverse to the direction of computed tensile stress shall have no piping porosity. For all other groove welds, the frequency of piping porosity shall not exceed one in 4 in [100 mm] of length and the maximum diameter shall not exceed 3/32 in [2.5 mm].	X								

Note: An "X" indicates applicability for the connection type; a shaded area indicates non-applicability

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
This document has been prepared & published under the authority of the Technical Quality Working Group					Doc No: TQ TP-0002

Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 22 of 25

Enclosure 7 TABLE; Advantages and Limitations of the Various Ways of Magnetizing a Part

Magnetizing Technique and Material Form	Advantages	Limitations
I. Direct Contact Part Magnetization		
Head/Tailstock Contact		
Solid, relatively small parts (castings, forgings, machined pieces) that can be processed on a horizontal wet unit	1. Fast, easy technique	1. Possibility of arc burns if poor contact conditions exist.
	2. Circular magnetic field surrounds current path	2. Long parts should be examined in sections to facilitate bath application without resorting to an overly long current shot.
	3. Good sensitivity to surface and near-surface discontinuities.	
	4. Simple as well as relatively complex parts can usually be easily processed with one or more shots.	
	5. Complete magnetic path is conducive to maximizing residual characteristics of material.	
Large castings and forgings	1. Large surface areas can be processed and examined in relatively short time.	1. High amperage requirements (16 000 to 20 000 A) dictate costly DC power supply.
Cylindrical parts such as tubing, pipe, hollow shafts, etc.	1. Entire length can be circularly magnetized by contacting, end to end.	1. Effective field limited to outside surface and cannot be used for inside diameter examination.
Long solid parts such as billets, bars, shafts, etc.	1. Entire length can be circularly magnetized by contacting, end to end.	1. Output voltage requirements increase as the part length increases, due to greater value of the impedance and/or resistance as the cables and part length grows.
	2. Current requirements are independent of length.	2. Ends must be conductive to electrical contact and capable of carrying required current without excessive heat.
	3. No end loss.	
Prods: Welds	1. Circular field can be selectively directed to weld area by prod placement.	1. Only small area can be examined at one time.
	2. In conjunction with half-wave rectified alternating current and dry powder, provides excellent sensitivity to subsurface discontinuities as well as surface type.	2. Arc burns due to poor contact.
	3. Flexible, in that prods, cables, and power packs can be brought to examination site.	3. Surface must be dry when dry powder is being used.

Revision:	13	Date:	07/10/2024	Amendment:	Visual Examination reference removed from 3.1, Enclosure 6 added
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Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 23 of 25

Magnetizing Technique and Material Form	Advantages	Limitations
Large castings or forgings	1. Entire surface area can be examined in small increments using nominal current values.	1. Coverage of large surface area require a multiplicity of shots that can be very time-consuming.
	2. Circular field can be concentrated in specific areas that historically are prone to discontinuities.	2. Possibility of arc burns due to poor contact. Surface should be dry when dry powder is being used.
	3. Equipment can be brought to the location of parts that are difficult to move.	3. Large power packs (over 6000A) often require a large capacity voltage source to operate.
	4. In conjunction with halfwave rectified alternating current and dry powder, provides excellent sensitivity to near surface subsurface type discontinuities that are difficult to locate by other methods.	4. When using HW current or FW current on retentive materials, it is often necessary that the power pack be equipped with a reversing DC demagnetizing option.
II. Indirect Part Magnetization		
Central Conductor		
Miscellaneous parts having holes through which a conductor can be placed such as: - Bearing race - Hollow cylinder - Gear - Large nut	1. When used properly, no electrical contact is made with the part and possibility of arc burns eliminated.	1. Size of conductor must be ample to carry required current.
	2. Circumferentially directed magnetic field is generated in all surfaces, surrounding the conductor (inside diameter, faces, etc.).	2. Larger diameters require repeated magnetization with conductor against inside diameter and rotation of part between processes. Where continuous magnetization technique is being employed, examination is required after each magnetization step.
	3. Ideal for those cases where the residual method is applicable.	
	4. Light weight parts can be supported by the central conductor.	
	5. Smaller central conductor and multiple coil wraps may be used to reduce current requirements.	
Large clevis		
Pipe coupling, casing/tubing Tubular type parts such as: - Pipe/Casting - Tubing - Hollow shaft	1. When used properly, no electrical contact is made with the part and possibility of arc burns eliminated.	1. Outside surface sensitivity may be somewhat less than that obtained on the inside surface for large diameter and extremely heavy wall sections.
	2. Inside diameter as well as outside diameter examination.	
	3. Entire length of part circularly magnetized.	

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Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 24 of 25

Magnetizing Technique and Material Form	Advantages	Limitations
Large valve bodies and similar parts	1. Provides good sensitivity for detection of discontinuities located on internal surfaces.	1. Outside surface sensitivity may be somewhat less than that obtained on the inside diameter for heavy wall sections.
Coil/Cable Wrap		
Miscellaneous medium-sized parts where the length predominates such as a crankshaft	1. All generally longitudinal surfaces are longitudinally magnetized to effectively locate transverse discontinuities.	1. Length may dictate multiple shot as coil is repositioned.
		2. Longitudinal magnetization of complex parts with upsets such as crankshafts will lead to dead spots where the magnetic field is cancelled out. Care must be taken to assure magnetization of all areas in perpendicular directions.
Large castings, forgings, or shafting	1. Longitudinal field easily attained by means of cable wrapping.	1. Multiple magnetization may be required due to configuration of part.
Miscellaneous small parts	1. Easy and fast, especially where residual magnetization is applicable.	1. L/D (length/diameter) ratio important consideration in determining adequacy of ampere-turns.
	2. No electrical contact	2. Effective L/D ratio can be altered by utilizing pieces of similar cross-sectional area.
	3. Relatively complex parts can usually be processed with same ease as those with simple cross section.	3. Use smaller coil for more intense field.
		4. Sensitivity diminishes at ends of part due to general leakage field pattern.
		5. Quick break desirable to minimize end effect on short parts with low L/D ratio.
Induced Current Fixtures		
Examination of ring-shaped part for circumferential- type discontinuities.	1. No electrical contact.	1. Laminated core required through ring.
	2. All surface of part subjected to toroidal-type magnetic field.	2. Type of magnetizing current must be compatible with method.
	3. Single process for 100 % coverage.	3. Other conductors encircling field must be avoided.
	4. Can be automated.	4. Large diameters require special consideration.

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Test Procedure (TP)	Technical Quality Sulzer Pumps	
Non-destructive testing – Magnetic particle testing of ferromagnetic materials		Page: 25 of 25

Magnetizing Technique and Material Form	Advantages	Limitations
Ball examination	1. No electrical contact.	1. For small-diameter balls, limited to residual magnetization.
	2. 100 % coverage for discontinuities in any direction with three-step process and proper orientation between steps.	
	3. Can be automated.	
Disks and gears	1. No electrical contact.	1. 100 % coverage may require two-step process with core or pole-piece variation, or both.
	2. Good sensitivity at or near periphery or rim.	2. Type of magnetizing current must be compatible with part geometry.
	3. Sensitivity in various areas can be varied by core or pole-piece selection.	
Yokes:		
Examination of large surface areas for surface-type discontinuities.	1. No electrical contact.	1. Time consuming.
	2. Highly portable	2. Must be systematically repositioned in view of random discontinuity orientation.
	3. Can locate discontinuities in any direction with proper orientation.	
Miscellaneous parts requiring examination of localized areas.	1. No electrical contact.	1. Must be properly positioned relative to orientation of discontinuities.
	2. Good sensitivity to direct surface discontinuities.	2. Relatively good contact must be established between part and poles.
	3. Highly portable.	3. Complex part geometry may cause difficulty.
	4. Wet or dry technique.	4. Poor sensitivity to subsurface-type discontinuities except in isolated areas.
	5. Alternating-current type can also serve as demagnetizer in some instances.	

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