BRITISH STANDARD

BS EN ISO
17638:2009

Non-destructive testing of welds — Magnetic particle testing (ISO 17638:2003)

ICS 25.160.40

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN ISO 17638:2009. It is identical to ISO 17638:2003. It supersedes BS EN 1290:1998 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/46, Non-destructive testing.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2010

ISBN 978 0 580 66701 5

Amendments/corrigenda issued since publication

Date	Comments

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 17638

November 2009

ICS 25.160.40

Supersedes EN 1290:1998

English Version

Non-destructive testing of welds - Magnetic particle testing (ISO 17638:2003)

Contrôle non destructif des assemblages soudés - Contrôle par magnétoscopie (ISO 17638:2003)

Zerstörungsfreie Prüfung von Schweißverbindungen - Magnetpulverprüfung (ISO 17638:2003)

This European Standard was approved by CEN on 24 October 2009.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN ISO 17638:2009: E

Foreword

The text of ISO 17638:2003 has been prepared by Technical Committee ISO/TC 44 “Welding and allied processes” of the International Organization for Standardization (ISO) and has been taken over as EN ISO 17638:2009 by Technical Committee CEN/TC 121 “Welding” the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2010, and conflicting national standards shall be withdrawn at the latest by May 2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1290:1998.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 17638:2003 has been approved by CEN as a EN ISO 17638:2009 without any modification.

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 17638 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*.

Non-destructive testing of welds — Magnetic particle testing

1 Scope

This International Standard specifies techniques for detection of surface imperfections in welds in ferromagnetic materials, including the heat affected zones, by means of magnetic particle testing. The techniques are suitable for most welding processes and joint configurations. Variations in the basic techniques that will provide a higher or lower test sensitivity, are described in Annex A.

This International Standard does not specify acceptance levels of the indications. Further information on acceptance levels for indications may be found in EN 1291 or in product or application standards.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3059, *Non-destructive testing — Penetrant testing and magnetic particle testing — Viewing conditions*

ISO 9934-2, *Non-destructive testing — Magnetic particle testing — Part 2: Detection media*

ISO 9934-3, *Non-destructive testing — Magnetic particle testing — Part 3: Equipment*

ISO 17635, *Non-destructive testing of welds — General rules for fusion welds in metallic materials*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17635 apply.

4 Safety precautions

International, national and local safety and environmental protection regulations shall be observed at all times.

Special consideration shall be given to toxic, inflammable and/or volatile materials, electrical safety and unfiltered UV radiation.

5 General

5.1 Information required prior to testing

Prior to testing, the following items shall be specified (where applicable):

a) specific test procedure;

b) certification requirements for NDT personnel;

c) extent of coverage;

d) state of manufacture;

e) testing techniques to be used;

f) overall performance test;

g) any demagnetization;

h) acceptance level;

i) action necessary for unacceptable indications.

5.2 Additional pre-test information

Prior to testing, the following additional information can also be required:

a) type and designation of the parent and weld materials;

b) welding process;

c) location and extent of welds to be tested;

d) joint preparation and dimensions;

e) location and extent of any repairs;

f) post-weld treatment (if any);

g) surface conditions.

Operators may ask for further information that could be helpful in determining the nature of any indications detected.

5.3 Personnel qualification

Magnetic particle testing of welds and the evaluation of results for final acceptance shall be performed by qualified and capable personnel. It is recommended that personnel be qualified in accordance with ISO 9712 or an equivalent standard at an appropriate level in the relevant industry sector.

5.4 Surface conditions and preparation

Areas to be tested shall be free from scale, oil, grease, weld spatter, machining marks, dirt, heavy and loose paint and any other foreign matter that can affect the sensitivity of the test method.

It may be necessary to improve the surface condition, e.g., by use of abrasive paper or local grinding to permit accurate interpretation of indications.

Any cleaning or surface preparation shall not be detrimental to the material, the surface finish or the magnetic testing media.

5.5 Magnetizing

5.5.1 Magnetizing equipment

Unless otherwise specified, e.g., in an application standard, the following types of alternating current-magnetizing equipment shall be used:

a) electromagnetic yokes;

b) current flow equipment with prods;

c) adjacent or threading conductors or coil techniques.

The use of direct current-magnetization or permanent magnets shall be specified prior to testing.

The magnetizing equipment shall conform to ISO 9934-3.

Where prods are used, precautions shall be taken to minimize overheating, burning or arcing at the contact tips. Removal of arc burns shall be carried out where necessary. The affected area shall be tested by a suitable method to ensure the integrity of the surface.

5.5.2 Verification of magnetization

A tangential magnetic field strength of 2 kA/m to 6 kA/m (r.m.s.) is recommended.

Verification of the magnetic field strength shall be carried out using one of the following methods:

a) a component containing fine, natural or artificial imperfections in the least favourable locations;

b) measurement of the tangential field strength as close as possible to the surface using a Hall effect probe. The appropriate tangential field strength can be difficult to measure close to abrupt changes in the shape of a component, or where flux leaves the surface of a component;

c) calculation of the approximate current value in order to achieve the recommended tangential field strength; the calculation can be based on the current values specified in Figures 5 and 6;

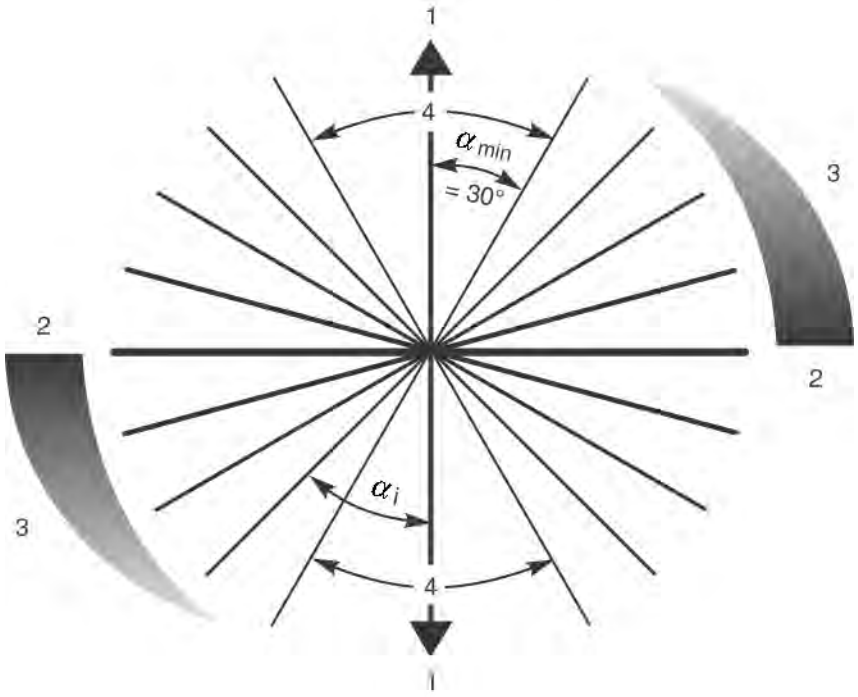
d) other methods based on established principles.

NOTE Flux indicators, placed in contact with the surface being tested, can provide a guide to the magnitude and direction of the tangential field, but should not be used to verify that the field strength is acceptable.

5.6 Application techniques

5.6.1 Field directions and testing area

The detectability of an imperfection depends on the angle of its major axis with respect to the direction of the magnetic field. This is explained for one direction of magnetization in Figure 1.



α is the angle between the magnetic field and the direction of the imperfection.
α_{min} is the minimum angle for imperfection detection.
α_i is an example of imperfection orientation.

Key

1 magnetic field direction
2 optimum sensitivity
3 reducing sensitivity
4 insufficient sensitivity

Figure 1 — Directions of detectable imperfections

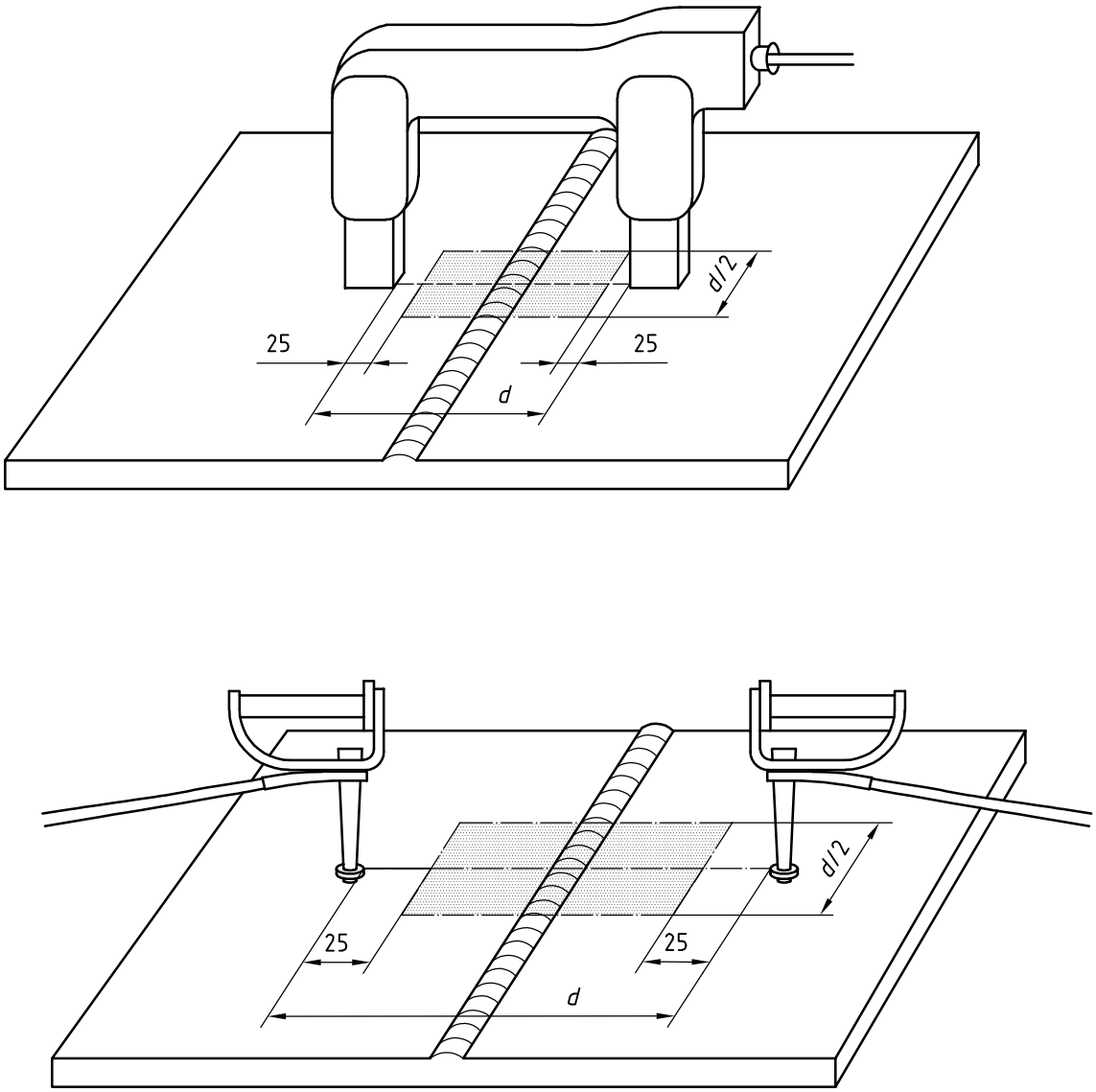
To ensure detection of imperfections in all orientations, the welds shall be magnetized in two directions approximately perpendicular to each other with a maximum deviation of 30°. This can be achieved using one or more magnetization methods.

Testing in only one field direction is not recommended but may be carried out if specified, e.g., in an application standard.

When using yokes or prods, there will be an area of the component in the vicinity of each pole piece or tip that will be impossible to test due to excessive magnetic field strength. This is usually seen as furring of particles.

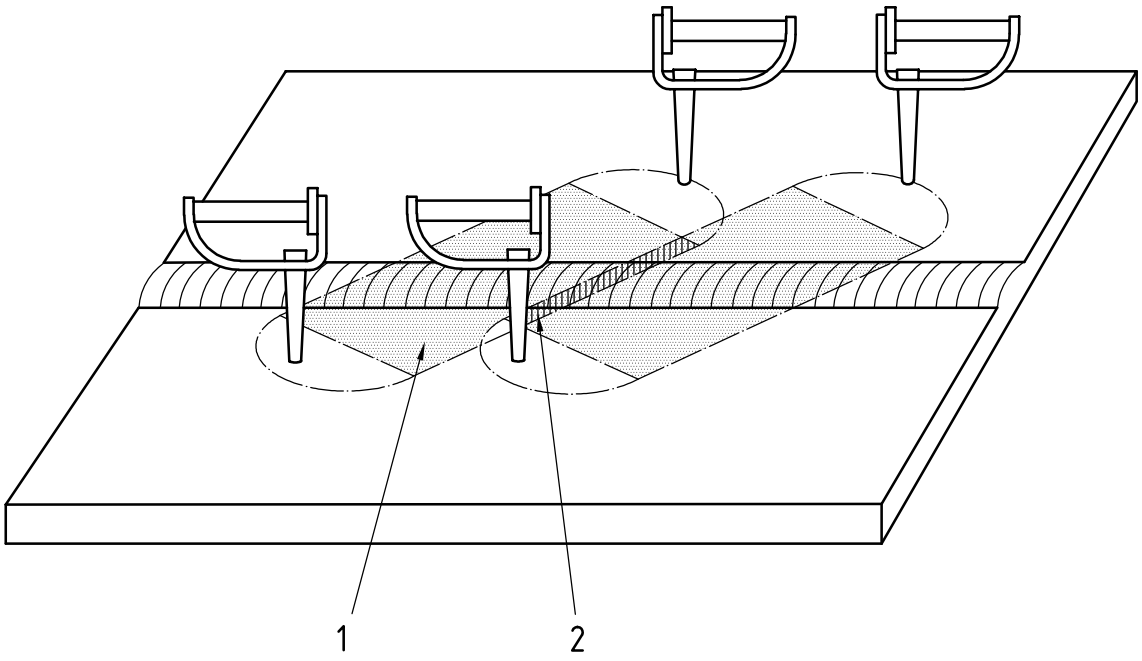
Care shall be taken to ensure adequate overlap of the testing areas as shown in Figures 2 and 3.

Dimensions in millimetres



d is the yoke/prod separation

Figure 2 — Examples of effective testing area (shaded) for magnetizing with yokes and prods



Key

1 effective area

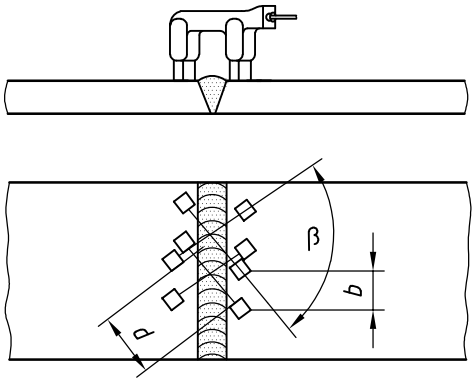
2 overlap

Figure 3 — Overlap of effective areas

5.6.2 Typical magnetic testing techniques

Magnetic particle testing techniques for common weld joint configurations are shown in Figures 4, 5 and 6. Values are given for guidance purposes only. Where possible the same directions of magnetization, and field overlaps should be used for other weld geometries to be tested. The width of the flux current path in the material, d, shall be greater or equal to the width of the weld and the heat affected zone + 50 mm and in all cases the weld and the heat affected zone shall be included in the effective area. The direction of magnetization with respect to the orientation of the weld shall be specified.

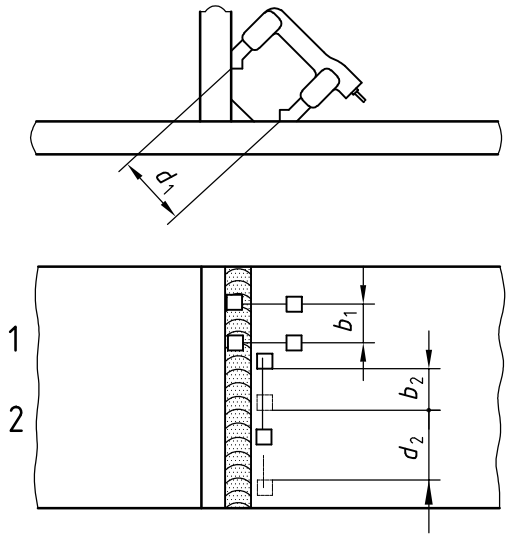
Dimensions in millimetres



$d \geqslant 75$

$b \leqslant d/2$

$\beta \approx 90°$

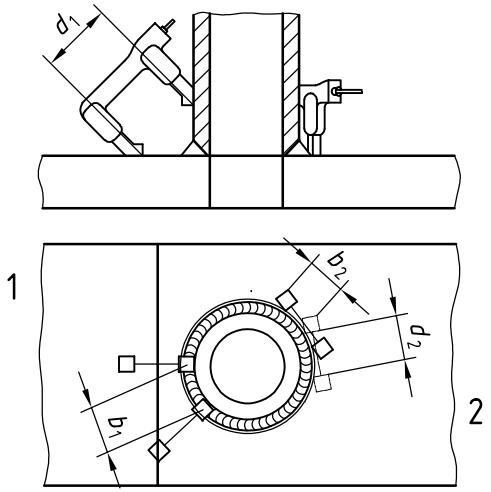


$d_1 \geqslant 75$

$b_1 \leqslant d_1/2$

$b_2 \leqslant d_2 - 50$

$d_2 \geqslant 75$

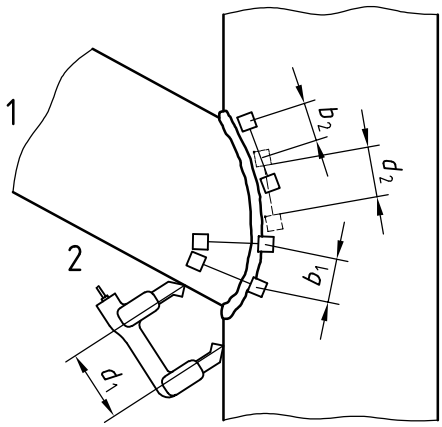


$d_1 \geqslant 75$

$d_2 \geqslant 75$

$b_1 \leqslant d_1/2$

$b_2 \leqslant d_2 - 50$



$d_1 \geqslant 75$

$d_2 > 75$

$b_1 \leqslant d_1/2$

$b_2 \leqslant d_2 - 50$

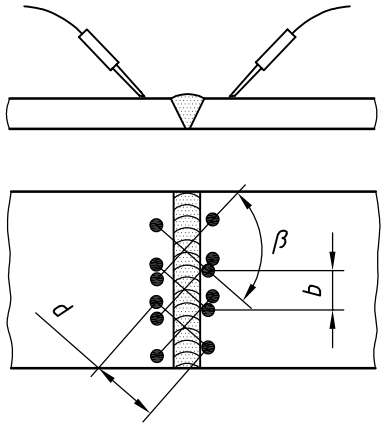
Key

1 longitudinal cracks

2 transverse cracks

Figure 4 — Typical magnetizing techniques for yokes

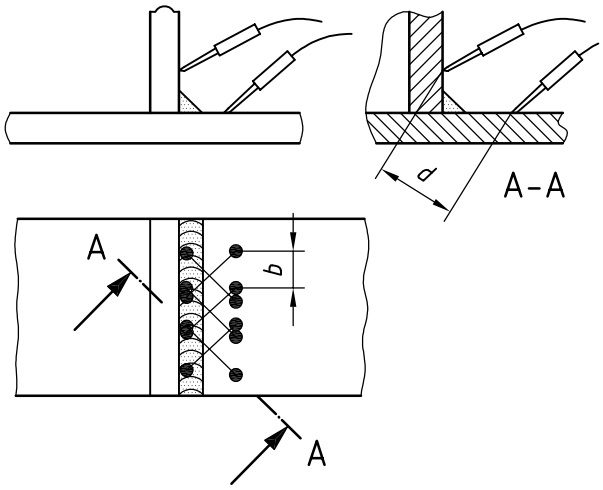
Dimensions in millimetres



$d \geqslant 75$

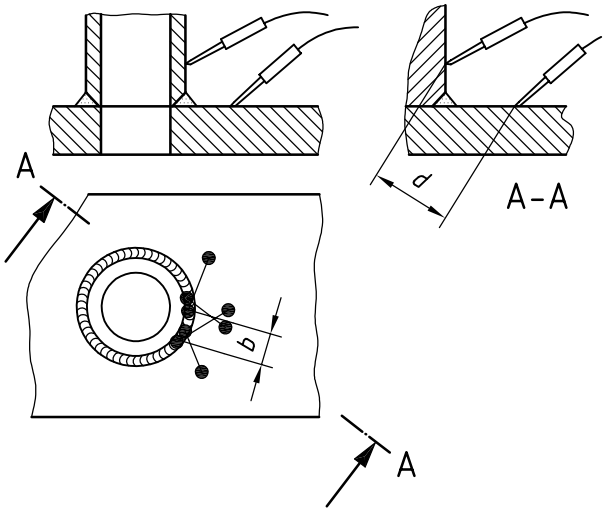
$b \leqslant d/2$

$\beta \approx 90°$



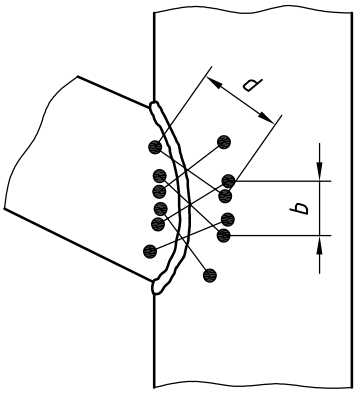
$d \geqslant 75$

$b \leqslant d/2$



$d \geqslant 75$

$b \leqslant d/2$

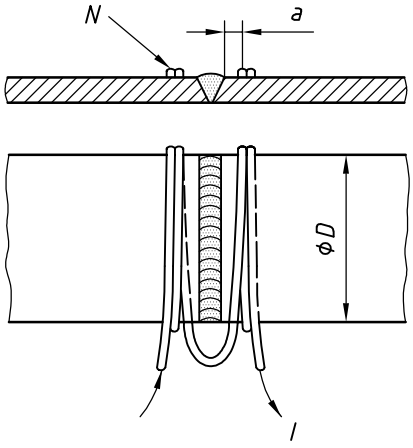


$d \geqslant 75$

$b \leqslant d/2$

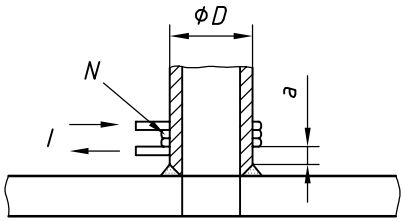
Figure 5 — Typical magnetizing techniques for prods, using a magnetizing current $\geqslant$ 5 A/mm (r.m.s.) prod spacing

Dimensions in millimetres



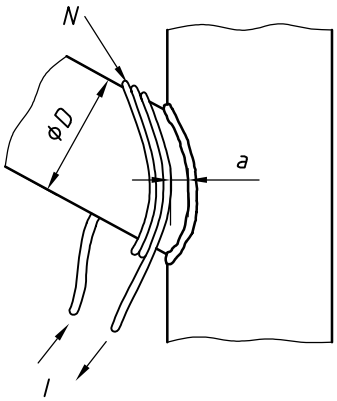
$20 \leqslant a \leqslant 50$

$N \cdot I \geqslant 8D$



$20 \leqslant a \leqslant 50$

$N \cdot I \geqslant 8D$



$20 \leqslant a \leqslant 50$

$N \cdot I \geqslant 8\mathrm{D}$

N is the number of turns
I is the current (r.m.s)
a is the distance between weld and coil or cable

Figure 6 — Typical magnetizing techniques for flexible cables or coils (for longitudinal cracks)

5.7 Detection media

5.7.1 General

Detection media may be either in dry powder or liquid form in accordance with ISO 9934-2.

5.7.2 Verification of detection media performance

Verification of the detection media shall be carried out periodically to confirm continuing satisfactory performance.

The verification shall be carried out on components having known or artificial surface imperfections, or on pre-magnetized reference pieces.

Indications obtained with the medium to be verified shall be compared against those obtained from a medium having a known and acceptable performance. For this purpose the reference indications may be:

a) real imperfections;

b) photograph(s);

c) replica(s).

5.8 Viewing conditions

The viewing conditions shall be in accordance with ISO 3059.

5.9 Application of detection media

After the object has been prepared for testing, the detection medium shall be applied by spraying, flooding or dusting immediately prior to and during the magnetization. Following this, time shall be allowed for indications to form before removal of the magnetic field.

When magnetic suspensions are used, the magnetic field shall be maintained within the object until the majority of the suspension carrier liquid has drained away from the test surface. This will prevent any indications being washed away.

Depending on the material being tested, its surface condition and magnetic permeability, indications will normally remain on the surface even after removal of the magnetic field due to residual magnetism within the part. However, the presence of residual magnetism shall not be presumed and post evaluation techniques after removal of the prime magnetic field source are only permitted when a component has been proven by an overall performance test to retain magnetic indications.

5.10 Overall performance test

When specified, an overall performance test of the system sensitivity for each procedure shall be carried out on site. The performance test shall be designed to ensure a proper functioning of the entire chain of parameters including the equipment, the magnetic field strength and direction, surface characteristics, detection media and illumination.

The most reliable test is to use representative test pieces containing real imperfections of known type, location, size and size-distribution. Where these are not available, fabricated test pieces with artificial imperfections, or flux shunting indicators of the cross or shim-type may be used.

The test pieces shall be demagnetized and free from indications resulting from previous tests.

NOTE It may be necessary to perform an overall performance test of the system sensitivity for each specific procedure on site.

5.11 False indications

False indications which may mask relevant indications can arise for many reasons, such as undercut and changes in magnetic permeability in, e.g., the heat affected zone. Where masking is suspected the test surface shall be dressed or alternative test methods should be used.

5.12 Recording of indications

Indications can be recorded in one or more of the following ways by using:

a) description in writing;

b) sketches;

c) photography;

d) transparent adhesive tape;

e) transparent varnish for “freezing” the indication on the surface tested;

f) peelable contrast-aids;

g) video recording;

h) epoxy or chemical magnetic particle mixtures;

i) magnetic tapes;

j) electronic scanning.

5.13 Demagnetization

After testing welds with alternating current, residual magnetization will normally be low and there will generally be no need for demagnetization of the object under test.

If demagnetization is required, it shall be carried out using a defined method and to a predefined level.[1)]

5.14 Test report

A test report shall be prepared.

The report should contain at least the following:

a) name of the company carrying out the test;

b) the object tested;

c) date of testing;

d) parent and weld materials;

e) any post weld heat treatment;

f) type of joint;

g) material thickness;

h) welding process(es);

i) temperature of the test object, if outside the ambient temperature range;

---

1) For metal cutting processes a typical residual field strength value of $H \leqslant 0{,}4$ kA/m is recommended.

j) identity of the test procedure and description of the parameters used, including:

— type of magnetization;

— type of current;

— detection media;

— viewing conditions;

k) details and results of the overall performance test, where applicable;

l) acceptance levels;

m) description and location of all recordable indications;

n) test results with reference to acceptance levels;

o) names, relevant qualification and signatures of personnel who carried out the test.

Annex A
(informative)

Variables affecting the sensitivity of magnetic particle testing

A.1 Surface conditions and preparation

The maximum test sensitivity that can be achieved by any magnetic testing method is dependent on many variables but can be seriously affected by the surface roughness of the object and any irregularities present. In some cases it can be necessary to:

— dress undercut and surface irregularities by grinding;

— remove or reduce the weld reinforcement.

Surfaces covered with a thin non-magnetic paint e.g. a primer may also be tested, provided the paint surface is unbroken and the thickness of the coating does not exceed 50 µm. Above this thickness the sensitivity of the method decreases and may be demonstrated to be sufficiently sensitive before proceeding with the test.

A.2 Magnetizing equipment characteristics

The use of alternating current gives the best sensitivity for detecting surface imperfections.

Yokes produce an adequate magnetic field in simple butt-welds but where the flux is reduced by gaps or the path is excessive through the object, as in T-joints a reduction of sensitivity can occur.

For complex joint configurations, e.g. branch connections with an inclined angle of less than 90°, testing using yokes might be inadequate. Prods or cable wrapping with current flow will, in these cases, prove more suitable.

A.3 Magnetic field strength and permeability

The field strength required to produce an indication strong enough to be detected during magnetic particle testing is dependent mainly, on the magnetic permeability of the object.

Generally, magnetic permeability is high in softer magnetic materials, e.g., low alloy steels and low in harder magnetic materials, e.g., martensitic steels. Because permeability is a function of the magnetizing current, low permeability materials usually require application of a higher magnetization value than do softer alloys to produce the same flux density. It is essential, therefore, to establish that flux density values are adequate before beginning the magnetic particle testing.

A.4 Detection media

Magnetic particle suspensions will usually give a higher sensitivity for detecting surface imperfections than dry powders.

Fluorescent magnetic detection media usually give a higher test sensitivity than colour contrast media, because of the higher contrast between the darkened background and the fluorescent indication. The sensitivity of the fluorescent method will, nevertheless, decrease in proportion to any increase in the roughness of the surface to which magnetic particles adhere and can cause a disturbing background fluorescence.

Where the background illumination cannot be adequately lowered or where background fluorescence is disturbing, coloured detection media in conjunction with the smoothing effect of a contrast aid will usually give better sensitivity.

Bibliography

[1] ISO 9712, Non-destructive testing — Qualification and certification of personnel

[2] EN 1291, Non-destructive examination of welds — Magnetic particle testing of welds — Acceptance levels

BSI - British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001 Email: orders@bsigroup.com You may also buy directly using a debit/credit card from the BSI Shop on the Website http://www.bsigroup.com/shop

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact Information Centre. Tel: +44 (0)20 8996 7111 Fax: +44 (0)20 8996 7048 Email: info@bsigroup.com

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002 Fax: +44 (0)20 8996 7001 Email: membership@bsigroup.com

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsigroup.com/BSOL

Further information about BSI is available on the BSI website at http://www.bsigroup.com.

Copyright

BSI Group
Headquarters 389
Chiswick High Road,
London, W4 4AL, UK
Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
www.bsigroup.com/
standards