INTERNATIONAL STANDARD

ISO 14324

First edition
2003-07-01

Resistance spot welding — Destructive tests of welds — Method for the fatigue testing of spot welded joints

Soudage par résistance — Essais destructifs des soudures — Méthode pour les essais de fatigue sur assemblages soudés par points

Reference number
ISO 14324:2003(E)

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
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Published in Switzerland

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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.

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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.

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International Standard ISO 14324 was prepared in collaboration with the International Institute of Welding which has been approved by the ISO Council as an international standardizing body in the field of welding.

Resistance spot welding — Destructive tests of welds — Method for the fatigue testing of spot welded joints

1 Scope

This International Standard specifies test specimens and procedures for fatigue testing spot welds, at ambient conditions, under repeated tensile loading to produce either shear or cross-tension loading of the spot weld, in steel of sheet thicknesses of 0,5 mm to 6 mm. The test results are not, in general, directly applicable to the fatigue behaviour of a spot-welded component or structure. This procedure can be used for other materials provided proper test conditions (e.g., heating) have been determined.

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 669, *Resistance welding — Resistance welding equipment — Mechanical and electrical requirements*

ISO 14271, *Vickers hardness testing of resistance spot, projection and seam welds (low load and microhardness)*

ISO 14272, *Specimen dimensions and procedure for cross tension testing resistance spot and embossed projection welds*

ISO 14273, *Specimen dimensions and procedure for shear testing resistance spot, seam and embossed projection welds*

ISO 14329, *Resistance welding — Destructive tests of welds — Failure types and geometric measurements for resistance spot, seam and projection welds*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
cross-tension fatigue test
fatigue test that entails the application of a repeated tensile load to the cross-tension fatigue test specimen mounted between the jaws of the fatigue-testing machine

3.2
endurance limit
maximum load range at which the test specimen can endure a designated number of load cycles without failing

3.3
fatigue life
N
number of cycles that can be applied at a specified load before failure occurs

3.4
fatigue limit[1)]
maximum load range at which the test specimen can endure an infinite number of load cycles

3.5
L-N **curve**[1)]
curve drawn by plotting the load range as ordinate and the fatigue life (or fatigue endurance if the test is terminated before failure) as abscissa, also called the load range-number of load cycles curve

NOTE It is normal practice to use logarithmic axes.

3.6
load amplitude
L_a
half of the load range

$L_a = 0{,}5\Delta L$

3.7
load ratio
R
minimum load divided by the maximum load

$R = L_{min}/L_{max}$

3.8
load range
ΔL
difference between the maximum and minimum loads

$\Delta L = L_{max} - L_{min}$

3.9
maximum load
L_{max}
highest algebraic value of the repeated load

3.10
mean load
L_m
average of the maximum and minimum loads

$L_m = 0{,}5(L_{max} + L_{min})$

3.11
minimum load
L_{min}
lowest algebraic value of the repeated load

3.12
repeated load
L
load varying simply and periodically between constant maximum and minimum values

---

1) Since test results are usually scattered, it may be necessary to establish the L-N curve and the fatigue limit using statistics.

3.13
shear fatigue test
fatigue test that entails the application of a repeated tensile load (hereafter called the load) to the shear fatigue test specimen mounted between clamping jaws of the fatigue-testing machine

3.14
test sheets
metal sheets for spot welding

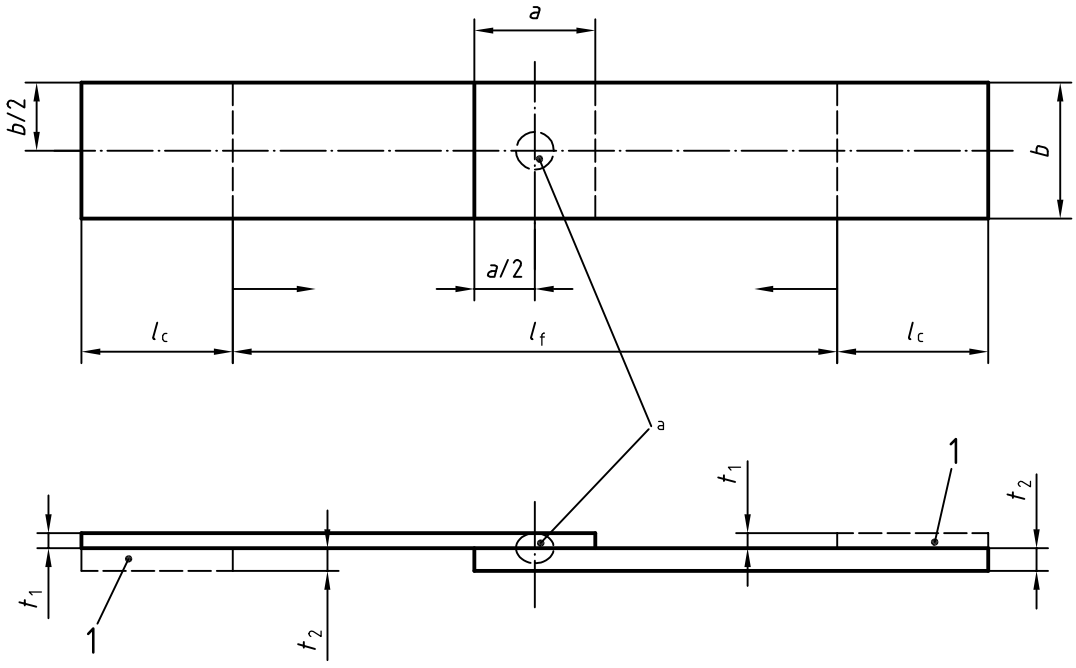
3.15
test specimen
spot welded test sheets

4 Test specimens

4.1 Shape and dimensions

4.1.1 Shear fatigue test

Specimen width b, overlap a, and free length between clamps l_f of the test plates and test specimen used in the shear fatigue test shall be as shown in Figure 1 and Table 1. For joints between plates of different thickness, the dimensions given refer to the thinner plate. Shim plates of appropriate thickness should be used to centre the load.



Key

1 shim plate

NOTE Clamping length l_c should exceed specimen width b.

[a] Spot weld

Figure 1 — Design of shear fatigue test specimen ($t_1 \leqslant t_2$)

Table 1 — Dimensions of shear fatigue test specimens

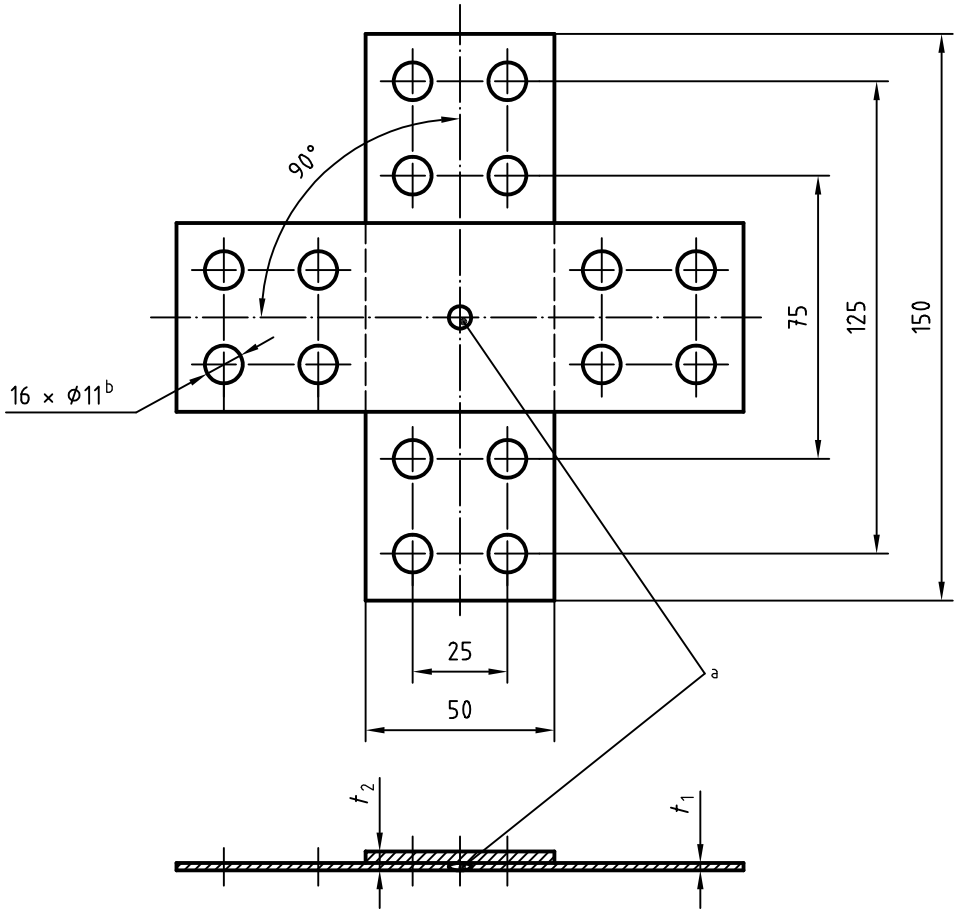
Dimensions in millimetres

Thickness t_1	Specimen width b	Overlap a	Free length between clamps l_f
$0,5 \leqslant t_1 \leqslant 1,5$	$45 \pm 0,5$	35	160
$1,5 < t_1 \leqslant 3$	$60 \pm 0,5$	45	200
$3 < t_1 \leqslant 6$	$90 \pm 0,8$	60	240

4.1.2 Cross-tension fatigue test

Figure 2 shows the design of the cross-tension fatigue test specimen.

Dimensions in millimetres



a Spot weld

b Through holes

Figure 2 — Design of cross-tension fatigue test specimen ($t_1 \leqslant t_2$)

4.2 Test sheets

4.2.1 Test sheets may be in the sheared condition but all edge burrs should be removed.

4.2.2 Care should be taken to ensure that the test sheets are not distorted or bent. Unevenness influences the test results and increases scatter.

4.3 Fabrication of test specimen

4.3.1 When spot-welding the test specimen, a suitable jig should be used to ensure alignment of each sheet. The spot weld should be positioned near the centre of the overlapped area, with a tolerance on eccentricity of $\pm$ 0,3 mm for sheet thickness $\leqslant$ 3,2 mm or $\pm$ 0,5 mm for sheet thickness $>$ 3,2 mm and $\leqslant$ 6 mm, in either type of specimen.

4.3.2 In order to prevent bending of the shear fatigue test specimen when clamping it to the testing machine, either suitable shim plates or offset clamps should be used. The distance between the end of each shim plate and the centre of the spot weld shall be one-half of the value l_f given in Table 1.

5 Testing machine

The testing machine shall have the following capabilities:

a) the clamping jaws of the testing machine shall be capable of securely holding the test specimen or the jig so that it does not slip during testing; moreover, any discrepancy between the centre lines of the jaws shall be minimized;

b) it shall be capable of sufficiently withstanding the maximum load used and of keeping to the accuracy prescribed in f) for the test duration;

c) the testing arrangement should be such that the development of fatigue cracking in either side of the specimen can be monitored visually or by using suitable equipment;

d) testing machines with load or displacement control shall be capable of indicating or recording either the mean load and the load range, or the maximum load and the minimum load, together with the number of applied load cycles;

e) the testing machine shall not automatically restart if stoppages occur due to interruption of the electrical supply or other reasons;

f) the maximum error in the load shall be either 3 % of the indicated load or 0,5 % of the rated capacity of the testing machine.

6 Test methods

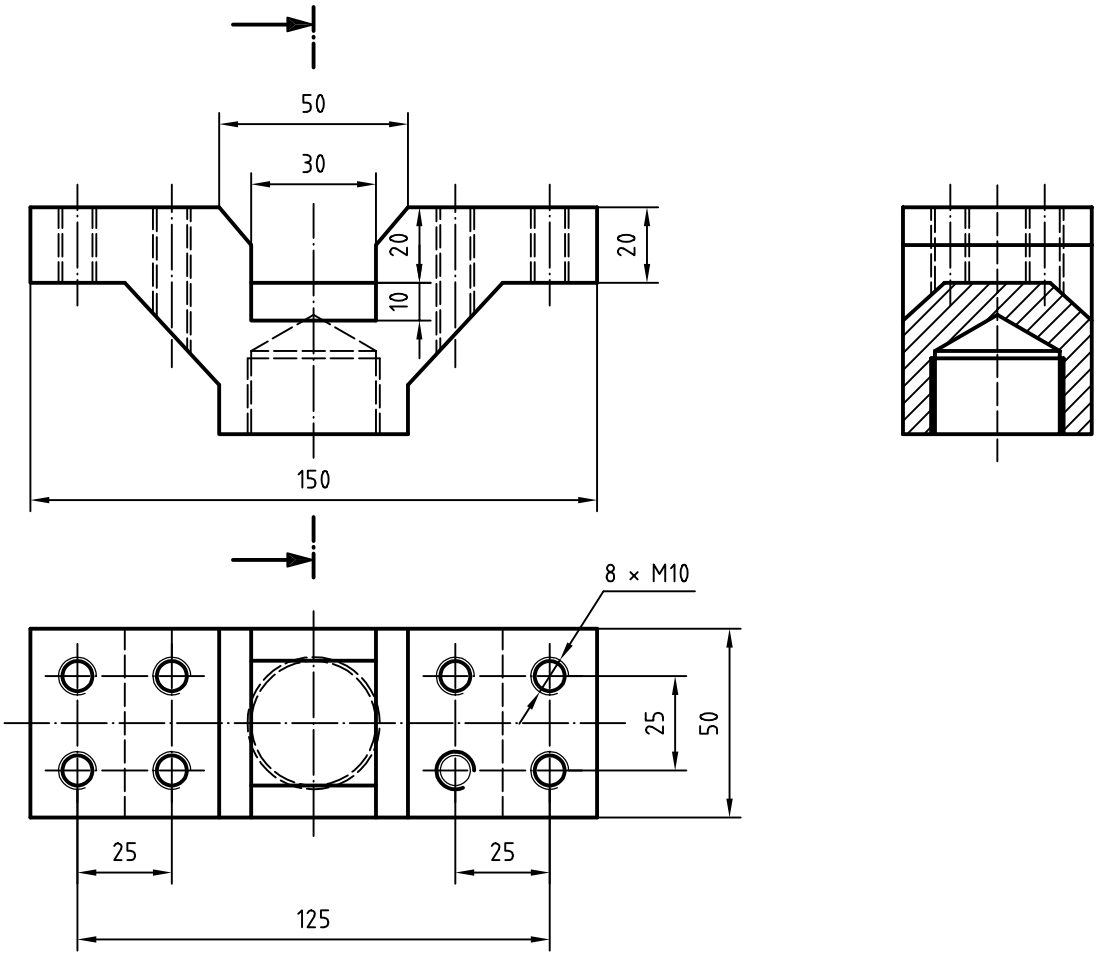
6.1 Test jig

The shape and dimensions of a jig used in the cross-tension test are shown in Figure 3. The chamfered side of the clamping plates shall be positioned on the spot welded side of the test specimen.

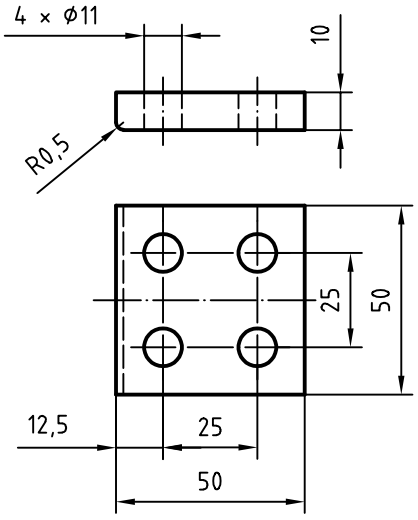
6.2 Clamping of test specimens

At the time of clamping the test specimen, the loading axis of the testing machine and the centre line of the test specimen should coincide. Also, the test specimen shall be firmly mounted in the testing machine, so that it does not loosen during the test. However, the method of clamping shall not impose appreciable forces on the spot weld in the test specimen. When clamping the test specimen, shim plates shall be used to avoid misalignment of the test specimen as shown in Figures 1 and 4.

Dimensions in millimetres

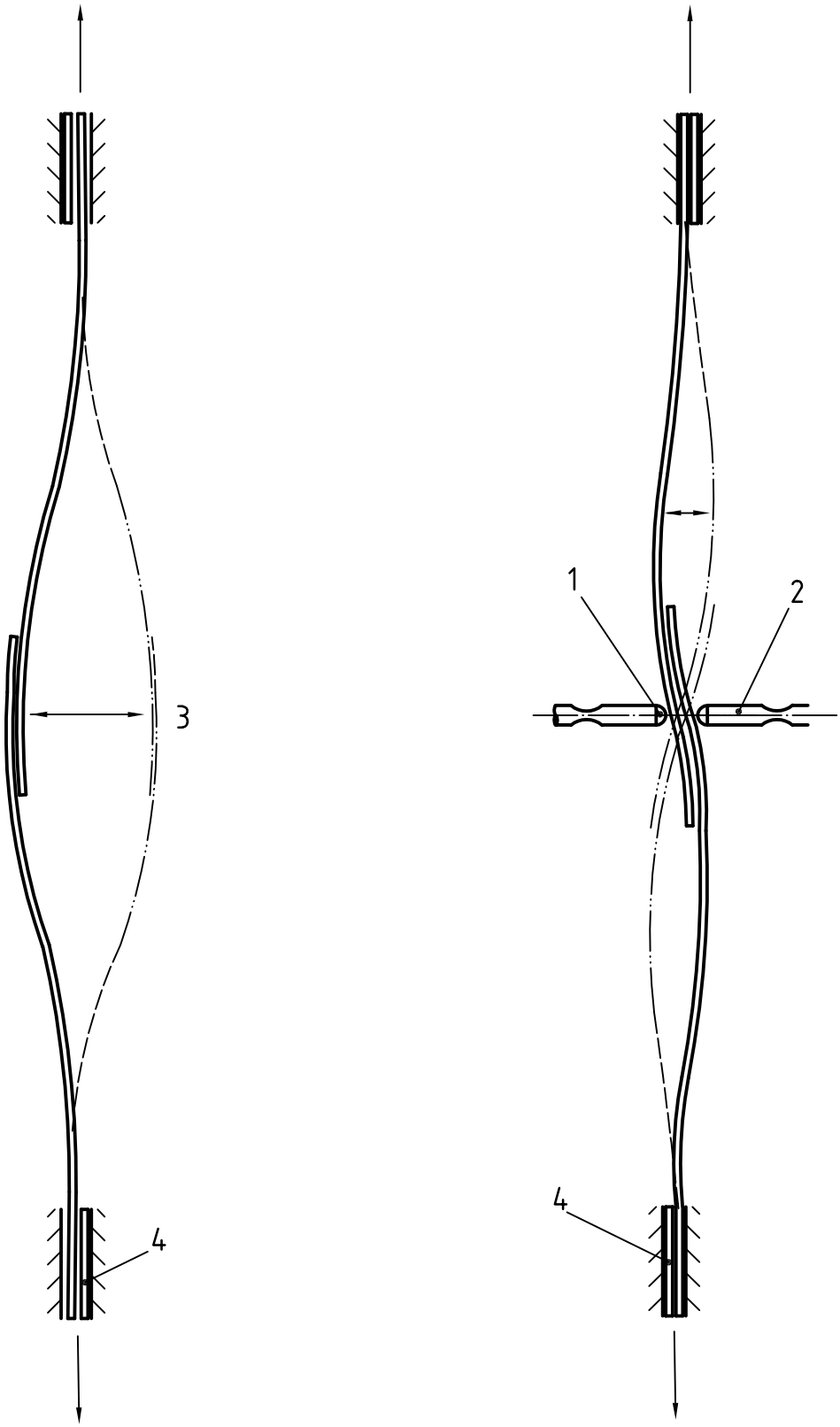


a) Fitting part for fatigue test machine main body (2 pieces)



b) Clamping plate (4 pieces)

Figure 3 — Shapes and dimensions of a jig used in cross-tension fatigue test



a) undesired oscillation **b) acceptable S-type oscillation**

Key

1 low friction surface
2 guide
3 transverse oscillations
4 shim plates

Figure 4 — Unacceptable and acceptable types of transverse oscillations arising during fatigue testing of spot welds in thin sheet

6.3 Test procedure

6.3.1 When commencing the test, the specified load range should be reached as quickly as possible. During this time, the load should not exceed the specified maximum load.

6.3.2 During the test, the maximum load and the minimum load shall be maintained constant.

6.3.3 Transverse oscillations can occur when testing lap welded specimens in thin sheet. Care shall be taken to ensure that if such oscillations do occur, they are only of the S-type (see Figure 4), so that the spot weld is at the oscillation node. This can be achieved by use of a suitable guide to prevent out-of-plane deflections, as shown in Figure 4. The material and design of the guide shall be such that no damage to the spot weld occurs.

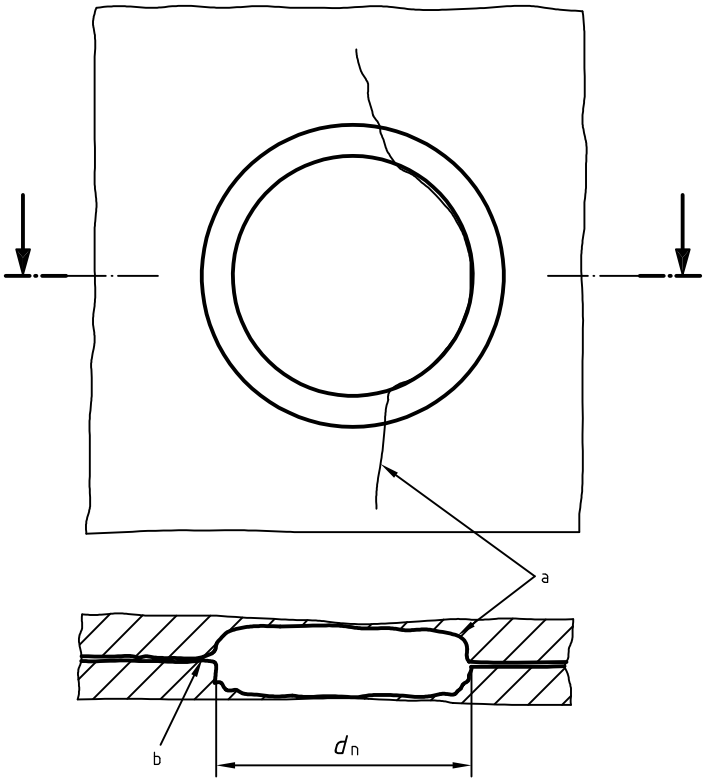
6.3.4 Ideally, the test shall be conducted without interruption. However, if for any reason a test is stopped, records shall be kept of the endurance when the test stopped and the period of time before testing resumed.

6.4 Termination of test

The test shall be terminated when:

a) the specimen fails; failure is defined as the development of cracks of a specified length, at least one diameter of the spot weld (d_n), but of the same value for every test, on one or both outer surfaces of the test specimens, or as complete separation of the test specimens (see Figure 5);

b) the test reaches a specified endurance (e.g., 10^7 cycles) with the test specimens still unbroken. Note that unbroken specimens should not be re-tested.



NOTE End of the test: crack length $> d_n$

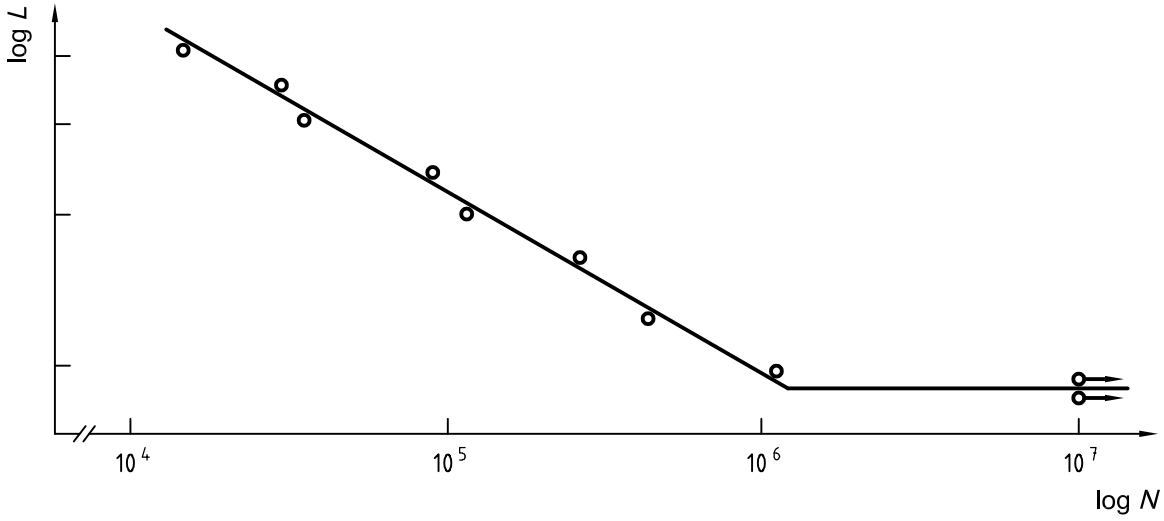
a Crack propagation

b Crack initiation

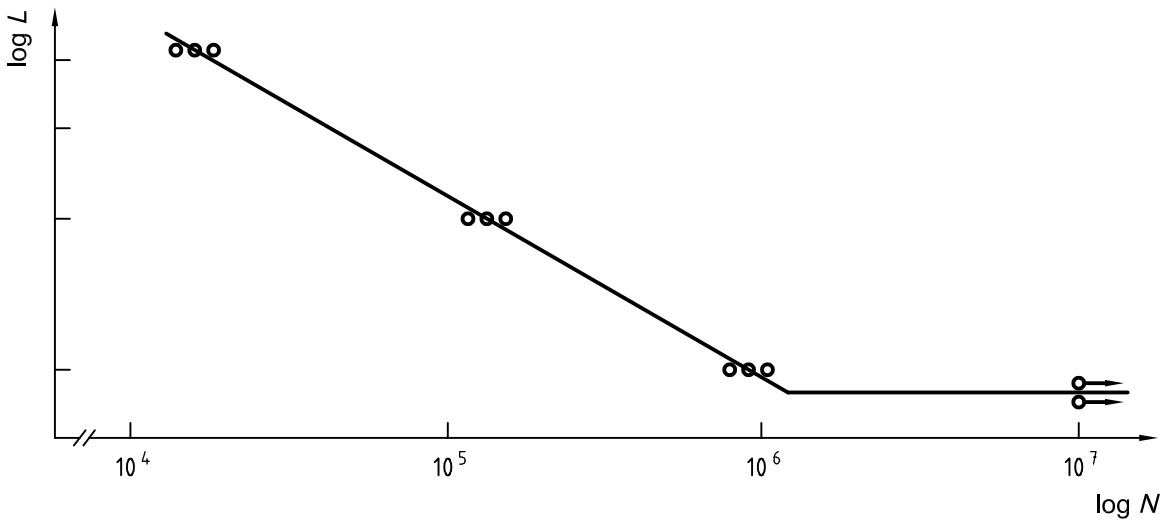
Figure 5 — Definition of failure

6.5 Determination of L-N data

Established testing procedures should be adopted to determine the L-N curve and fatigue or endurance limit. At least 10 test specimens should be used to establish the L-N curve with additional test specimens used specifically to establish the fatigue or endurance limit. Loads should be selected to cover the range of endurances of interest, to be compatible with the method used to determine the L-N curve (see Figure 6). At least three load levels should be used which will result in endurances in the range 10^4 to 10^7 cycles. For higher accuracy at least seven test specimens should be used at each level. Every test in this series should be performed at either the same load ratio, R, or mean load, which should be noted with the test results.



a) Several load levels with no replication



b) Few load levels with replication

Figure 6 — Examples of fatigue data (arrows denote unbroken specimens)

7 Analysis and presentation of test results

The test results may be presented in tabular or graphical form or both. In all cases, the load range, corresponding endurance limit, usually expressed in scientific notation to at least three significant figures (e.g., $2{,}34 \times 10^8$ cycles) and load ratio, R, should be included. For graphical presentation, the load range is plotted as the ordinate and endurance as the abscissa. It is common practice to use double logarithmic scales since the L-N curve will usually be linear. A log scale is always used for the abscissa. Results for unbroken specimens are usually plotted with an arrow pointing rightwards (see Figure 6). The L-N curve and fatigue or endurance limit can be determined using established practice, either by judgement or using statistical methods.

8 Test report

The test report shall contain the following information:

a) date and place of tests;

b) type, name and plate thickness of the test material. The plate thickness shall be given in millimetres as the arithmetic mean value measured in central positions on five arbitrarily selected test sheets, and the value shall be rounded off to two decimal places;

c) chemical composition of the test material;

d) heat treatment and surface treatment conditions, etc., of the test material;

e) mechanical properties of the test material;

f) reference standard(s) and type of test (shear or cross-tension). Note any test deviations;

g) shape and dimensions of the test specimen;

h) identification of weld equipment in accordance with ISO 669;

i) static shear load (arithmetic mean value obtained from nine test specimens in accordance with ISO 14273); tension load (cross-tension type) (arithmetic mean value obtained from nine test specimens in accordance with ISO 14272); nugget diameter, nugget thickness, and nugget diameter of heat affected zone (dimensions of nugget and heat affected zone in accordance with ISO 14329); sheet separation; electrode indentation; hardness (hardness value obtained from three test specimens in accordance with ISO 14271);

j) name, type (constant load or constant displacement type), rated capacity, type of clamping of the testing machine;

k) test conditions, such as load range, mean load, load ratio, R, and cycling frequency: criterion for termination of the test (see 6.4);

l) table of test results (if the specimen consists of two different materials or sheet thicknesses, or both, the one in which the fatigue crack developed should be identified);

m) L-N curves, fatigue limit or endurance limit;

n) reference standard.

ICS 25.160.40

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