INTERNATIONAL STANDARD

ISO 3690

Second edition
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Welding and allied processes — Determination of hydrogen content in ferritic steel arc weld metal

Soudage et techniques connexes — Détermination de la teneur en hydrogène dans le métal fondu pour le soudage à l'arc des aciers ferritiques

Reference number
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 3690 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.

This second edition cancels and replaces the first edition (ISO 3690:1977), which has been technically revised.

Annex A of this International Standard is for information only.

Introduction

During welding processes hydrogen is absorbed by the weld pool from the arc atmosphere. During cooling some of this hydrogen escapes from the solid bead by diffusion but some also diffuses into the HAZ and parent metal. The amount which does so depends on several factors such as original amount absorbed, the size of the weld and the time-temperature conditions of cooling. Other factors being equal, the more hydrogen present in the weld the greater the risk of cracking. The principal sources of hydrogen in welding are:

— moisture contained in and picked up by electrode coatings and fluxes;

— other hydrogenous materials which may break down in the heat of the arc;

— oil, dirt and grease on the plate surface or trapped in the surface layers of welding wires;

— atmospheric moisture during welding.

Measurements of weld hydrogen level therefore provide the means of deciding the degree to which a given welding consumable is introducing hydrogen to the weld pool. They may thus help to categorize the sources of hydrogen and classify different welding consumables. In addition, such measurements provide a starting point for calculating preheating temperatures and temperatures of heat treatment to remove hydrogen after welding.

Hydrogen is unlike other elements in ferritic weld metal in that it diffuses rapidly at normal room temperatures and some of it may be lost before an analysis can be made. This, coupled with the fact that the concentrations to be measured are usually at the parts per million level, means that special sampling and analysis procedures are needed. In order that results be comparable between different laboratories and can be used to develop hydrogen control procedures, some international standardization of these sampling and analysis methods is necessary.

It has become clear from work within the International Institute of Welding that the same sampling and analysis procedure can be used with minor modifications to deal with a number of fusion welding procedures and also for purposes other than the simple classification of consumables. The purpose of this document is therefore to define a standardized procedure of sampling and analysis of weld metal for the determination of hydrogen. The essential features of the International Standard provide for the production of a weld specimen in the form of a rapidly quenched single bead, and the procedure is described in 3.1; 3.2 of this International Standard gives details of the procedures to be used when different welding processes are under investigation. The specimen obtained in this way is then compatible with the recommended analytical techniques specified in 3.3.

There are two principal ways in which this International Standard is intended to be used:

a) To provide information on the levels of weld hydrogen arising from the use of consumables in specific states (e.g. wet or dry), or as a result of the use of specific welding parameters (e.g. different current levels). For such purposes the method can be applied with a variety of welding parameters and states of consumable, and these will be chosen on each occasion in order to provide the specific information sought. It is important however to state such conditions when results are reported so that misunderstandings can be avoided.

b) To enable consumables to be classified and to assist in quality control. In such cases consumables have to be treated in like manner — i.e. with fixed conditions of drying temperature and time, welding current and so on.

It is understood that mercury is a hazardous substance, and that its use may be restricted in some countries. It should be recognized that this International Standard provides a reference method against which all other methods are to be calibrated. Once a proper calibration of an alternate method against this reference method is established, normal testing can be conducted with the alternate method. Then the reference method need only be used in rare instances, such as for checking calibration or in cases of dispute.

Welding and allied processes — Determination of hydrogen content in ferritic steel arc weld metal

1 Scope

This International Standard specifies the sampling and analytical procedure for the determination of diffusible and residual hydrogen in ferritic weld metal arising from the welding of ferritic steel using arc welding processes with filler metal. Collection of the hydrogen over mercury is the primary method. Provided that the weld specimen size is maintained within limits dictated by the size of the test block, variations in welding parameters are permissible in order to investigate the effect of such variables on the weld hydrogen content. The techniques described in this International Standard constitute a reference method which should be used in cases of dispute.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 14175, *Welding consumables — Shielding gases for arc welding and cutting*.

3 Test procedures

3.1 Production of weld specimens

3.1.1 Principle

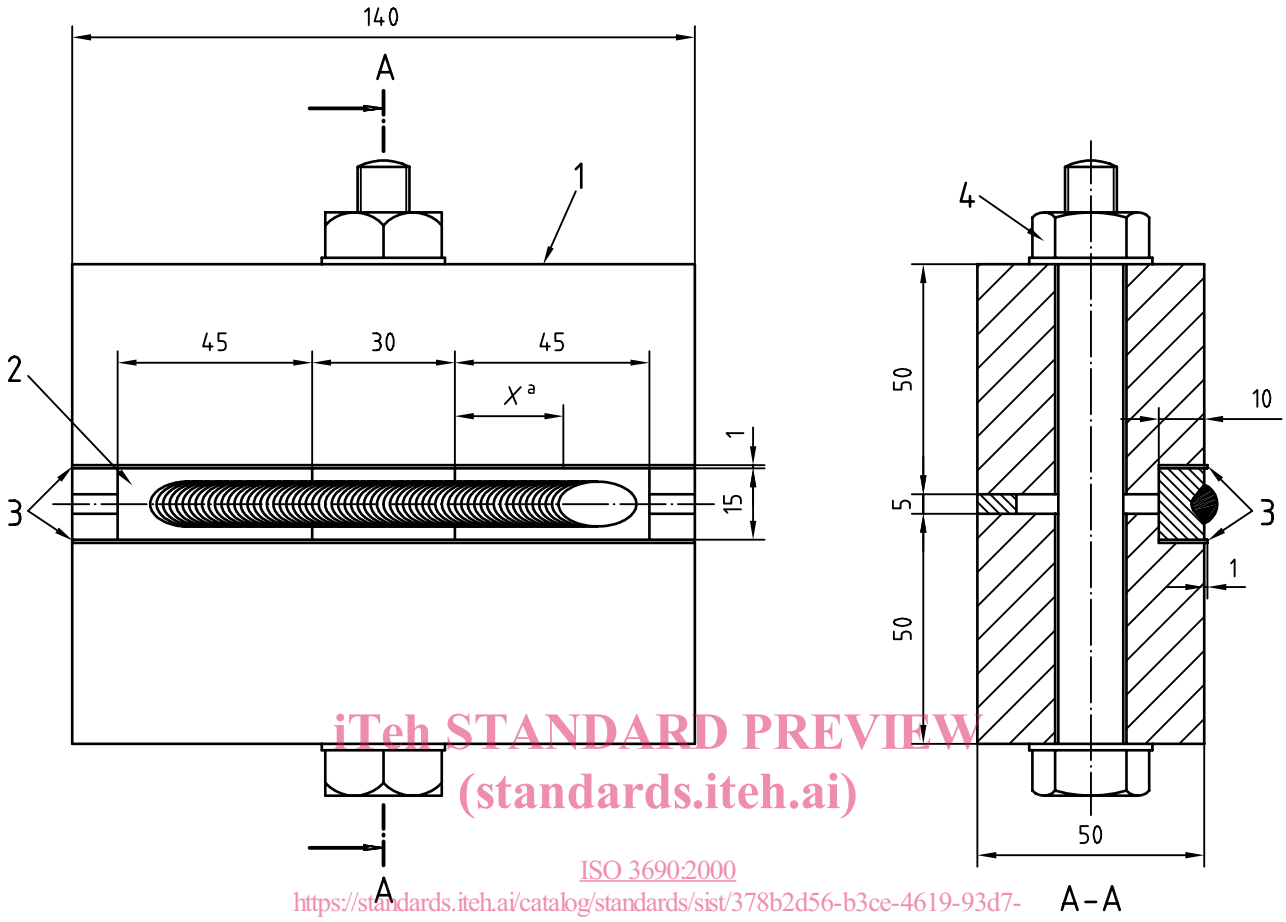
The welding process to be tested is used to deposit a single weld bead which is rapidly quenched and subsequently stored at –78 °C or lower until required for preparation and analysis.

3.1.2 Welding fixture

A copper welding jig for heat inputs up to 2 kJ/mm, which may be water cooled, is shown in Figure 1. It is designed to promote the proper alignment and clamping of the test piece assembly by means of the single clamping unit which is used with a ring spanner or other suitable means. See 3.1.4 for evidence of proper alignment and clamping. A welding jig without water cooling may be used as long as the same dimensions are retained and as long as the temperature is controlled in the manner described in 3.1.4 below.

The welding jig shown in Figure 2 will allow the production of test welds with a heat input greater than 2 kJ/mm and up to about 3 kJ/mm.

Dimensions in millimetres



Key

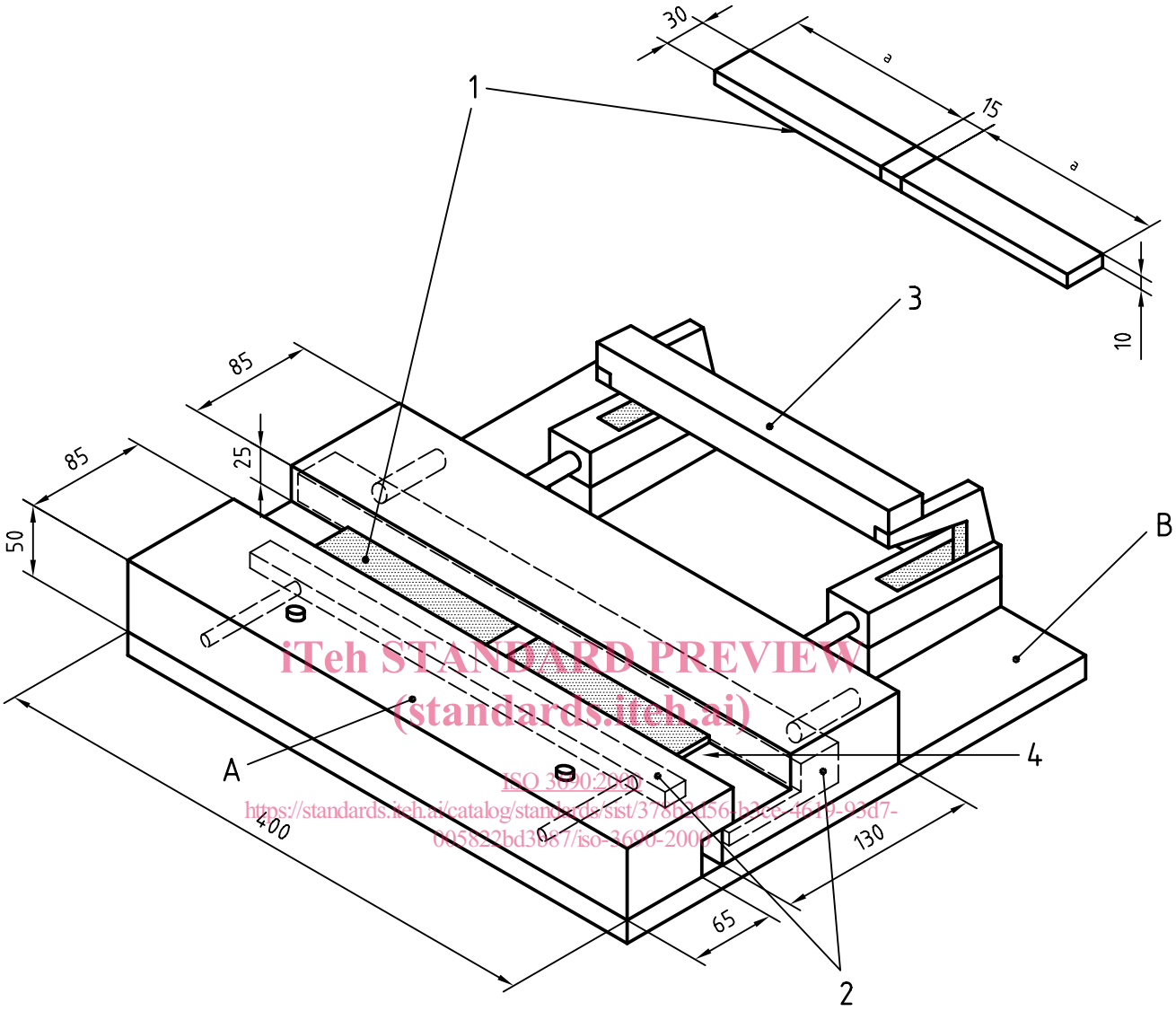
1 Copper block
2 Test piece assembly
3 Copper foil
4 M12 bolt

NOTE Water cooling channels may be used.

a Dimension $X \leqslant 25$ mm.

Figure 1 — Welding fixture and test piece assembly for weld deposits made with heat inputs up to 2 kJ/mm

Dimensions in millimetres



Key

1 Test piece assembly
2 Water cooling jacket
3 Lever clamp
4 Copper foil is inserted here
A Made of copper
B Made of mild steel

NOTE 1 1 mm copper inserts (not shown) for SA are 300 mm × 45 mm.

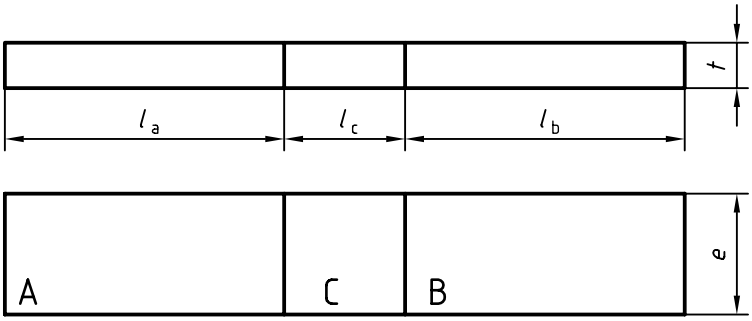
NOTE 2 The run-off bead length shall be such that the trailing end of the crater is on the run-off piece but within 25 mm of the test piece. See distance *X* in Figure 1 for clarity.

[a] 135 mm for submerged arc welding or 85 mm for gas or self-shielded welding.

Figure 2 — Welding fixture and test piece assembly for weld deposits made with heat inputs greater than 2 kJ/mm up to 3 kJ/mm

3.1.3 Test piece assemblies

The test piece assembly shall be prepared from a plain carbon non-rimming steel with a carbon content of not more than 0,18 % and sulfur content of not more than 0,02 %. The test assembly shall be made according to the dimensions shown in Figure 3, with a tolerance of ± 0,25 mm on all dimensions except the length of the run-on and run-off pieces. The lengths shown in Figure 3 for the run-on and run-off pieces are suggestions only.



Dimensions in millimetres

Test assembly		$l_a = l_b$	l_c	e	t
Figure 1		45	30	15	10
Figure 2	Reference 3.2.2	135	15	30	10
	Reference 3.2.3	85	15	30	10
A/B	Run-on / Run-off test piece.				
C	Centre test piece.				
NOTE The centre test piece has the same dimensions in all the three cases.					

Figure 3 — Dimensions of the weld test assembly

All surfaces shall be finished at right angles to ensure good contact between adjacent pieces during the welding operation. Each test piece assembly may be finished with one operation on a surface grinder so as to ensure a uniform width, or closer dimensional control may be exercised to obtain proper clamping. See 3.1.4 for evidence of proper clamping.

Prepare three or more sets of test pieces and number them by engraving or stamping the opposite side to that to be used for welding. Number and degrease each centre test piece in each set. Determine the weight of each centre test piece (m_1) to the nearest 0,01 g. Degas the centre test pieces in a vacuum, or dry inert carrier gas, at 650 °C ± 10 °C for 1 h and cool in a vacuum or inert carrier gas prior to weighing. It is permissible to degas the steel from which the test piece assembly is made prior to machining operations, in which case it is not necessary to degas the centre piece after machining. It is also permissible to degas in air when this is followed by complete removal of surface oxide by grit blasting with a clean, dry abrasive. In case of dispute, the run-on and run-off pieces shall also be degassed.

Certain welding processes, such as submerged arc, or those using high current levels, may produce weld beads incompatible with the dimensions of test piece assembly as shown aligned in Figure 1. In this case, the test assembly shown in Figure 2 shall be used. The centre test piece is the same for both assemblies: it is rotated 90° about a vertical axis. The run-on and run-off pieces shall be compatible with the new cross-section and the length increased to accommodate the longer weld bead. Those welding processes or parameters which necessitate this alternative test piece assembly are specified in 3.2. For all welding processes the test piece assembly is clamped in

the welding fixture using annealed copper foil as shown in Figures 1 and 2. The annealed copper foil may be used to prevent erosion of the fixture. The foil may be annealed repeatedly and quenched in water after each annealing. Oxide scale after annealing is removed by pickling with dilute nitric acid (10 %) followed by washing with distilled water and drying.

3.1.4 Welding and test piece storage

The temperature of the welding jig before each weld is made shall be ambient or not more than 25 °C above ambient. If difficulty is caused by condensation of water on the jig and test piece assembly, it will be necessary to use cooling water thermostatically controlled to ambient temperature or as much as 25 °C higher. Using the welding process as specified in 3.2, and parameters appropriate to the type of investigation, make a single weld bead on the test piece assembly that is clamped in the welding jig as shown in Figure 1 or Figure 2.

a) Welding shall be initiated on the run-on piece at a point sufficiently distant from the centre test piece such that a stable arc and a stable deposit shape are achieved before reaching the centre test piece.

b) Welding shall be terminated with the trailing edge of the crater within 25 mm of the centre piece.

c) After extinction of the arc, and without any delay, the clamp shall be released and the test piece assembly removed and quenched as rapidly as possible to below room temperature in stirred iced water and then transferred to a low-temperature bath saturated with solid carbon dioxide, or to liquid nitrogen.

d) Once chilled, the underside of the central test piece shall be examined to assess the uniformity and extent of heat tinting. Properly aligned and clamped test assemblies shall show parallel and uniform heat tinting of the underside of the central test piece, and dark oxidation shall not extend to the edges of the underside of the central test piece.

e) Slag shall be removed, the run-on and run-off pieces broken off and the centre piece returned to cold storage. The centre pieces may be stored at –78 °C in the solid carbon dioxide bath for a period of up to three days, or at – 196 °C in liquid nitrogen for a number of weeks if necessary, before analysis.

f) For purposes of classifying welding consumables, during welding of the test assembly, the ambient absolute humidity shall be at least 3 g of water vapour per 1 000 g of dry air. (This corresponds to 20 °C and 20 % relative humidity.) When the absolute humidity, measured using a sling hygrometer or other calibrated device, equals or exceeds this condition, the test shall be acceptable as demonstrating compliance with the requirements of this International Standard provided that the actual test results satisfy the diffusible hydrogen requirements of the applicable consumable classification standard.

3.1.5 Recording of data

All welding details such as current, voltage, travel speed, filler metal type and composition, etc. shall be recorded on the appropriate weld data sheet as given in 3.2. It is particularly important to record atmospheric temperature and humidity at the welding station. All these data are reported with the analytical results.

3.2 Welding procedures for the production of weld specimens

The welding process under investigation shall have its operating parameters defined so as to permit the production of a single weld bead on the test piece assembly described in 3.1.

3.2.1 to 3.2.3 describe the procedures for different welding processes.