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2nd edition, 1-1-1986

TECHNICAL SPECIFICATION FOR THE ACCEPTANCE AND SUPPLY OF COATED ELECTRODES FOR MANUAL ARC WELDING OF CARBON, CARBON-MANGANESE AND LOW-ALLOY STEELS

Status of leaflet:

- *obligatory* for all UIC and ORE technical documents,
- *recommendatory* for the technical documents of UIC Member Railways.

REVISIONS

Leaflet 897-1, 2nd edition, 1-1-1986			
Amendment		Amendment	
No.	Date	No.	Date

NOTE

This leaflet is part of a set which includes:

- Leaflets in sub-section 89 (897-1 to 897-13): Welding.

CONTENTS

1 - PURPOSE

1.1 - This specification governs the acceptance and supply of coated electrodes for manual arc welding of carbon, carbon-manganese and low-alloy steels used in the manufacture and repair of rolling stock.

It sets out the minimum conditions required for acceptance purposes and for checking that supplied items comply with approved quality levels.

For special applications, the Railway may also stipulate, on the order or its appended documents, check-tests and special requirements relating to packing, markings and identification colours.

1.2 - Classification

The electrodes shall be defined on the order or its appended documents by the system of symbols laid down in UIC Leaflet 897-2.

2 - CHARACTERISTICS

2.1 - Electrodes

2.1.1 - Physical characteristics

The metal core shall be of uniform quality, with no trace of segregation or oxides, no scaling or other irregularities.

The coating shall be of sufficiently even thickness over both its width and its length, to ensure uniformity of fusion, and shall not possess any defect likely to be detrimental to its use. The coating shall be mechanically sound.

Under normal conditions of voltage and current, as well as those indicated by the supplier, there shall be no difficulty in striking and re-striking the arc, which shall remain stable with no random extinction.

The fusion of the coating shall be uniform in relation to the weld bead, not displaying any loosening or uneven burn-off.

Spatter shall be of moderate size only.

It shall be possible for the slag to be removed easily using a hand tool.

The level of smoke produced during fusion shall be reasonably low.

2.1.2 - Geometrical characteristics

The dimensions and tolerances permitted on the dimensions shall be in accordance with those specified on the order or its appended documents; in the absence of any indications on these documents, the tolerances to be complied with are as follows:

1) On the nominal length: ± 2 mm,

2) On the nominal diameter of the metal core: ± 3% with a maximum of ± 0.1 mm,

3) On the external diameter: ± 3% at all points with a maximum of ± 0.15 mm,

4) On the eccentricity, the maximum value of "e" shown in Figure 6 of Appendix 1 shall not exceed 5% of the nominal diameter of the electrode.

2.1.3 - Symbolisation

The symbolisation of the product shall conform to UIC Leaflet 897-2.

2.1.4 - Marks

Each packet or box of electrodes shall bear the following marks:

- the name of the manufacturer,
- the commercial description of the electrode,
- the number of the manufacturing batch,
- the symbolisation of the electrode in accordance with UIC Leaflet 897-2,
- the diameter of the core and the length of the electrode in mm,
- the number of electrodes per packet,
- the type of current to be used, as well as the minimum and maximum values of the current used,
- in the event of use with DC, the polarity to be used,
- instructions for drying and use,
- the date of manufacture, or the code enabling this to be ascertained must also be stated if so specified in the order or its appended documents.

Each electrode is identified by an inscription on the coating.

2.1.5 - Vapours and fumes given off - Threshold Limit Value (TLV)

During fusion of the electrode, the coating shall not give off vapours or fumes in quantities likely to be harmful under ordinary conditions of use.

With regard to the nature and quantity of fumes, vapours, dust and gases given off, the relevant mandatory working regulations shall be observed.

2.2 - Deposited metal and welded assembly

2.2.1 - Physical characteristics and radiography

No defect due specifically to the electrode shall be accepted when acceptance-testing and checking of supplied materials are carried out.

The required quality standards are those of classes B 1S and A 1 of UIC Leaflet 897-12, Appendices 2 and 3.

The values obtained for the nominal recovery and deposition coefficient shall be in accordance with those specified in the order or its appended documents.

2.2.2 - Chemical characteristics

2.2.2.1 - Chemical analysis

Metal deposition and sampling shall be effected in accordance with the Railway's directives.

2.2.2.2 - Hydrogen content

H if $10 < H_2 \leqslant 15$ cm³/100 gr. under mercury

LH if $H_2 \leqslant 10$ cm³/100 gr. under mercury

2.2.3 - Mechanical characteristics

2.2.3.1 - On deposited metal

Class of steel	Tensile strength Rm (N/mm²)	Yield strength Re (N/mm²)	Elongation at failure A (%)
Fe 360 to Fe 430	430/550	⩾ 355	⩾ 24
Fe 510 and assimilated	510/650	⩾ 380	⩾ 22

Impact-strength: The test temperatures are:

First impact-strength digit	Test temperature (°C)
0	-
1	+ 20
2	0
3	- 20
4	- 30
5	- 40

The mean value (for 3 tests) of the fracture energy in respect of this first impact-strength digit shall be greater than 28 J, no value being less than 20 J.

Second impact-strength digit	Test temperature (°C)
1	+ 20
2	0
3	- 20
4	- 30
5	- 40

The mean value (for 3 tests) of the fracture energy in respect of this second impact-strength digit shall be greater than 47 J, no value being less than 32 J.

2.2.3.2 - On welded joints

The tensile strength shall be greater than the minimum tensile-strength value of the base metal.

- Notched bar impact-strength: see 2.2.3.1 above

- Bend test: Bending through 180° round a radiused former with a thickness equal to twice the thickness of the plate for steels in grades Fe 360 to Fe 430, and to three times the thickness of the plate for grade Fe 510 steels shall not cause cracking. Small superficial cracks which do not extend in depth during bending shall not be considered as a defect. Discovery of larger cracks when taking delivery shall lead to a further check involving an extra bend test as well as a tensile test as per Appendix 2.

3 - MANUFACTURE

The method of manufacture of the electrodes shall be left to the manufacturer's discretion.

The manufacturer shall state the main characteristics of the electrodes and, at the Railway's request, the nature of the manufacturing process.

The manufacturer shall not change the manufacturing method without first warning the Railway.

4 - INSPECTION

4.1 - Inspection of electrodes

The manufacturer shall ensure continuous quality control of his products. He shall have available the requisite installations and equipment for this purpose.

Before submission, each batch of electrodes shall be subjected, under the supplier's responsibility, to the deposited-metal and welded joint tests.

The representative of the Railway shall check the inspection carried out by the manufacturer. He is authorised to take test samples for this purpose.

4.1.1 - Submission

4.1.1.1 - Condition of the electrodes on submission

The electrodes shall be offered ready for delivery.

4.1.1.2 - Batching of the supplies for inspection

The electrodes shall be presented grouped into batches; each batch shall contain only electrodes of the same classification, with the same type of coating and the same nominal diameter.

The size of the batch and batching per load shall be specified in the order or its appended documents.

4.1.1.3 - Advice of submission

The date of submission shall be advised to the representative of the Railway in writing.

This advice shall indicate the quantity of electrodes submitted in each batch, as well as the references of the order by which they are covered. At the time of submission, a certificate showing that the provisions in this specification have been complied with, shall be handed to the representative of the Railway.

4.1.2 - Type and number of checks and tests

The electrodes shall be subjected to the following tests and checks.

4.1.2.1 - Acceptance

Type of checks and tests	Number of checks or tests	
	electrodes $\leqslant$ 2.5 mm in diameter	electrodes $>$ 2.5 mm in diameter
A Checks on electrodes		
- Physical characteristics	1	1
- Geometrical characteristics	1	1
- Fusion test	1	1
B Tests on deposited metal		
- Chemical analysis (1)	1	1
- Verification of hydrogen content or equivalent verification (1)		1
- Tensile test		1
- Impact-strength test (V-notch)		6
C Tests on welded joints		
- Radiographic examination (1)		1
- Tensile test		1
- Impact-strength test (V-notch)		6
- Bend test	2 (3)	2
- Hot-cracking test (1)		1
D Recovery and deposition coefficient (2)		1

(1) To be specified in the order or its appended documents.
(2) Per diameter of electrodes with recovery $\geqslant$ 105% to be tested. To be specified in the order or its appended documents.
(3) Only in the case of electrodes 2.5 mm in diameter.

4.1.2.2 - Inspection of supplied materials

The type and number of checks and tests shall be the same as for acceptance testing purposes, except that the Railway shall select either tests on deposited metal or tests on welded joints.

4.1.3 - Sampling and preparation of samples and test-pieces

4.1.3.1 - Selection of samples

The representative of the Railway shall select, at random, from each batch submitted, the electrodes which he intends for testing, and shall mark the packets or packing indelibly.

4.1.3.2 - Welding of samples

4.1.3.2.1 - General

The samples shall be welded with the electrodes selected.

The steels used shall conform with ISO/R 630:

- at least of grade B,
- in class Fe 360 to 430, for electrodes with a tensile strength of 430 to 550 N/mm^2,
- in class Fe 510 or low-alloy steel in the case of electrodes with a tensile strength of 510 to 650 N/mm^2.

The dimensions of the samples shall be in accordance with those shown in Appendices 1 and 2.

Welding shall be performed in accordance with standard practice.

The current shall always be less than the maximum value indicated by the manufacturer.

The electrode shall be capable of being struck and welded easily at the minimum current specified by the manufacturer.

During tests, the open-circuit voltage at the position of welding shall have the value recommended by the manufacturer.

If either direct or alternating current can be used, the welding shall be carried out using alternating current.

Between each pass, the weld shall be cooled in still air, until a temperature of 250 °C is reached, measured on the surface half way along the weld and 30 mm from its edges.

Each electrode shall be completely used leaving a stub end of not more than 50 mm.

No repair is permitted.

4.1.3.2.2 - Nature of the samples and test-pieces

Checks and tests shall be carried out for each diameter of electrode.

The conventional weld positions are:

Type of samples and test-pieces	Weld position
- for fusion tests	- the weld positions specified by the symbolisation
- for tests on deposited metal (Appendix 1)	- flat
- for tests on welded joints (Appendix 2)	- flat or vertical-up when the symbolisation of the electrode allows this position (1)
- for recovery and deposition coefficient tests	- flat
(1) to be specified in the order or its appended documents	

The sample shown in Appendix 1 of this specification shall be welded as follows:

Weld beads shall be deposited in the normal manner.

The thickness of each weld bead shall be between 2 mm and 4 mm.

The direction of welding shall be reversed for each pass.

The sample shown in Appendix 2 of this specification shall be welded as follows for electrodes of > 2.5 mm diameter:

a) flat

- The first pass shall be deposited using electrodes 3.15 mm in diameter, of the same class as the electrode to be tested;
- The subsequent passes shall be deposited using electrodes of the diameter to be checked;
- The passes shall be deposited in the normal manner.

b) vertical upwards

- The first pass shall be deposited using electrodes 3.15 mm in diameter, of the same class as the electrodes to be tested;
- The subsequent passes shall be deposited using electrodes of the diameter to be checked, limiting weaving to 3.5 times the diameter of the electrode;
- After removal of the root pass, further passes shall be made in the same position using the electrode to be tested.

The 6 mm thick sample, shown in Appendix 2 of this specification, is for electrodes of 2.5 mm diameter.

As regards samples for recovery and deposition-coefficient tests, the mode of operation to be adopted is laid down in UIC Leaflet 897-3.

4.1.3.3 - Preparation of test-pieces

4.1.3.3.1 - General

The weld beads shall be uniform.

The cutting and machining of test-pieces shall be carried out cold and with suitable precautions, to ensure that no appreciable heating of the metal occurs.

The edges shall be smoothed with a file or other tool.

The samples and test-pieces shall not undergo any thermal or mechanical treatment (1).

4.1.3.3.2 - Hydrogen content

The sample intended for checking the hydrogen content shall consist of a section complying with one of the three combinations recommended in Appendix 3 of this specification.

4.1.3.3.3 - Tensile, impact strength and bend tests

The various test-pieces shall be selected as indicated in:

- Appendix 1 of this specification for tests on deposited metal,
- Appendix 2 of this specification for tests on welded joints.

4.1.3.3.4 - Radiographic examination

The radiographic examination shall be carried out on welded samples, before machining.

(1) However, in order to accelerate diffusion of the hydrogen, the tensile test-piece for the test on deposited metal may be brought up to a temperature of 250°C before the test for a period of at least 6 hours but not exceeding 16 hours, with the purchasing Railway's agreement.

4.1.4 - Performance of the checks and tests

4.1.4.1 - Physical and dimensional inspection of the electrodes

Determination of the mean external diameter shall be carried out by taking the average of the measurements taken at points one-third and two-thirds down the length of the electrodes.

Determination of the eccentricity shall be effected by any suitable means.

The diameter and length of the wire of the metal core and the concentricity of the coating shall be checked on 5 electrodes.

The electrode must be capable of being bent, leaving a residual deflection of 20 mm in its centre without deterioration of the coating.

4.1.4.2 - Welding test

The welding deposition test shall be carried out in the positions prescribed by the symbolisation of the electrode.

It is designed to verify easy handling of the electrode in each of these positions.

4.1.4.3 - Hydrogen content

The hydrogen content shall be determined in accordance with Appendix 3 to this specification.

4.1.4.4 - Tensile test

4.1.4.4.1 - For tests on deposited metal

The tensile test-piece and the performance of the test must be in accordance with the provisions of ISO/R 82 Recommendation. The diameter of the test-piece shall be 10 mm and the gauge length 50 mm.

4.1.4.4.2 - For tests on welded joints

The tensile test-piece shall be in accordance with fig. 5 of Appendix 2 of this specification.

4.1.4.5 - Impact-strength test

The impact-strength test-piece and the performance of the test shall be in accordance with the provisions of ISO/R 148 Recommendation.

4.1.4.6 - Bending test

The test shall be carried out in accordance with the provisions in ISO/R 85 Recommendation.

4.1.4.7 - Radiographic examination

The radiographic examination shall be carried out on the welded joints; the order or its appended documents shall state the quality of the image necessary for an appreciation of radiographic sensitivity.

The presence of at least one image quality indicator (I.Q.I.) per film is obligatory.

The X-rayed connection and film shall be clearly marked.

4.1.4.8 - Hot-cracking test

The hot-cracking test shall be carried out in accordance with the Railway's instructions.

4.2 - Inspection results

Any result not conforming with the specification shall lead to refusal of acceptance or of the supply.

A fresh sample may only be welded with the prior agreement of the representative of the Railway.

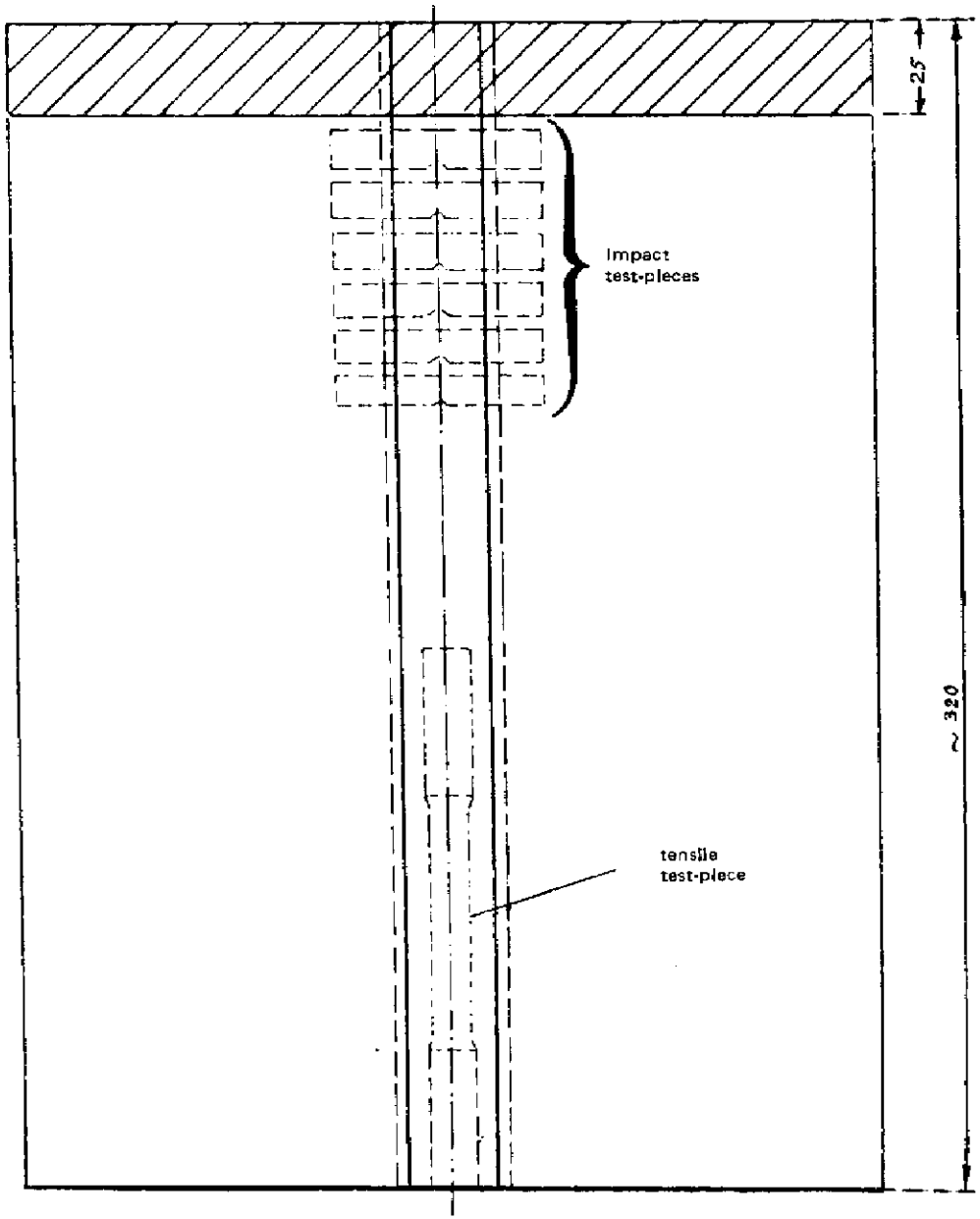
5 - DELIVERY

5.1 - Packaging

After inspection and marking by the representative of the Railway, unless otherwise stipulated in the order, the packing shall be sound enough to protect the electrodes during transport and storage, against any damage, including that brought about by dampness.

5.2 - Guarantee

In principle, acceptance shall be valid for a period of one year, but can be renewed by agreement between the manufacturer or supplier and the Railway.



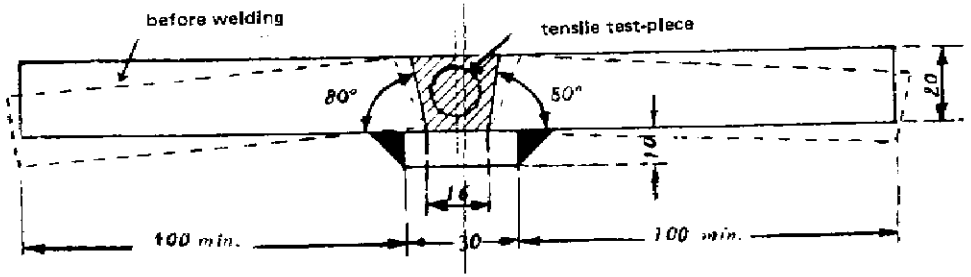


Figure 1

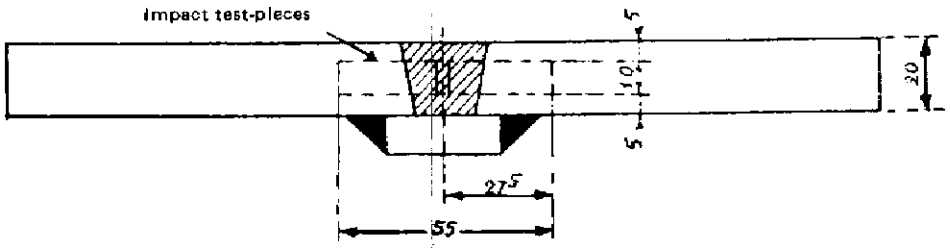


Figure 3

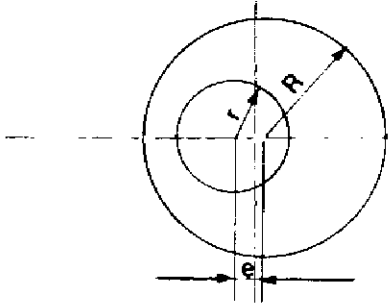
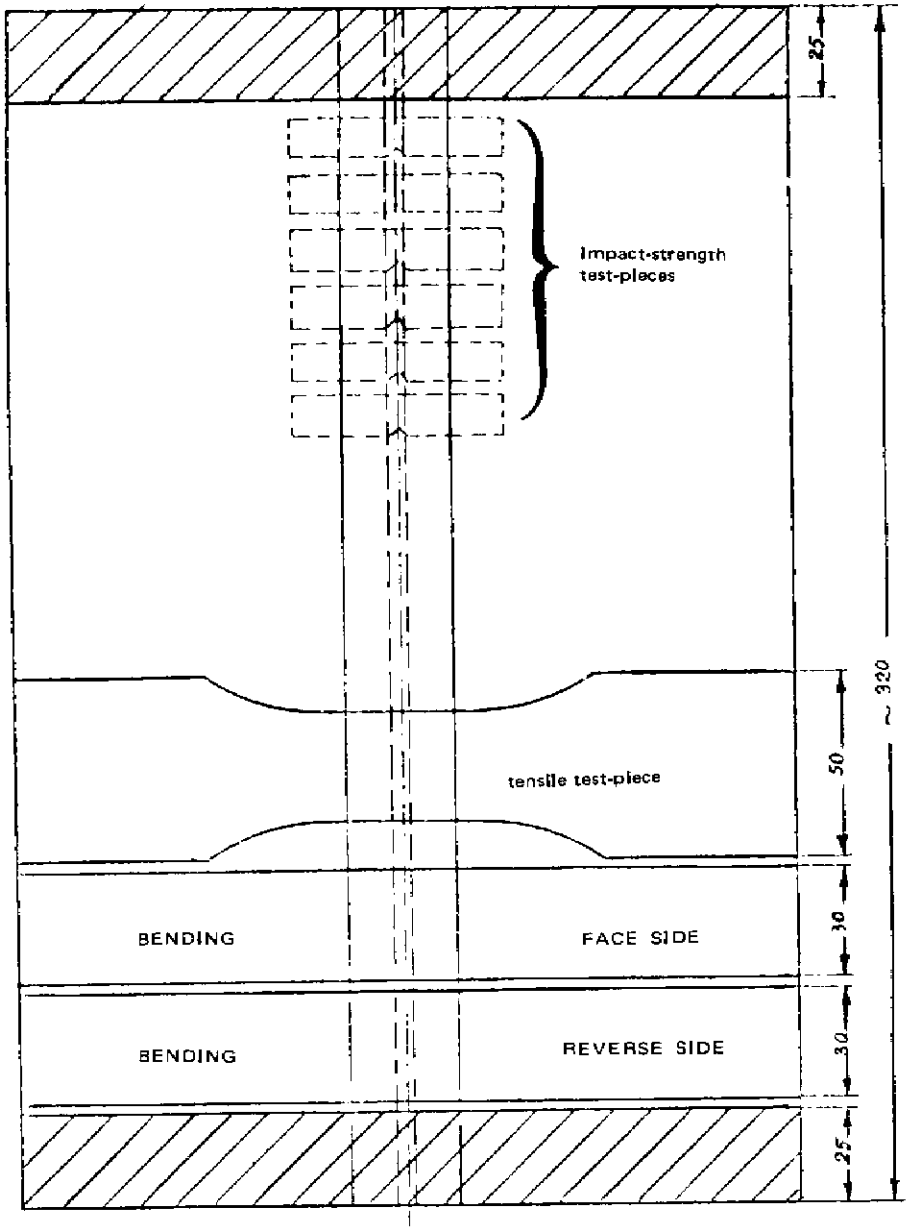


Figure 6



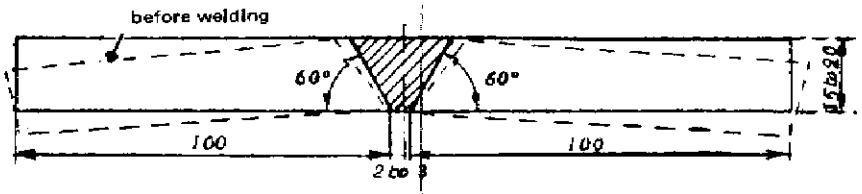


Figure 2

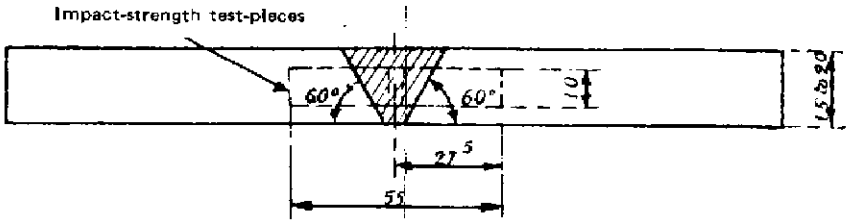


Figure 4

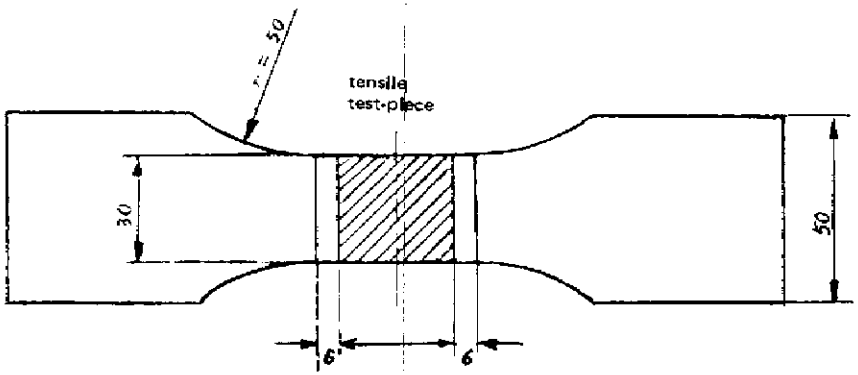


Figure 5

PROCEDURE FOR THE DETERMINATION OF HYDROGEN IN MILD AND LOW-ALLOY STEEL WELD METAL

The procedure described below has been adopted as an international method of reference. For routine purposes, the procedure defined in the German Standard DIN 8572 is suggested as an alternative, to be applied over a transition period in laboratories not accustomed to the use of mercury.

1 - Field of application

The present method is intended for assessment of the content of diffusible hydrogen in weld metal obtained with covered electrodes to which are applicable the recommended rules of testing given in Doc. IIS/IIW-56-60, "Method of testing and approval of electrodes for welding mild and low alloy high tensile steels", (Welding in the World, Vol. 1, No. 1, 1963 pp. 3-17). The same procedure for welding and sampling is also applicable for the determination of total hydrogen contents in mild and low-alloy steel weld metal.

2 - Parent plate material

The test-piece assembly is prepared from a semi-killed grade of steel containing not more than 0.20% C and not more than 0.05% S. Before use for the determination of total hydrogen contents, the test-pieces are degassed under conditions equivalent to those employed in the subsequent hot extraction.

NOTE: Doc. IIS/IIW-315-68 (ex doc. II-468-68) recommended for publication by Commission II "Arc welding" of the IIW and drawn up by Sub-Commission A "Metallurgy of the weld metal". Document drawn up by Commission II of the IIW but not committing the IIW as a whole.

3 - Electrodes

The electrodes to be tested under the present procedure should be of 4 mm core wire diameter, or of 3.15 mm in the case of electrodes of a metal recovery higher than 130%.

The electrodes to be tested are baked at 125°C for two hours if no directions for drying are supplied by the manufacturer; this procedure should not however, be applied to electrodes containing more than 5% by weight of cellulose in their coverings. If the electrode is claimed to be a hydrogen-controlled brand, the baking temperature should be 250°C; if the maker recommends a pre-drying treatment before the electrodes are used, this procedure should be followed.

4 - Welding fixture

A copper jig, as shown in Fig. 1, is used for the alignment and clamping of the test-piece assembly. The temperature of the jig should be 25°C $\pm$ 5°C before testing.

5 - Test-piece assembly

The test-piece assembly shown in Fig. 1 consists of run-on and run-off pieces and a central sample section of 30 mm total length. Duplicate determinations are made using the entire length of this section. It may be divided into four specimens of 7.5 mm length each, as indicated in Fig. 1, or into two specimens of 15 mm each, or one specimen of 15 mm and two

specimens of 7.5 mm. Three optional combinations are recommended.

a) Nos. 1 and 4 (2 x 7.5 mm) analysed jointly,
Nos. 2 and 3 (2 x 7.5 mm) analysed jointly,

b) Nos. 1 and 4 (2 x 7.5 mm) analysed jointly,
Central specimen (15 mm) analysed separately,

c) Two specimens (15 mm each) analysed separately.

The test-piece dimensions specified in Fig. 1 should be respected within the limits ± 0.25 mm; however, each set comprising run-on and run-off pieces and the central section should be finished with a single-grinding operation so as to ensure a uniform width.

The central specimens should be marked and weighed to the nearest 10 mg.

6 - Welding

Duplicate sets of test-pieces are welded for each brand of electrode to be tested. Beads of 100 mm overall length are deposited along the centre-line of the test-piece assembly. No burning-off before testing is allowed.

The welding current is the maximum stated by the manufacturer less 15 A, the machine setting being controlled within a tolerance of ± 5 A. The speed of welding should be adjusted to an electrode consumption between 1.2 and 1.3 cm per cm bead length. The time spent in laying the weld should be noted.

7 - Sampling

Three seconds after extinction of the arc, the jig is released and the test-piece assembly is quenched in iced water and subsequently in alcohol or acetone saturated with solid carbon dioxide. The sample pieces are wire brushed and broken apart when cold. Any interruption in cooling

must be brief, the intervals spent outside the cooling bath in these operations not exceeding 10 seconds each.

The samples may now be stored at dry ice temperature for a period of up to three days before analysis.

In transferring the samples from the cooling bath to the gas burette, a shield of dry nitrogen should be applied in order to avoid condensation of atmospheric humidity. The sequence of operations and the time spent in each of these should be as follows:

a) Wash in alcohol for a period between 3 and 5 seconds;

b) Wash in pure ether for a period between 3 and 5 seconds;

c) Dry in a blast of dry nitrogen supplied from a nozzle, particular attention being paid to the fractured faces of the specimen. This operation must be accomplished in not less than 20 and not more than 22 seconds.

d) A shield of dry nitrogen being maintained, transfer the sample to the outer limb (1) of the burette, where it is held in position clear of the mercury surface by means of a magnet. Evacuate the outer limb of the burette down to a pressure of roughly 0.1 mm mercury. The time spent in these operations must not be less than 20 or more than 25 seconds;

e) Transfer the sample through the mercury air-lock to its final position in the measuring limb of the burette. This operation must be accomplished within 5 seconds.

The total time spent between the transfer of the sample from the cooling bath and the commencement of the measurements should thus not exceed 60 seconds.

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(1) A modified procedure may be substituted for single-limb burettes; see section 9(b).

8 - Principle of analysis

The sample is maintained at room temperature for a sufficient time to release its content of diffusible hydrogen, which is measured by volumetric methods and plotted as function of unit mass of deposited weld metal.

The total hydrogen content is defined for the purpose of the present paper as the sum of the diffusible and residual contents, the latter being determined by hot extraction at 650°C under vacuum or in a carrier gas.

9 - Apparatus for determination of diffusible hydrogen

Examples of gas burettes for the measurement of cold extracted gas are shown in Fig. 2. Burettes of other design may be employed, provided that the following requirements are fulfilled:

a) Mercury is to be used as a confining liquid.

b) It should be possible to maintain the sample under vacuum for a brief period as specified in section 7 (d), in order to remove any trace of foreign gases trapped on the fractured surfaces of the sample. In burettes consisting of a single limb, this may be achieved through manipulation of the mercury level and the stop-cock, any gas released during the brief period of surface degassing being swept out of the burette before the measurements are taken.

c) It should be possible to read the volume of collected gas with a precision of at least 0.05 ml at standard temperature and pressure (STP). For measurements in the range of very low hydrogen contents, it is recommended either to transfer the extracted gas to an apparatus where the amount can be determined by more refined methods, or to use a burette of a design permitting a higher precision.

10 - Analytical procedure (diffusible hydrogen)

The sample is maintained under reduced pressure at 25°C ± 5° for a period of 72 hours, when the final volume is measured.

The samples are removed from the apparatus, ground lightly so as to remove any oxide skin, and weighed to the nearest 10 mg. If it is also desired to determine the amount of weld metal, the cross-section of the bead must be measured on tracings or photographs of the fractured faces. These measurements are made after hot extraction if the residual hydrogen content is also to be assessed.

11 - Evaluation (diffusible hydrogen)

The volume measured after 72 hours is converted to 0°C and 760 mm. This volume divided by one-hundredth of the gain in weight is the diffusible hydrogen content, in ml/100g deposited metal (1).

The weld metal weight is obtained by multiplication of the gain in weight by the average ratio (weld metal/deposit area) determined on the two faces of the specimen, and the diffusible hydrogen content, in ml/100g weld metal (1), is found by dividing the gas volume (STP) by one hundredth of this weight.

Each separate content must be noted, together with the average for each of the two beads tested and the overall average of the four values.

12 - Determination of the residual hydrogen content

Reference is made to Doc. IIS/IIW-153-64 "Determination of total hydrogen contents in weld metal" (Welding in the World, Vol. 3, No. 1, 1965, pp. 13-21) for a description of the apparatus and procedure.

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(1) Multiply by 0.9 for conversion to ppm.

13 - Acknowledgements

The diffusible hydrogen meter which appears in Fig. 2 is reproduced from the British Standard 1719 "Classification, coding and marking of covered electrodes for metal arc welding: 1963, classification and coding" by permission of the British Standards Institution, 2 Park Street, London, W.1., from whom copies of complete standards may be obtained.

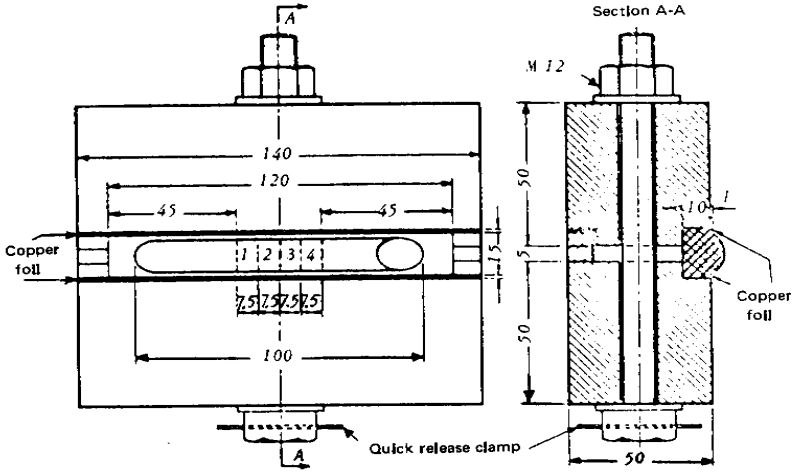
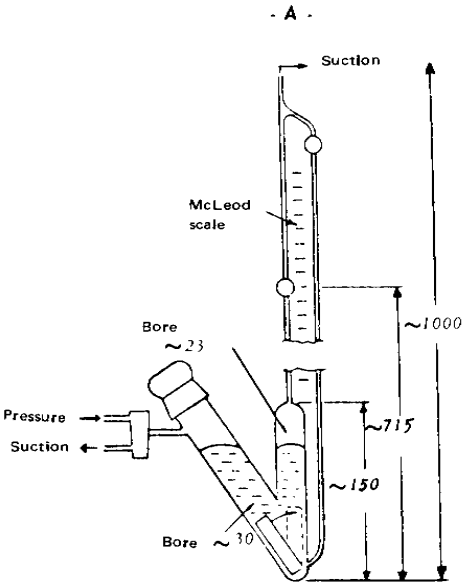
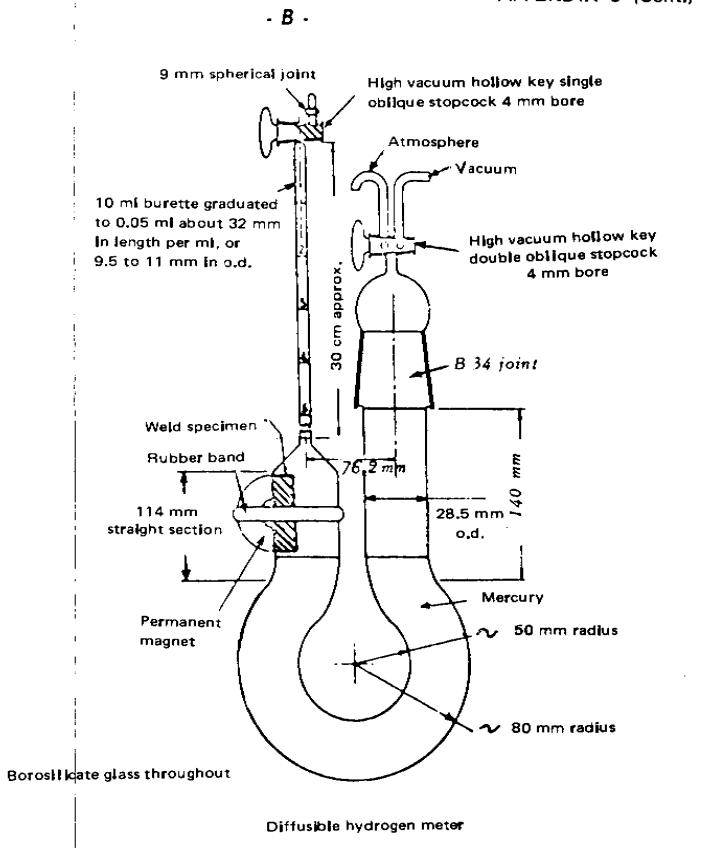


Figure 1

Recommended test-piece assembly

(two or four central sample slices are optional, as explained in the text)





Diffusible hydrogen meter

Figure 2

Examples of burette design

APPLICATION

Effective from 1 January 1986.

All Railways in the Union.

RECORD REFERENCES

Headings under which the question has been dealt with:

- Standardisation of welding materials (electrodes ...).
(Sub-Committee for Specifications, Paris, January 1971; January 1972).

- Question 5/S/27 - Standardisation of welding materials:
III) Amendments to existing leaflets.
(Sub-Committee for Specifications, Paris, January 1977).

- Question 5/Sa/FIC - Revision of leaflets.
Approval of revised leaflet 897-1.
(Traction and Rolling Stock Committee, Paris, June 1984).