SLOVENSKI STANDARD
SIST CEN ISO/TR 17844:2004

01-november-2004

Varjenje ï Primerjava standardiziranih metod za prepreļevanje razpok zaradi mraza (ISO/TR 17844:2004)

Welding - Comparison of standardised methods for the avoidance of cold cracks (ISO/TR 17844:2004)

Schweißen - Vergleich von genormten Verfahren zur Vermeidung von Kaltrissen (ISO/TR 17844:2004)

Soudage - Comparaison de méthodes normalisées pour éviter les fissures a froid (ISO/TR 17844:2004)

Ta slovenski standard je istoveten z: CEN ISO/TR 17844:2004

ICS:

25.160.10 Varilni postopki in varjenje Welding processes

SIST CEN ISO/TR 17844:2004 en

TECHNICAL REPORT

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

CEN ISO/TR 17844

September 2004

ICS 25.160.10

English version

Welding - Comparison of standardised methods for the avoidance of cold cracks (ISO/TR 17844:2004)

Soudage - Comparaison de méthodes normalisées pour éviter les fissures à froid (ISO/TR 17844:2004)

Schweißen - Vergleich von genormten Verfahren zur Vermeidung von Kaltrissen (ISO/TR 17844:2004)

This Technical Report was approved by CEN on 5 December 2003. It has been drawn up by the Technical Committee CEN/TC 121.

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

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

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. CEN ISO/TR 17844:2004: E

Contents

Foreword

This document CEN ISO/TR 17844:2004 has been prepared by Technical Committee CEN/TC 121 “Welding”, the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 44 “Welding and allied processes”.

This document includes a Bibliography.

Introduction

The purpose of this document is to compare currently available methods for determining welding procedures for avoiding hydrogen induced cold cracking during fabrication.

This subject has been extensively studied in recent years and many methods of providing guidance on avoidance of cold cracking have been published. These methods vary considerably in how comprehensively the subject has to be treated. It was considered appropriate to set certain important working criteria for selecting the published methods to be included in this document. In deciding which criteria would be adopted it was agreed that these should include the capabilities for effective use by industry, the end user. Thus the methods should be able to be used on the basis of traditionally available information and relevant factors. The agreed list of criteria was set to include the following main input parameters

— steel composition;

— welding heat input;

— joint geometry and material thickness;

— weld hydrogen level;

— preheat

and in addition

— graphical/computer format of data.

Using the above criteria, the following methods were selected.

— *CE* (EN 1011-2/ISO/TR 17671-2, C.2-Method A);

— *CET* (EN 1011-2/ISO/TR 17671-2, C.3-Method B);

— CE_N (JIS B 8285);

— P_{cm} (ANSI/AWS D1.1).

Each method is considered in a separate clause, under the following headings.

— Description of type of test data used to devise the guidelines, e.g. CTS, y-groove, etc;

— Parent metal composition and range of applicability;

— Material thickness and range of applicability;

— Hydrogen level and welding processes;

— Heat input;

— Other factors/special considerations;

— Determination of preheat (step-by-step example description).

An informative Annex compares and contrasts the predictions of the methods in respect of ten different steels and a range of material thickness, joint geometry's, heat inputs and hydrogen levels.

It is important that any calculations using a given method are undertaken using the current edition of the appropriate standard.

1 Scope

In addition to EN 1011-2/ISO/TR 17671-2, this document contains further methods for avoidance of cold cracking used by other members of ISO. This document gives guidance for manual, semi-mechanized, mechanized and automatic arc welding of ferritic steels, excluding ferritic stainless steels, in all product forms.

Further information about the materials and process parameters is given in Clauses 2 to 5.

NOTE 1 All references are listed in the annex "Bibliography".

NOTE 2 All used abbreviations in this document are explained in EN 1011-2/ISO/TR 17671-2 and Annex B.

2 *CE*-method

2.1 Cracking test method

This method is based on an original concept of critical hardness to avoid HAZ (heat affected zone) hydrogen cracking. It has been empirically developed incorporating the extensive results of HAZ hardenability studies and cracking tests, the latter mainly but not exclusively being the CTS test type. In its present general format the scheme was originally published in 1973 and, with modifications and updates, has been continuously incorporated in British Standards for nearly 25 years. The experience of its use, both in the UK and elsewhere, has been extremely satisfactory.

2.2 Parent metal composition range

The parent metals covered are carbon, carbon manganese, fine grained and low alloyed steels (groups 1 to 3 of CR ISO 15608:2000).

The steels that were used over many years to develop the method have covered a wide range of compositions and it is believed that they are adequately represented by Table 1.

Table 1 — Range of chemical composition of the main constituents for parent metal for *CE*-method

Element	Percentage by weight
Carbon	≥ 0,05 ≤ 0,25
Silicon	≤ 0,8
Manganese	≤ 1,7
Chromium	≤ 0,9
Copper	≤ 1,0
Nickel	≤ 2,5
Molybdenum	≤ 0,75
Vanadium	≤ 0,20

Carbon equivalent values (in %) for parent metals are calculated using the following equation (1):

$$CE_{IIW} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (1)$$

and are applicable to steels with carbon equivalents in the range *CE* = 0,30 % to 0,70 %.

If of the elements in this formula only carbon and manganese are stated on the mill sheet for carbon and carbon manganese steels, then 0,03 % should be added to the calculated value to allow for residual elements and impurities. Where steels of different carbon equivalents or grades are to be joined, the higher carbon equivalent value should be used.

This carbon equivalent formula may not be suitable for boron containing steels.

2.3 Plate thickness and joint geometry

The influence of plate thickness and joint geometry is determined by calculating the combined thickness. This should be determined as the sum of the parent metal thickness averaged over a distance of 75 mm from the weld centre line (see Figure 1).

Combined thickness is used to assess the heat sink of a joint for the purpose of determining the cooling rate.

If the thickness increases greatly beyond 75 mm from the weld centre line, it may be necessary to use a higher combined thickness value.

Steels with thicknesses, t, in the range 6 mm ≤ t ≥ 100 mm were used in the tests to develop the scheme.

2.4 Hydrogen level and welding process

2.4.1 Hydrogen scales

The hydrogen scales to be used for any arc welding process depend principally on the weld diffusible hydrogen content (according to EN ISO 3690) and should be as given in Table 2.

Table 2 — Hydrogen scales

Diffusible hydrogen content (ml/100 g deposited material)	Hydrogen scale
> 15	A
10 ≤ 15	B
5 ≤ 10	C
3 ≤ 5	D
≤ 3	E

Data from a wide range of arc welding processes has been used in developing the scheme and these include manual metal arc (111), gas metal arc with solid wire (131, 135) and tubular wire (136, 137), the latter of both gas shielded and self shielded types, and submerged arc welding (121).

NOTE The numbers in brackets are process numbers according to EN ISO 4063.

2.4.2 Selection of hydrogen scales

The following is general guidance on the selection of the appropriate hydrogen scale for various welding processes.

Manual metal arc welding with basic covered electrodes can be used with the scale B to D depending on the electrode manufacturer's/supplier's classification of the consumable. Manual metal arc welding with rutile or cellulosic electrodes should be used with scale A.

Flux cored or metal cored consumables can be used with scales B to D depending on the manufacturer's/supplier's classification of the wire electrodes. Submerged arc welding with one wire electrode (121) and flux consumable combinations can have hydrogen levels appropriate to scales B to D, although most typically these will be scale C but therefore need assessing for each named product combination and condition. Submerged arc fluxes can be classified by the manufacture/supplier but this does not necessarily confirm that a practical flux wire combination also meets the same classification.

Solid wire electrodes for gas-shielded arc welding (131, 135) and for TIG welding (141) may be used with scale D unless specifically assessed and shown to meet scale E. Scale E may also be found to be appropriate for some cored wires (136, 137) and some manual metal arc covered electrodes, but only after specific assessment. In achieving these low levels of hydrogen consideration should be given to the contribution of hydrogen from the shielding gas composition and atmospheric humidity.

For plasma arc welding (15), specific assessment should be made.

NOTE The numbers in brackets are process numbers according to EN ISO 4063.

2.5 Heat input

Heat input values (in kJ/mm) for use with Figure 2 a) to m) should be calculated in accordance with EN 1011-1/ ISO/TR 17671-1 and EN 1011-2/ISO/TR 17671-2.

For manual metal-arc welding, heat input values are expressed in Tables 3 to 6 in terms of electrode size and weld run lengths.

The details given in Tables 3 to 6 relate to electrodes having an original length of 450 mm. For other electrode lengths the following equation (2) may be used:

$$Run\ length(mm) = \frac{(Electrode\ diameter)^2 \times L \times F}{Heat\ input} \qquad (2)$$

where

L is the consumed length of the electrode (in mm) (normally the original length of 450 mm less 40 mm for stub end);

F is a factor (in kJ/mm^3) having a value depending on the electrode efficiency, as follows:

efficiency approximately 95 %	*F* = 0,0368
95 % < efficiency ≤ 110 %	*F* = 0,0408
110 % < efficiency ≤ 130%	*F* = 0,0472
efficiency > 130%	*F* = 0,0608

Table 3 — Run length for manual metal-arc welding – 95 % electrode efficiency, approximately

Heat input kJ/mm	Run length from 410 mm of a 450 mm electrode of diameter					
	2,5 mm	3,2 mm	4,0 mm	5,0 mm	6,0 mm	6,3 mm
0,8	120	195	300	470		
1,0	95	155	240	375	545	600
1,2		130	200	315	450	500
1,4		110	170	270	390	430
1,6		95	150	235	340	375
1,8		85	135	210	300	335
2,0			120	190	270	300
2,2			110	170	245	270
2,5			95	150	215	240
3,0			80	125	180	200
3,5				110	155	170
4,0				95	135	150
4,5				85	120	135
5,0					110	120
5,5					100	110

Table 4 — Run length for manual metal-arc welding – 95% < electode efficiency ≤ 110%

Heat input kJ/mm	Run length from 410 mm of a 450 mm electrode of diameter					
	2,5 mm	3,2 mm	4,0 mm	5,0 mm	6,0 mm	6,3 mm
0,8	130	215	325	525		
1,0	105	170	270	420	600	
1,2	85	145	225	350	500	555
1,4		120	190	300	430	475
1,6		105	165	260	375	415
1,8		95	150	230	335	370
2,0		85	135	210	300	330
2,2			120	190	275	300
2,5			105	165	240	265
3,0			90	140	200	220
3,5				120	170	190
4,0				105	150	165
4,5				95	135	150
5,0				85	120	135
5,5					110	120

Table 5 — Run length for manual metal-arc welding – 110 %< electrode efficiency ≤ 130 %

Heat input kJ/mm	Run length from 410 mm of a 450 mm electrode of diameter					
	2,5 mm	3,2 mm	4,0 mm	5,0 mm	6,0 mm	6,3 mm
0,8	150	250	385	605		
1,0	120	200	310	485		
1,2	100	165	260	405	580	
1,4	85	140	220	345	500	550
1,6		125	195	300	435	480
1,8		110	170	270	385	425
2,0		100	155	240	350	385
2,2		90	140	220	315	350
2,5			125	195	280	305
3,0			105	160	230	255
3,5			90	140	200	220
4,0				120	175	190
4,5				110	155	170
5,0				95	140	155
5,5				90	125	140

Table 6 — Run length for manual metal-arc welding – electrode efficiency > 130%

Heat input kJ/mm	Run length from 410 mm of a 450 mm electrode of diameter				
	3,2 mm	4,0 mm	5,0 mm	6,0 mm	6,3 mm
0,8	320	500			
1,0	255	400	625		
1,2	215	330	520		
1,4	180	285	445		
1,6	160	250	390	560	620
1,8	140	220	345	500	550
2,0	130	200	310	450	495
2,2	115	180	285	410	450
2,5	100	160	250	360	395
3,0	85	135	210	300	330
3,5		115	180	255	285
4,0		100	155	225	245
4,5		90	140	200	220
5,0			125	180	200
5,5			115	165	180

2.6 Special considerations

2.6.1 Conditions which might require more stringent procedures

The preheating conditions presented in Figure 2 a) to m) have been found from experience to provide a satisfactory basis for deriving safe welding procedures for many welded fabrications. However, the risk of hydrogen cracking is influenced by several parameters and these can sometimes exert an adverse influence greater than accounted for in Figure 2 a) to m). The following covers some of the factors that may increase the risk of cracking to above that envisaged in drawing up the data in Figure 2. Precise quantification of the effects of these factors on the need for a more stringent procedure and on the changes to the welding procedure required to avoid cracking cannot be made at present. The following should therefore be considered as guidelines only.

Joint restraint is a complex function of section thickness, weld preparation, joint geometry and the stiffness of the structure. Welds made in section thicknesses above approximately 50 mm and root runs in double bevel butt joints may require more stringent procedures.