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Health and safety in welding and allied processes — Transparent welding curtains, strips and screens for arc welding processes

Hygiène et sécurité en soudage et techniques connexes — Rideaux, lanières et écrans transparents pour les procédés de soudage à l'arc

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 9, *Health and safety*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 25980:2014), which has been technically revised.

The main changes are as follows:

— hazard level G has been removed;

— requirements regarding luminous and effective blue-light transmittance have been added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html. Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: https://committee.iso.org/sites/tc44/home/interpretation.html.

Health and safety in welding and allied processes — Transparent welding curtains, strips and screens for arc welding processes

1 Scope

This document specifies safety requirements for transparent welding curtains, strips and screens to be used in workplaces where arc welding is taking place. They are intended to provide protection against harmful levels of optical radiation and spatter for workers who are in the vicinity of arc welding processes but not involved in the welding itself. They are intended to reduce the discomfort glare from the arc but also allow sufficient luminous transmittance to permit a view into the workspace behind.

The transparent welding curtains can also be used in other applications as long as the UV- and blue-light emissions are less than in arc welding and the transmitted infrared irradiance is below applicable exposure limits. They are designed to be used at a distance from the arc of at least 1 m.

Welding curtains, strips and screens specified in this document are not intended to replace welding filters. For intentional viewing of welding arcs, other means of protection are used, see ISO 16321-1 and ISO 16321-2.

This document is not applicable to protection against laser radiation, for which ISO 19818-1 applies.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 4007:2018, *Personal protective equipment — Eye and face protection — Vocabulary*

ISO/CIE 11664-1, *Colorimetry — Part 1: CIE standard colorimetric observers*

ISO/CIE 11664-2, *Colorimetry — Part 2: CIE standard illuminants*

ISO 18526-2:2020, *Eye and face protection — Test methods — Part 2: Physical optical properties*

ISO 18526-3:2020, *Eye and face protection — Test methods — Part 3: Physical and mechanical properties*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4007 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
transparent
characteristic of welding curtains, strips and screens that permit visibility of the working place without implying to be glass clear

3.2
effective ultraviolet transmittance
τ_{UV}
normalized value of the spectral transmittance averaged between 200 nm and 400 nm weighted by the relative spectral effectiveness function for ultraviolet

Note 1 to entry: The effective ultraviolet transmittance is usually expressed as a percentage and calculated using Formula (1).

3.3
effective blue-light transmittance
τ_B
normalized value of the spectral transmittance averaged between 300 nm and 700 nm weighted by the relative spectral effectiveness function for blue light

Note 1 to entry: The effective blue-light transmittance is usually expressed as a percentage and calculated using Formula (2).

3.4
luminous transmittance
τ_V
ratio of the luminous flux transmitted to the incident luminous flux for a specified illuminant and photopic vision

Note 1 to entry: The luminous transmittance is usually expressed as a percentage and calculated using Formula (3).

[SOURCE: ISO 4007:2018, 3.10.1.32, modified — Note 1 to entry revised, Note 2 to entry removed.]

4 Requirements

4.1 Transmittance

4.1.1 Infrared transmittance

This document does not provide infrared transmittance requirements. The intensity of the infrared radiation from the welding arc at a distance of more than 1 m is too low to represent a hazard.

Annex A provides information on the basis of the transmittance requirements of this document.

4.1.2 Effective ultraviolet transmittance

When tested in accordance with 5.1.2, the weighted effective ultraviolet transmittance, τ_{UV}, in the wavelength range between 200 nm and 400 nm shall be less than 0,002 %.

NOTE Measurement of spectral transmittance at wavelengths below 250 nm creates measurement problems with noise. Most plastic materials (e.g. PVC and PC) have a very high attenuation and provide sufficient protection at wavelengths < 250 nm.

4.1.3 Effective blue-light transmittance

When tested in accordance with 5.1.3, the weighted effective blue-light transmittance, τ_B, in the wavelength range between 300 nm to 700 nm shall be less than 1,0 %.

4.1.4 Luminous transmittance

When tested in accordance with 5.1.4, the classification based on the luminous transmittance can be expressed in the grades according to Table 1. Annex B provides information on the selection of curtain and grade.

Table 1 — Luminous transmittance

Grade	Luminous transmittance $\tau_{v,D65}$ %	
	Minimum	Maximum
Light	29,0	100,0
Medium	8,5	29,0
Dark	1,0	8,5
Extra dark[a]	0,02	1,0

NOTE The maximum values are taken as equal to or less than and the minimum values are taken as greater than.

[a] Extra dark is normally intended for separation of adjacent operations.

4.2 Resistance to ultraviolet radiation

To ensure that the required protection is maintained and the discomfort glare protection is not markedly altered after exposure to UV radiation, the curtain shall be exposed to a xenon arc that has similar spectral characteristics to welding arcs.

After exposure to UV radiation due to the test specified in 5.2, the curtain shall remain in conformity with 4.1.2 and 4.1.3 and the relative change in luminous transmittance shall not be greater than ± 20 %.

4.3 Resistance to flame spread

When tested in accordance with 5.3.3, the welding curtain, strip or screen material is considered to be satisfactory if for all three samples:

— the flame does not reach the test mark with the burner in position;

— the flame self-extinguishes after removal of the burner;

— the material does not continue to glow for more than 3,0 s after removal of the burner.

4.4 Seam and eyelet strength

If eyelets are used and when welding curtains with thickness < 0,5 mm are tested in accordance with 5.4, there shall be no tearing of any seam or eyelet and/or removal of any eyelet.

5 Test and calculation methods

5.1 Transmittance

5.1.1 General

After preparation, the test specimens shall be maintained at a temperature of (23 ± 5) °C and relative humidity of less than 70 % for a minimum of 16 h before testing.

The methods for measuring spectral transmittance according to ISO 18526-2:2020, Clause 6 shall be applied.

5.1.2 Effective ultraviolet transmittance

τ_{UV} (%) is calculated using Formula (1):

$$\tau_{UV} = 100 \times \frac{\int_{200\text{ nm}}^{400\text{ nm}} \tau(\lambda) \cdot S(\lambda) \cdot d\lambda}{\int_{200\text{ nm}}^{400\text{ nm}} S(\lambda) \cdot d\lambda} \quad (1)$$

where

$\tau(\lambda)$ is the spectral transmittance in the range 200 nm to 400 nm;

$S(\lambda)$ is the spectral efficiency for UV radiation;

λ is the wavelength in nm.

5.1.3 Effective blue-light transmittance

τ_B (%) is calculated using Formula (2):

$$\tau_B = 100 \times \frac{\int_{300\text{ nm}}^{700\text{ nm}} \tau(\lambda) \cdot B(\lambda) \cdot d\lambda}{\int_{300\text{ nm}}^{700\text{ nm}} B(\lambda) \cdot d\lambda} \quad (2)$$

where

$\tau(\lambda)$ is the spectral transmittance in the range 300 nm to 700 nm;

$B(\lambda)$ is the blue-light hazard function;

λ is the wavelength in nm.

5.1.4 Luminous transmittance

For the purposes of this document, CIE illuminant D65, $\tau_{v,D65}$ (%), is used and calculated using Formula (3).

$$\tau_{v,D65} = 100 \times \frac{\int_{380\text{nm}}^{780\text{nm}} \tau(\lambda) \cdot S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda}{\int_{380\text{nm}}^{780\text{nm}} S_{D65}(\lambda) \cdot V(\lambda) \cdot d\lambda} \quad (3)$$

where

$\tau(\lambda)$ is the spectral transmittance in the range 380 nm to 780 nm;

$V(\lambda)$ is the CIE 2° spectral luminous efficiency function for photopic vision in accordance with ISO/CIE 11664-1;

$S_{D65}(\lambda)$ is the spectral distribution of the incident radiation of CIE standard Illuminant D65 in accordance with ISO/CIE 11664-2;

λ is the wavelength in nm.

NOTE The values of the product $S_{D65}(\lambda) \cdot V(\lambda)$ are given in ISO 4007:2018, Table A.3 and can be interpolated when necessary.

5.2 Resistance to ultraviolet radiation

To ensure the stability of the spectral absorption properties of the curtain, a sample shall be tested in accordance with ISO 18526-3:2020, 6.8.3 in a xenon arc test chamber for an exposure time of (100,0 ± 0,2) h. The spectral transmittance is then tested to ensure that the curtain still meets the attenuation requirements of 4.1.2 and 4.1.3. Record the relative change in luminous transmittance as a percentage.

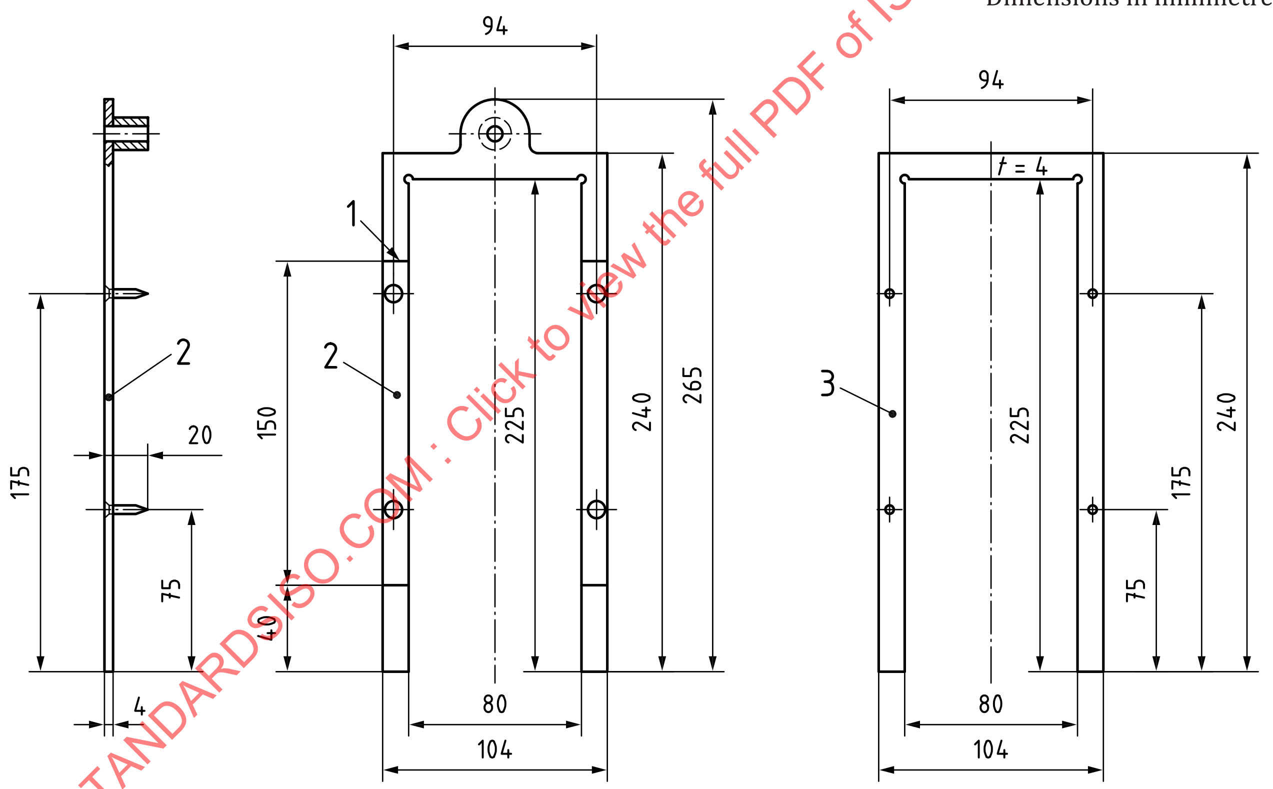
5.3 Resistance to flame spread

5.3.1 Test apparatus

The following apparatus is required:

5.3.1.1 Sample holder, made of rigid metal or non-flammable material with the construction and dimensions shown in Figure 1. The test marks are on the front of part 1 and the locating pins project from the rear of part 1, see Figure 2.

Dimensions in millimetres



Key

1 test mark

2 sample holder part I

3 sample holder part II

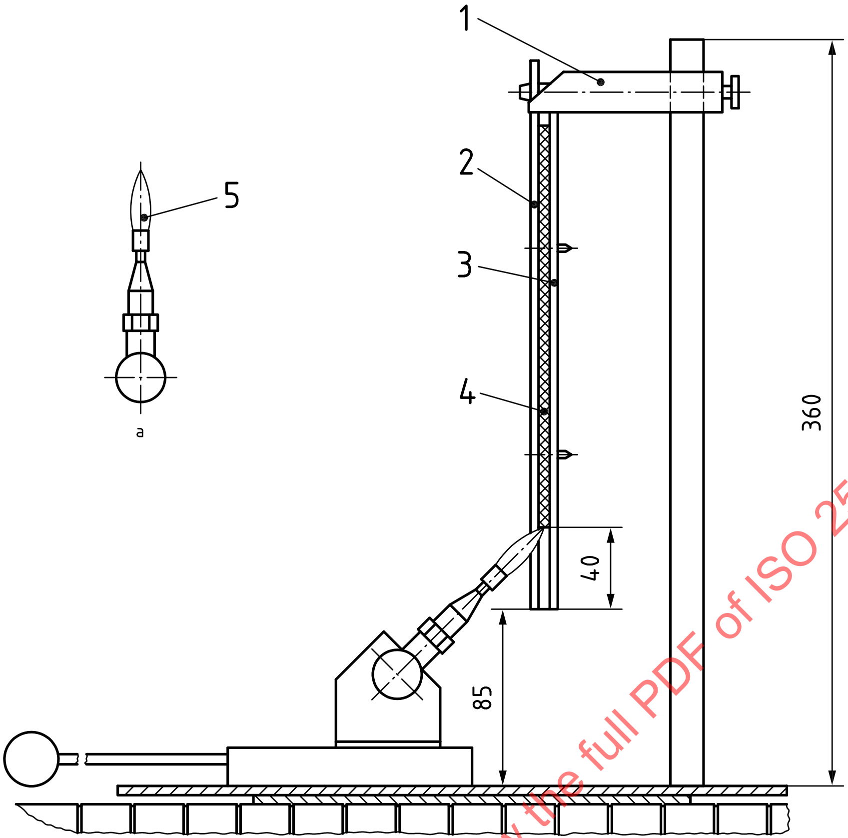
t thickness of sample holder

NOTE All dimensions have tolerances of ± 0,5 mm.

Figure 1 — Sample holder

5.3.1.2 Propane burner, having a nominal visible flame height of 20 mm when put in an upright position (see Figure 2).

Dimensions in millimetres



Key

1 mounting device
2 sample holder part I
3 sample holder part II
4 sample
5 flame
a Position of the burner when setting the flame height.

NOTE All dimensions have tolerances of ± 0,5 mm.

Figure 2 — Burner and testing setup

5.3.2 Test specimens

There shall be three samples cut from the welding curtain, (190 ± 5) mm long and (90 ± 2) mm wide.

5.3.3 Test procedure

a) Testing shall be carried out at (23 ± 5) °C and a relative humidity of less than 70 % in a draught-free environment.

b) Clamp the sample between the two parts of the sample holder (see Figure 2). The lower end of the sample shall be (40 ± 2) mm above the lower end of the sample holder.

c) Suspend the sample and holder as shown in Figure 2.

d) Set the burner upright and allow to burn for at least 60 s.

e) Turn the burner by an angle of 45°.

f) Direct the burner at the bottom of the sample so that the tip of the flame hits the sample in the geometric centre of the lower edge.

g) After 15 s remove the burner and observe whether or not the flame self-extinguishes and the material has ceased to glow within 3,0 s.

h) Carry out a visual inspection to see if the flame has reached the test mark 150 mm above the lower end of the sample.

5.3.4 Test report

Report whether:

a) the flame does not reach the test mark with the burner in position;

b) the flame self-extinguishes after removal of the burner;

c) the material does not continue to glow for more than 3,0 s after removal of the burner.

5.4 Seam and eyelet strength

5.4.1 Test apparatus

The following apparatus is required:

5.4.1.1 Bench stand with an attached horizontal clamp to hold sheet material 100^{+4}_{-6} mm wide evenly in its jaws, allowing the material to hang down freely. The stand shall have a metallic hook of circular cross-section of nominal 6 mm diameter to attach the sheet material by an eyelet. The stand shall allow a sample to hang freely by at least 600 mm.

5.4.1.2 Minimum weight of 7 kg attached to a metallic hook of circular cross-section of nominal 6 mm diameter.

5.4.1.3 Clamp as in item a) but not attached to the stand, with a hole allowing the weight to be hung from the clamp using the attached hook as in item b).

5.4.2 Test specimens

5.4.2.1 Specimen 1

The dimensions of the test specimen shall be 100^{+4}_{-6} mm along the side containing the eyelet under test (if any) and parallel to the seam under test (if any). The other dimension is not critical and should be between 150 mm and 200 mm. If the sample has no eyelet it should be provided with a punched hole with a diameter of 10^{+1}_{-1} mm and 25^{+1}_{-1} mm short of the sides.

5.4.2.2 Specimen 2

The dimensions of the test specimen shall be between 200 mm and 350 mm along the side containing two eyelets under test (if any). The eyelets should be 25^{+1}_{-1} mm short of the cutting edge and parallel to the seam under test (if any). The other dimension is not critical and should be between 100 mm and 200 mm, measured from the underside of the seam. If the sample has no eyelets it should be provided with two punched holes with a diameter of 10^{+1}_{-1} mm and 25^{+1}_{-1} mm short of three sides.

5.4.2.3 Specimen 3

The dimension of the test specimen shall be 350 mm long and 100 mm wide. The sample should have no seams or eyelets.

5.4.3 Test procedure

The procedure shall be as follows:

a) Samples with one eyelet under test (specimen 1): Attach the specimen to the hook on the stand using the eyelet. Attach the clamp at the lower end of the specimen and apply the weight gradually to the hook of the clamp. The weight shall be freely suspended for at least 60 s.

b) Samples with two eyelets under test (specimen 2): Attach the specimen to the hook on the stand using one eyelet. Apply the weight gradually to the lower eyelet of the specimen using the attached hook. The weight shall be freely suspended for at least 60 s.

c) Samples with no eyelets under test (specimen 3): Attach the specimen to the stand by using the clamp. Attach the other clamp to the lower end of the specimen and apply the weight gradually to the hook of this clamp. The weight shall be freely suspended for at least 60 s.

Inspect the samples for tearing of any seam, tearing of any eyelet and/or removal of any eyelet and record.

5.4.4 Test report

Any tearing of a seam, tearing of an eyelet or removal of an eyelet shall be reported.

6 Marking

6.1 General

When checked in accordance with ISO 18526-3:2020, Clause 8, all markings shall be at least 10 mm high and shall be clear and sufficiently durable to remain legible throughout the lifetime of the curtain, screen or strips.

6.2 Mandatory markings

The markings shall be:

a) manufacturer's, distributor's or importer's name or trademark;

b) month and year of manufacture;

c) number of this document (i.e. ISO 25980);

d) grade of the curtain.

7 Information for users

The manufacturer shall provide with each welding curtain, strip and screen at least the following information:

a) name and address of the manufacturer, distributor or importer;

b) number and year of publication of this document (i.e. ISO 25980:2023);

c) model identification;

d) special instructions for storage, use and maintenance, if any;

e) a statement “that welding curtains, strips or screens with defects must be replaced or repaired”;

f) the following warning: "WARNING: LOCATE AT A DISTANCE OF NOT LESS THAN 1 METRE FROM THE ARC."

g) specific instructions for cleaning, if any;

h) instructions for fitting;

i) any special precautions regarding disposal of used curtains.

The manufacturer should additionally provide the following information, if applicable:

— details of the fields of use, protection capabilities and performance characteristics;

— any specific instructions for fitting with or to suitable accessories;

— spare parts.

Annex A
(informative)

Basis of the transmittance requirements of this document

A.1 General

Welding curtains, screens and strips (welding curtains, for short) are intended to protect workers in the vicinity of welding, other than the welder, from the effects of optical radiation generated by the welding process. The process of electric arc welding produces high levels of ultraviolet (UVR) and visible radiation. It also produces moderate levels of near infrared radiation (NIR).

ISO 19734:2021, 4.2 and Table 1 contains a comprehensive list of the effects of optical radiation on the eye. The spectral sensitivity for each process of damage and the exposure limits are contained in the publications of the International Commission on Non-Ionizing Radiation Protection.[5,6] All of these effects are relevant to the consideration of welding curtains.

Protection of the welder, who is close to and looking at the welding arc, is well covered by ISO 16321-2 and is achieved with fixed or auto-darkening filters in a goggle, helmet or hand shield. The recommended shade number of the welder's filter, see ISO 19734:2021, Table 6, is related to the type of welding and, in electric welding, the current used.

Other workers in the vicinity are exposed to lower doses since they are at a greater distance and are not viewing the arc for extended periods of time.

The possible exceptions are pingueculae and pterygium, although the evidence is contradictory to some extent. Since these two conditions arise from radiation incident from the side rather than the front of the face, it could be the radiation from the welding arcs of other workers in the vicinity rather than their own work that is responsible.

Welding curtains are intended to protect those other workers in the vicinity who are at a further distance from the arc and have no need to look at the arc. These applications can include both manual and robotic welding.

The original booths, screens and curtains were opaque but, for over 40 years, transparent curtains have been used. These have the advantage that, while they protect skin and eyes and reduce glare from the welding arc, they also allow a view into the welding workplace so that the workers can be observed to ensure that they are well and to facilitate appropriate supervision. The workers are also given a view of their surrounding workplace and workers, minimising any feeling of isolation. However, there does need to be adequate reduction of discomfort glare.

A.2 Welding arc data used

In this document, the protective requirements have been derived from the sensitivity to damage of the skin and cornea (from UVR), the retina (from the biological effects of UVA and short wavelength visible and the thermal effects of visible and NIR). Furthermore, the requirements of this document have been based on the spectral data from 189 welding arcs in the INFR data set, including welding of non-alloy steels, highly alloyed steels, cast iron, copper alloys and aluminium alloys.[7] Data on a further seven arcs in the IFA data set[8] did not contain wavelengths beyond 800 nm, so E_{IR} could not be calculated, but they were used for visible and UVR calculations.

The derivation is on the basis that the worker to be protected is at least 1 m away from the arc.

A.3 Protection of the crystalline lens from infrared radiation

The value of infrared irradiance, E_{IR}, in W·m^2 at 1 m was calculated according to ICNIRP[5] for each arc in the INFR set according to Formula A.1:

$$E_{IR} = \sum_{780\ \text{nm}}^{3\,000\ \text{nm}} E_{\lambda} \cdot \Delta\lambda \qquad \text{(A.1)}$$

where

E_{λ} is the spectral irradiance at wavelength λ;

$\Delta\lambda$ is the bandwidth in nm.

There was a total of three arcs (of the 189) for which the value of E_{IR} at 1 m was found to exceed the unlimited time exposure limit of 100 W·m^{-2}.[5] The actual values were 132 W·m^{-2}, 143 W·m^{-2} and 157 W·m^{-2}. To exceed the limit in the worst case would require the worker to be at that 1 m distance and for the arc to be ignited continuously for a total time exceeding 550 s (9,4 min). This is unlikely so that the possibility of exceeding the exposure level in practical circumstances is remote. In the worst case the infrared irradiance is reduced to 100 W·m^{-2} at a distance of 1,25 m. In addition, there is a safety margin in the setting of any limit.

As a consequence, setting a minimum distance for the curtain from the arc of 1 m was considered to provide sufficient protection against infrared radiation and there is no need for an infrared transmittance requirement to be set in this document.

A.4 Protection of the skin and cornea from ultraviolet radiation

The value of the integrated irradiance, E_s, in W·m^2 at 1 m was calculated for each arc in the INRS and IFA data sets (196 arcs) according to Formula (A.2).

$$E_s = \sum_{200\ \text{nm}}^{400\ \text{nm}} E_{\lambda} \cdot S(\lambda) \cdot \Delta\lambda \qquad \text{(A.2)}$$

where

E_{λ} is the spectral irradiance at wavelength λ;

$S(\lambda)$ is the actinic ultraviolet hazard weighting function;

$\Delta\lambda$ is the bandwidth in nm.

The values of $S(\lambda)$ are provided in Table 1 of Reference [6].

All the 196 arcs had a value of E_S at 1 m greater than the 8 h exposure limit of 0,001 W·m^{-2}.[6] The worst case was a value of 48,9 W·m^{-2} for welding aluminium alloy at 220 A. To reduce this value to below the exposure limit of 0,001 W·m^{-2} requires a welding curtain maximum transmittance of $\tau_{UV} < 0{,}002$ %. The worst case of the data contained in Table 24-2 in Reference [9] indicates a need for a maximum transmittance 0,004 %, so this is essentially consistent. The requirement of $\tau_{UV} < 0{,}002$ % is also consistent with the requirement in the previous edition of this document.

A.5 Protection of the retina from the blue-light hazard

The largest arc in the sample had a diameter of 6,3 mm. At a distance of 1 m this subtends 0,006 rad. This is less than the small image limit of 0,011 rad,[5] so the arc can be analysed as a small image.

The value of effective blue-light irradiance, E_B, in W·m^2 at 1 m was calculated for each arc according to Formula (A.3).

$$E_B = \sum_{300\text{ nm}}^{700\text{ nm}} E_\lambda \cdot B(\lambda) \cdot \Delta\lambda \qquad \text{(A.3)}$$

where

E_λ is the spectral irradiance at wavelength λ;

$B(\lambda)$ is the blue-light hazard weighting function;

$\Delta\lambda$ is the bandwidth in nm.

The values of $B(\lambda)$ are provided in Table 2 of Reference [6].

170 of the 196 arcs had a value of E_B > 1 W·m^{-2}. The highest value was 26,7 W·m^{-2}. Reduction of this value to below the ICNIRP[5] exposure limit of ≤ 1 W·m^{-2} for a source with a small angular subtense (≤11 mrad) requires a transmittance of τ_B ≤ 3,7 %. The value of 1,0 % has been adopted as the maximum for effective blue-light transmittance. Effective blue-light transmittance was not specified in the previous edition of this document.

Earlier studies[10]–[12] used a maximum value of ≤ 0,01 W·m^{-2}, which is now associated with larger sources (>11 mrad).[5] The dose from small sources is less because the normal small repetitive eye movements (micro-nystagmus) will distribute the dose over an area of retina.

A.6 Reduction of discomfort glare

In this document, the luminous transmittance is used to provide guidance to the users on the amount by which a curtain will reduce the discomfort glare of the welding arc.

CIE standard illuminant A is representative of an incandescent lamp, once widely used for interior lighting. Welding arcs and modern factory lighting are much richer in the blue end of the spectrum so the luminous transmittance to CIE standard illuminant A will possibly not give an accurate guide to reduction of discomfort glare. In particular, it will under-represent the discomfort glare reduction of red and orange curtains. As a consequence, CIE standard illuminant D65, having a spectral distribution much more like the modern high intensity discharge or LED factory lighting and welding arcs, is used in this document.

The previous edition of this document required the measurement of luminous transmittance to CIE standard illuminant A, but there was no requirement based on that value. The requirement of a hazard level, G, less than 1, in effect, limited curtains to a maximum luminous transmittance of 12 % (CIE A) or 7 % (CIE D65), so lighter curtains, as permitted under national standards and which had proved useful in practice, could not comply.[13]

The value of luminous transmittance to CIE standard illuminant D65, $\tau_{v,D65}$, is calculated for each arc according to Formula (A.4).

$$\tau_{v,D65} = \frac{\sum_{380\text{ nm}}^{780\text{ nm}} \tau(\lambda) \cdot S_{D65}(\lambda) \cdot V(\lambda) \cdot \Delta\lambda}{\sum_{380\text{ nm}}^{780\text{ nm}} S_{D65}(\lambda) \cdot V(\lambda) \cdot \Delta\lambda} \qquad \text{(A.4)}$$

where

$\tau(\lambda)$ is the spectral transmittance of the curtain at wavelength λ;

$S_{D65}(\lambda)$ is the spectral distribution of the incident radiation of CIE standard Illuminant D65 according to ISO/CIE 11664-2;