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INTERNATIONAL STANDARD

ISO 11758

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Rubber and plastics hoses — Exposure to a xenon arc lamp — Determination of changes in colour and appearance

Tuyaux en caoutchouc et en plastique — Exposition à la lampe à arc au xénon — Détermination du changement de coloration et d'aspect

Reference number
ISO 11758:1995(E)

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.

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.

International Standard ISO 11758 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 1, *Hoses (rubber and plastics)*.

Annexes A, B and C form an integral part of this International Standard.

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Introduction

Measuring the effect of a light source on hoses is of value as a means of inspecting the conservation of the colour, which is often indicative, and the integrity of the coating material that protects the components making up the hose.

Accordingly, this International Standard pursues a threefold aim:

a) to carry out accelerated artificial ageing using existing material, with a source approximating as closely as possible to natural light;

b) to measure the effects of this light source on hoses;

c) to set a limit on deterioration, by agreement between the manufacturer and the user.

A related International Standard is ISO 8580:1987, *Rubber and plastics hoses — Determination of ultra-violet resistance under static conditions*, which refers only to fluorescent lights.

The only other International Standard in this field, ISO 4665-3:1987, *Rubber, vulcanized — Resistance to weathering — Part 3: Methods of exposure to artificial light*, is not specific to hoses.

Rubber and plastics hoses — Exposure to a xenon arc lamp — Determination of changes in colour and appearance

WARNING — Persons using this International Standard should be familiar with normal laboratory practice. This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with any national regulatory conditions.

1 Scope

This International Standard specifies a method for exposing rubber and plastics hoses to a laboratory light source for the purpose of evaluating the changes in colour and appearance produced by such exposure.

NOTE 1 A xenon arc was chosen from among a variety of sources since, when correctly filtered and maintained, it yields a spectrum closely similar to that of daylight.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 105-A02:1993, *Textiles — Tests for colour fastness — Part A02: Grey scale for assessing change in colour.*

ISO 105-B01:1994, *Textiles — Tests for colour fastness — Part B01: Colour fastness to light: Daylight.*

ISO 4665-1:1985, *Rubber, vulcanized — Resistance to weathering — Part 1: Assessment of changes in properties after exposure to natural weathering or artificial light.*

ISO 4665-3:1987, *Rubber, vulcanized — Resistance to weathering — Part 3: Methods of exposure to artificial light.*

CIE Publication No. 85:1989,[1] *Solar spectral irradiance.*

3 Principle

Sections of rubber or plastic hose are exposed, without stress and in a defined environment, to radiation from a xenon lamp for a predetermined period and inspected in order to assess visually any change in colour and appearance.

NOTE 2 Other exposure conditions may be used and other parameters assessed, provided they are defined by agreement between the producer and the user.

1) Published by the International Commission on Illumination, Central Bureau, P.O. Box 169, A-1033 Vienna, Austria.

4 Apparatus

4.1 Laboratory light source

4.1.1 Quartz-jacketed xenon arc lamps emit radiation in a range which extends from below 270 nm in the ultraviolet through the visible spectrum and into the infrared.

For simulation of direct natural exposure, the radiant energy shall be filtered to provide a spectral power distribution that closely approximates to that of terrestrial daylight (method A) as described in CIE Publication No. 85: 1989.

Filters to reduce the irradiance at wavelengths below 320 nm shall be used when simulating daylight filtered through window glass (method B).

Filters to reduce non-actinic infrared energy may be desirable when heating of the specimen adversely influences the photochemical reaction rate or causes thermal degradation not experienced during real-time direct natural exposure.

The characteristics of xenon arcs and filters are subject to change in use due to ageing, and they shall be replaced at appropriate intervals. Further, they are subject to change due to the accumulation of dirt, and they shall be cleaned at appropriate intervals. Replacement and cleaning shall be carried out in accordance with the manufacturer's or supplier's instructions.

4.1.2 Recommendations on the wavelength distribution of UV radiation from filtered xenon arc sources, together with tolerance limits, are given in table 1 for artificial weathering (method A) and table 2 for simulated exposure to daylight behind window glass (method B).

Table 1 — Relative spectral irradiance for artificial weathering (method A)

Wavelength, λ nm	**Relative spectral irradiance** %
$290 < \lambda \leqslant 800$	100 1)
$\lambda \leqslant 290$	0
$290 < \lambda \leqslant 320$	0,6 ± 0,2
$320 < \lambda \leqslant 360$	4,2 ± 0,5
$360 < \lambda \leqslant 400$	6,2 ± 1,0

1) The spectral irradiance over the range 290 nm to 800 nm is defined as 100 %.

Table 2 — Relative spectral irradiance for daylight behind window glass (method B)

Wavelength, λ nm	**Relative spectral irradiance** %
$300 < \lambda \leqslant 800$	100 1)
$\lambda \leqslant 300$	0
$300 < \lambda \leqslant 320$	< 0,1
$320 < \lambda \leqslant 360$	3,0 ± 0,5
$360 < \lambda \leqslant 400$	6,0 ± 1,0

1) The spectral irradiance over the range 300 nm to 800 nm is defined as 100 %.

4.1.3 For reference purposes, an irradiance in the passband 280 nm to 800 nm of 550 W/m^2 has been selected (see CIE Publication No. 85:1989). It is not necessarily the preferred irradiance. When mutually agreed upon, another irradiance may be selected. Report the irradiance and the passband selected.

4.1.4 The irradiance at any point on the surface of the test piece shall not vary by more than ±10 % compared to any other point in the test-piece holder plane along a line parallel to the axis of the light source.

NOTE 3 Depending on the test enclosure (4.2), this requirement on the spectral irradiance may be considered to apply to time-averaged values.

4.2 Test enclosure

The test enclosure shall contain a rack designed to hold the test pieces while allowing cooling air to circulate over them. If the lamps cause large quantities of ozone to be formed, the ozone shall be prevented from coming into contact with the test pieces, e.g. by evacuating the cooling air to the outside of the building.

WARNING — Ozone is toxic. Operators should be protected from exposure to ozone (see annex A).

The light source shall be placed so that the energy to which the test pieces are exposed does not vary by more than ±10 % over the entire surface of the test pieces.

To reduce the effect of eccentricity when more than one lamp is used in the same enclosure in order to improve the light quality, the evenness of distribution shall be improved by causing the rack holding the test pieces to revolve around the light source and, if necessary, by periodically moving each test piece up and down.

The test-piece holders can also be caused to rotate about their own axes so as to allow both sides of the test pieces to be exposed to direct light-source radiation. This method helps to keep the test pieces at a low temperature. Periods of darkness can also be obtained by periodically switching the light source on and off. If the exposure cycle includes either of these features, an explicit statement to that effect shall be included in the test report.

4.3 Black-standard thermometer

The black-standard thermometer is used to determine the temperature of dark test pieces of low thermal conductivity while they are held in the holders during exposure.

The thermometer shall consist of a plane stainless-steel plate with a thickness of about 0,5 mm, a length of about 70 mm and a width of about 40 mm. The surface of the plate facing the light source shall be coated with a thin black layer with good resistance to ageing. The black panel shall absorb at least 95 % of all incident flux to 2 500 nm. The temperature of the panel shall be measured with a platinum resistance sensor mounted so that it makes good thermal contact with the centre of the panel on the side not exposed to the light source. This side of the panel shall be fixed to a 5-mm-thick baseplate made of unfilled poly(vinylidene fluoride) (PVDF) with a central recess which forms an air space round the sensor. The distance between the sensor and the floor of the recess shall be about 1 mm.

The length and width of the baseplate shall be sufficient to ensure that, when fitting the thermometer to the test-piece holder, the metal mounts of the test-piece holder are at least 4 mm from the edges of the metal panel so that there is no thermal contact between the metal panel and the test-piece holder.

NOTE 4 The difference between the black-standard thermometer described above and the black-panel thermometer which was formerly used in most cases consists essentially in the heat-insulating mounting of the black panels. The temperatures indicated therefore correspond to those on the exposed surfaces of test pieces made of black, poorly conducting materials. The surface temperatures of light-coloured or well conducting test pieces will generally be below the black-standard temperature. The surface temperature depends among other things on the absorptive and emissive power and thermal conductivity of the test piece, as well as heat transmission between the test piece and the air and the test-piece holder, and is therefore not predictable exactly.

In order to determine the range of surface temperatures of the exposed test pieces and to control better the irradiation or artificial-weathering conditions in the apparatus, the use of a white-standard thermometer, of a design analogous to that of the black-standard thermometer described above, is recommended in addition to the black-standard thermometer. Instead of the black coating, a white coating is used, with a good resistance to ageing, whose remission rate between 300 nm and 1 000 nm wavelength is at least 90 % and between 1 000 nm and 2 500 nm at least 60 %.

For ease of regulation of the temperature, a thermostat can be used, with the sensor placed inside the test enclosure.

Due to the nature of the material and its projected use, the recommended test temperature is 55 °C ± 5 °C, but other temperatures may be used by agreement between the interested parties.

For special-purpose hoses, higher temperatures can be used. In such cases, the effects of thermal degradation are more likely to affect the test results.

4.4 Relative-humidity measuring device

The relative humidity of the air circulating over the test pieces can, if necessary, be maintained at a chosen value measured by wet- and dry-bulb thermometers, or by any other suitable instrument placed inside the test enclosure and protected from the lamp radiation.

The recommended relative humidity is (65 ± 5) %, but other values may be used by agreement between the interested parties.

NOTE 5 Given that the temperature of the test pieces varies depending on their colour and thickness, the moisture content of the air in the vicinity of each test piece cannot be regarded as corresponding to the relative humidity of the air as derived from the measurements.

4.5 Water-spraying

Testing without spraying is recommended. By agreement between the interested parties, testing with spraying may be carried out, in accordance with annex B.

4.6 Test-piece holders

The test-piece holders may be in the form of an open frame, leaving the back of the test piece free. They shall be constructed of inert materials that do not affect the results, e.g. aluminium or stainless steel. They may also be designed to support the back of the test piece. Brass, steel and copper shall not be used near to the test pieces.

4.7 Equipment for determining the level of exposure

One of the following means shall be used, depending upon the method chosen.

4.7.1 Exposure-measuring instrument, comprising photoelectric detectors mounted alongside the test pieces and connected to an integrator to measure the total energy received during a certain period, or the energy received at a given wavelength.

The photoelectric detectors shall be sensitive to radiation received within a solid angle identical to that within which radiation is received by the test pieces. The photodetector spectrum response shall be known, particularly in the regions of the spectrum that cause alterations in the characteristics of the test pieces. Details of the instrument shall be determined by agreement between the interested parties.

The instrument shall be calibrated in joules per square metre for a given light source. Calibration shall not be performed by variations in luminous intensity or temperature.

NOTES

6 Prolonged exposure of the detectors inside the enclosure could appreciably affect the instrument's reliability.

7 Research is in progress in various countries on the spectrum response required to give the best estimate of the correlation of exposure level to the effect of the exposure on plastics.

For certain materials, it is known that the effect of the shorter-end ultraviolet waveband is particularly significant, but it is not currently possible to recommend any particular spectrum response.

4.7.2 Blue-wool references as specified in ISO 105-B01 and the grey scale as specified in ISO 105-A02 may be used (see annex C).

4.7.3 The use of other physical references, such as plastics (e.g. polyethylene), shall be subject to agreement between the interested parties.

5 Test pieces

5.1 The test pieces shall be sections of hose cut to a length of approximately 15 cm conditioned in accordance with ISO 4665-3.

5.2 At least three test pieces shall be cut from the same hose, taken if possible from different sections of the hose, e.g. from each end and from the middle.

5.3 Another test piece shall be kept in darkness as a control test piece, in order to permit evaluation of colour changes.

6 Procedure

6.1 Mounting the test pieces

Mount the hose sections in the test-piece holders, ensuring that they are subject to no stress.

Mount sections that curve naturally in such a way that the convex side is exposed to the light.

6.2 Exposure of references and test pieces

Expose blue-wool or other physical references in the same way as the test pieces in order to determine the level of exposure (see 4.7.2).

In the case of test pieces used to determine changes in colour or appearance, a portion of each of the test pieces may, if it is wished, be protected by an inert, reflecting metal screen throughout the duration of the test. This provides an unexposed surface alongside the exposed surface for comparison. This is of value for monitoring changes under exposure, but the results entered in the test report shall always be based on the contrast with the test pieces in the test apparatus in order to reduce the effect of local variations in exposure.

Furthermore, all unused test-piece holders in the apparatus shall contain test pieces in order to ensure uniformity of test conditions.

6.3 Measuring the level of exposure

6.3.1 Using instruments

Where apparatus is used that determines the level of exposure, the level shall be expressed either as the quantity of energy received at a given wavelength, or as the total energy received, in each case in kilojoules per square metre, by the apparatus and the test pieces.

6.3.2 Using blue-wool references

Details of the use of blue-wool references are given in annex C.

6.3.3 Using other physical references

This depends upon the references used, and details shall be agreed between the interested parties.

6.3.4 General considerations

With the exception of the measurement of energy received at a given wavelength, the exposure levels measured by the foregoing means do not allow comparisons to be made between results obtained using different light sources.

It is well known that there are severe limitations to using blue-wool references, particularly when successive exposures of reference 7 are carried out. Successive exposures of reference 7 shall only be carried out if no better method is available.

The assessment of changes after exposure shall be performed in accordance with ISO 4665-1.

6.4 Test conditions

The following test conditions are preferred:

— Humidity: (65 ± 5)%;

— Black-body temperature: 55 °C ± 3 °C;

— Filter system as required for the method used (method A or B) (see 4.1.2);

— Continuous illumination, without water-spraying;

— Duration: 240 h ± 2 h, or as given in the product specification, with a light-source power input of 1 500 W and an irradiance of 150 W/m^2.

These conditions correspond to a contrast equal to 4 on the grey scale for the difference in colour between the exposed and non-exposed blue references (see 7.1);

Only one face (the front surface) of the test piece shall be used to assess the action of the light.

6.5 Removal and inspection

Remove the test pieces after exposure of the front surfaces for 250 h and inspect them visually.

7 Expression of results

7.1 Colour change

Any change in colour shall be assessed by reference to the grey scale as described in ISO 105-A02, together with the assessment of any accompanying changes in hue or brightness.

7.2 Cracking

The presence of any cracking shall be noted, together with its extent and geometry.

8 Test report

The test report shall include the following information:

a) the number of this International Standard;

b) all details necessary for the identification of the hose tested;

c) information on exposure (e.g. method A or method B, spraying or not spraying, the exposure level);

d) details of any colour changes or cracking;

e) details of any change in appearance other than colour and cracking (exudation, chalking, efflorescence, etc);

f) full details of the procedure where it departs in any respect from the procedure specified in this International Standard;

g) the date of the test.

Annex A
(normative)

Protection of operators

A.1 General

The complexity of the equipment used in radiation-exposure tests necessarily means that it must be used and maintained by qualified staff. This is not only so as to ensure correct performance of the test, but also on account of the risks to health and safety that must be dealt with.

A.2 Ultraviolet radiation

The most obvious dangers to guard against are those associated with the harmful effects of high-intensity near-ultraviolet radiation.

In the case of natural sunlight, the eyes are protected in two ways: the brightness of the sun makes it impossible to look at the sun directly, and ultraviolet radiation is considerably attenuated by the atmosphere. Such protection does not apply in the case of artificial light sources. The eyes must be protected by goggles or by the use of observation openings fitted with filters, particularly when installing the equipment. Test staff shall be warned that exposure, even for a short period, to radiation from artificial light sources can cause severe damage to the eyes, as well as severe erythema (radiation burns) on exposed areas of skin. As far as possible, the electrical power supply to the lamp should be cut off before any servicing is carried out in the enclosure. Where this is not possible, suitable protective clothing shall be used for this purpose, including protection for the hands and head, even for work in an environment irradiated by lamps fitted with filters.

A.3 Ozone and harmful emissions

Another serious risk from using xenon and other arc lamps is the possibility of local formation of toxic concentrations of ozone during the test period. However, maximum ozone production occurs on lighting the lamp, after which the heat envelope round the lamp tends to convert the ozone back into oxygen. Where pulsed-air cooling is not used, the air shall be removed by suction and expelled from the building, and shall not be routed into the lamp housing. This eliminates the major hazard caused by ozone. It is known that 1 ppm to 10 ppm (parts per million) by volume causes headaches, irritation of the nose and throat and watering of the eyes.

However, the toxic concentration of ozone must be regarded as below 0,1 ppm, below the threshold of easy detection by smell (0,5 ppm to 1,0 ppm). A suitable detection and measurement appliance is available on the market.

The combined action of heat and ultraviolet radiation on certain plastics (e.g. melamine laminates) may also cause toxic emissions. Accordingly, special care shall be taken in choosing the materials for constructing a test facility.

A.4 Lamp explosion hazard

Where high-pressure xenon-discharge lamps are used, the manufacturer's instructions for handling and storage shall be followed in every respect.

A.5 Electrical hazards

All electrical equipment shall conform to current regulations.

Normal preventive measures against electric shock shall be adopted, particularly for the high-tension ignition systems used with xenon-arc lamps. For this reason, a device shall be provided that prevents access to the inside of the test facility as soon as the lamp is, or is liable to be, under tension.

Annex B
(normative)

Water-spraying device

By agreement between the interested parties, test pieces may be sprayed intermittently with distilled or demineralized water, under the conditions given below.

Spraying devices shall be built of inert materials in order to avoid water contamination.

The water resistivity and pH shall be recorded.

The lengths of the dry and spraying periods shall be selected from those given in table B.1.

Table B.1 — Dry and spraying periods

Dry period min	**Spraying period** min
3	17
5	25
18	102

The maximum temperature shall be recorded at the end of the dry period.

Annex C
(normative)

Use of blue-wool references to measure exposure level

C.1 General

The blue-wool references were developed for textile testing and historically have been used with plastics and rubbers because of their availability. Because, in general, there is a need to expose plastics and rubbers for longer periods than those normally used for testing the colour fastness of textiles to light, a technique involving successive exposures of reference 7 has been introduced.

Because of the known differences between the spectral sensitivity of the different blue dyes, and the significant differences between the spectral energy distribution of the various artificial light sources, there is considerable doubt about the use of the blue-wool references for this purpose. However, their ready availability and the fund of data based on their use ensure that there is still a demand for their application in exposure tests on plastics and rubbers.

C.2 Procedure

Expose simultaneously a set of blue-wool references (see ISO 105-B01) comprising one strip each from reference 1 to reference 7.

Use the references to determine the exposure stages in accordance with table C.1 by comparing the difference in colour between the exposed and unexposed blue references with contrast 4 on the grey scale as specified in ISO 105-A02. Thus, stage 1/1 is reached when reference 1 gives a contrast equal to 4 on the grey scale, 2/1 when reference 2 shows a similar contrast, and in the same manner to stage 7/1 showing a contrast of 4 on the grey scale.

NOTE 8 The time taken to reach stage 7/1 is about 1 year in natural daylight in temperate climates.

Inspect the references as frequently as necessary to determine when each exposure stage is reached.

At stage 7/1, discard the references, mount a fresh reference 7 and continue exposure until the second reference 7 shows a contrast with the unexposed reference 7 equal to 4 on the grey scale. This stage is designated 7/2.

Discard the second reference 7 and mount another fresh reference 7. Stage 7/3 is reached when this reference in turn gives a contrast of 4.

Repeat this procedure as often as required, giving stages 7/4 to 7/*n* (but see 6.3.4).

C.3 Suppliers

A list of suppliers of the blue-wool references for testing colour stability under exposure to light and the grey scales for evaluating colour changes is available from the secretariat of ISO/TC 38, *Textiles*.

Table C.1 — Exposure stages

Stage	Description
1/1	Blue-wool reference 1 to grey-scale contrast 4
2/1	Blue-wool reference 2 to grey-scale contrast 4
3/1	Blue-wool reference 3 to grey-scale contrast 4
4/1	Blue-wool reference 4 to grey-scale contrast 4
5/1	Blue-wool reference 5 to grey-scale contrast 4
6/1	Blue-wool reference 6 to grey-scale contrast 4
7/1	First blue-wool reference 7 to grey-scale contrast 4
7/2	Second blue-wool reference 7 to grey-scale contrast 4
7/*n*	*n*th blue-wool reference 7 to grey-scale contrast 4

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