INTERNATIONAL STANDARD 877

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Plastics — Determination of resistance to change upon exposure under glass to daylight

Matières plastiques — Détermination de la résistance aux changements de propriétés par exposition sous verre à la lumière du jour

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FOREWORD

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Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 877 was drawn up by Technical Committee ISO/TC 61, *Plastics*, and was circulated to the Member Bodies in October 1973.

It has been approved by the Member Bodies of the following countries :

Austria	India	Spain
Bulgaria	Israel	Sweden
Canada	Italy	Switzerland
Czechoslovakia	Japan	Thailand
Egypt, Arab Rep. of	New Zealand	Turkey
Finland	Poland	United Kingdom
France	Portugal	U.S.A.
Germany	Romania	U.S.S.R.
Hungary	South Africa, Rep. of	Yugoslavia

The Member Body of the following country expressed disapproval of the document on technical grounds :

Belgium

Printed in Switzerland

Plastics — Determination of resistance to change upon exposure under glass to daylight

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies procedures for determining changes in colour and in mechanical or other properties of plastics upon exposure under window glass to daylight. The effects of weathering influences such as wind and rain are excluded.

2 REFERENCES

ISO/R 105/I, *Tests for colour fastness of textiles — First series.*

ISO 291, *Plastics — Standard atmospheres for conditioning and testing.*[1]

ISO 2579, *Plastics — Instrumental evaluation of colour difference.*[2]

ISO 3557, *Plastics — Recommended practice for spectrophotometry and calculation of colour in CIE systems.*[2]

ISO 3558, *Plastics — Assessment of the colour of near-white or near-colourless materials.*[2]

3 PRINCIPLE

3.1 Specimens of the plastic to be tested are exposed to daylight together with means of assessing the radiation dosage. These may comprise:

3.1.1 Physical standards which change in colour upon exposure to daylight, the degree of colour change indicating the radiation dosage.

3.1.2 Instrumental means of measuring daylight intensity and integrating this to give the radiation dosage over a period.

3.2 Changes in colour of the specimens after exposure are determined by visual or instrumental comparison with unexposed specimens stored in the dark.

3.2.1 Visual comparison is made using the ISO grey scale (see 4.3.1) which comprises pairs of grey patterns for determining the degree of contrast between exposed and unexposed specimens.

3.2.2 Instrumental methods may be used to determine the colour difference between exposed and unexposed specimens.

3.3 Changes in mechanical and other properties may be determined by applying appropriate tests to the exposed specimens and to the material before exposure or to unexposed specimens stored in the dark.

3.4 The main cause of change of properties of plastics exposed to sunlight is radiation in the near ultra-violet range (300 to 400 nm). The spectral quality and intensity of solar radiation at the earth's surface vary with climate, location, season and time of day. For this reason, except for exposures covering whole numbers of years, time of exposure is not a suitable parameter by which to assess the severity of solar radiation. If plastics are to be compared, it is preferable to expose them at the same time and place, under conditions approximating those expected in service.

4 APPARATUS

4.1 Exposure case

The exposure case shall consist essentially of an open-bottomed box covered with a framed lid of glass and containing a removable rectangular rack for carrying the test specimens and standards. The rack shall rest upon a supporting screen made of wire cloth, and ventilating holes covered with wire mesh made from corrosion-resistant material shall be provided in the upper side of the exposure case.

An example of the apparatus is given in figures 1 and 2.

1) At present at the stage of draft. (Revision of ISO/R 291-1963.)

2) At present at the stage of draft.

The exposure case shall be situated in the open facing the equator, It shall be so supported on legs that its lower front edge is approximately 760 mm from the ground, unless a greater distance is necessary to avoid any undesirable effects of contact with plant growth during the period of exposure. The lid, rack and screen shall all be inclined at 45° to the horizontal. Any angle other than 45° shall only be used by agreement between the interested parties.

NOTE — The inclination of 45° is adopted as a conventional value for use in all latitudes.

It is known that a significant amount of ultra-violet radiation is received by scattering from the sky in directions around the zenith. If it is desired that the specimens receive more of the scattered ultra-violet radiation, an inclination less than 45° to the horizontal may be specified.

The exposure case shall be so placed that no obstruction in an easterly, southerly or westerly direction in the northern hemisphere or in an easterly, northerly or westerly direction in the southern hemisphere subtends an angle of more than 20° with the horizontal at the centre of the case. No obstruction in a northerly direction in the northern hemisphere or in a southerly direction in the southern hemisphere shall subtend an angle of more than 70° with the horizontal at the centre of the case.

4.1.1 Lid

The lid of the exposure case shall consist of a framed sheet of good quality flat glass 3 mm thick, uniformly transparent and without defects, and having a transmittance of approximately 90 % at 370 nm and throughout the visible region of the spectrum and a transmittance of less than 1 % at 300 nm and shorter wavelengths. To maintain these characteristics it is usually necessary to replace the glass at intervals of not more than 2 years.

The lid shall be spaced 75 mm from the rack carrying the specimens to ensure adequate ventilation, and its unobstructed area shall be greater than that of the rack to avoid shading. The lid shall fit snugly and symmetrically into the case.

NOTE — For testing very thick specimens, care shall be taken that the spacing from the glass is not unduly reduced.

4.1.2 Rack

The removable rack shall consist of horizontal wooden battens attached at each end to side frames, as shown in figure 1. The battens shall be so arranged that there is an airspace 50 mm wide between them.

A series of flaps made from an inert material may be hinged to the battens so that part of each specimen is covered.

NOTE — The material used and the holder design shall take account of the need to minimize heat build-up in the specimen.

The rack shall fit snugly into the exposure case with the lower surface resting immediately on the upper surface of the wire screen.

4.1.3 Wire screen

The screen shall be made from corrosion-resistant woven wire cloth with mesh aperture about 0,16 mm.

It shall be supported on a rectangular frame, removable for cleaning, which fits snugly into the exposure case.

4.2 Means of determining exposure stage

One of the following is required according to the method selected.

4.2.1 Blue dyed wool standards No. 1 to No. 7, as specified in ISO/R 105/I, Part 11 (see also the annex to the present International Standard), and grey scale (see 4.3.1).

4.2.2 Other physical standards as agreed between the interested parties.

4.2.3 Instrumental means of measuring radiation dosage under the glass as defined in 4.1.1, comprising a photo-receptor system connected to an integrating device to indicate the total energy received over a given period.

The photo-receptor system shall be sensitive to radiation received over a solid angle similar to that over which radiation is received by the test specimens. The spectral response of the photo-receptor system shall be known and shall be flat throughout the spectral region utilized (see 4.1.1). The system to be used shall be agreed between the interested parties.

The instrument shall be calibrated in suitable units such as joules per square metre (J/m^2)*. The calibration shall hold both for parallel incident radiations (sunlight) and diffuse radiation (clear or cloudy sky) and shall not be affected by variations in light intensity or temperature.

NOTES

1 Research is proceeding in certain countries on the spectral response required to give the best estimate of daylight in relation to its effect on plastics. It is known that for some materials the short-wave end of the ultra-violet range is particularly important, but it is not possible at present to recommend a particular spectral response.

2 For the physical standards of light dosage (blue dyed wool standards), the spectral response is determined by the choice of the particular dyestuffs used.

3 If desired, means of measuring the temperature in the exposure case may be provided.

* $1\ J/m^2 = 1\ W \cdot s/m^2 = \frac{1}{4,186}\ cal/m^2 = \frac{1}{4,186} \times 10^{-4}$ Langley

4.3 Means of determining colour changes

One of the following is required according to the method selected.

4.3.1 Grey scale for assessing change of colour, as specified in ISO/R 105/I, Part 2 (see also the annex to the present International Standard). In this scale, Grade 1 corresponds to the greatest degree of contrast and Grade 5 to zero contrast (two patterns of identical colour).

4.3.2 Instrumental means of measuring colour or colour difference (see ISO 2579, ISO 3557 and ISO 3558).

4.4 Means of measuring other properties as required in accordance with the appropriate International Standards.

5 TEST SPECIMEN

For visual determination of colour change, strips about 20 mm wide from material in the form of sheet or film shall be used, long enough so that they can be fixed between adjacent battens on the exposure rack. For moulding and extrusion materials, moulded sheet shall first be prepared in accordance with the relevant International Standards.

For measurement of colour or of any other property, the form of test specimen shall be in accordance with the requirements of the particular specification or test to be used. When materials are to be compared, the test shall be carried out using test specimens of similar thickness.

For determination of change of colour, at least one test specimen is required, but more are necessary for materials which are not of uniform colour or uniform sensitivity to exposure. A further comparison specimen shall be stored in the dark at room temperature to minimize colour changes.

For determination of change in other properties, the number of specimens depends on the test selected and also, for tests in which the specimens cannot be used again, on the number of exposure stages at which tests are to be made.

6 PROCEDURE

6.1 Mounting of test specimens

Attach the specimens and standards, for example using a clamping device of inert material, to adjacent battens so that the central portion which is used for determination of colour change spans the space between battens. Allow a space of 6 mm on each side of the specimen for ventilation.

Mount specimens for mechanical and other tests appropriately. In no case shall the method of mounting impose significant stress on the test specimen.

Avoid solid backing where possible, but if backing of an inert material is essential, use a material agreed between the interested parties.

If desired, a portion of each test specimen may be covered by an opaque cover throughout the test. This gives an unexposed area adjacent to the exposed area for comparison. This is useful for checking the progress of exposure but the data reported shall always be based on the contrast with the unexposed comparison specimens.

6.2 Mounting of standards

The blue dyed wool standards, or other physical standards, shall be mounted in accordance with the procedure for test specimens given in 6.1 and adjacent to them.

Instrumental means of measuring radiation dosage shall be suitably mounted with the photo-receptor in the same plane as the specimens.

6.3 Glass lid

This shall be kept clean during the test.

6.4 Determination of exposure stage

6.4.1 *Using blue standards*

Expose a set of blue dyed wool standards comprising one strip each from No. 1 to No. 7 simultaneously with the test specimens for 24 h per day. Use the standards to determine the stages of radiation dosage (exposure stages) in accordance with the table, by comparing the difference in colour between the exposed and unexposed blue standards with the contrast No. 4 on the grey scale; thus, stage 1/1 is reached when standard 1 gives a contrast equal to No. 4 on the grey scale, stage 2/1 when standard 2 shows similar contrast, and in the same manner to stage 7/1 showing a contrast of 4 on the grey scale.

At stage 7/1, discard the blue standards and mount a second fresh standard 7. Continue the exposure until this second standard 7 shows a contrast with the unexposed standard 7 equal to No. 4 on the grey scale. This stage is designated 7/2.

Then discard the second standard 7 and mount a third fresh standard 7. Stage 7/3 is reached when this standard in turn gives a contrast of 4.

Repeat this procedure as often as required, giving stages 7/4 . . . 7/*N*.

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

TABLE — **Exposure stages**

Stage	Description
1/1	Blue standard 1 to grey scale contrast 4
2/1	Blue standard 2 to grey scale contrast 4
3/1	Blue standard 3 to grey scale contrast 4
4/1	Blue standard 4 to grey scale contrast 4
5/1	Blue standard 5 to grey scale contrast 4
6/1	Blue standard 6 to grey scale contrast 4
7/1	First blue standard 7 to grey scale contrast 4
7/2	Second blue standard 7 to grey scale contrast 4
7/*N*	*N*th blue standard 7 to grey scale contrast 4

6.4.2 *Using instrumental means*

When using instrumental determination of radiation dosage, the exposure stage is given in terms of the amount of energy received by the instrument and test specimens.

6.5 Determination of changes in properties after exposure

6.5.1 *General*

The determination of the changes in the properties shall be carried out at each exposure stage used. Depending on the resistance of the test specimen, it is generally not necessary to use all the exposure stages listed in 6.4.1, but only those at which significant alterations in properties are expected.

For control of quality, a test at a single suitably chosen exposure stage is usually sufficient. The specification for the material should then lay down :

a) the exposure stage to be used;

b) the maximum permissible change in properties at that stage.

For some purposes it may be required to determine the exposure stage at which a specified change in a property has occurred.

6.5.2 *Determination of colour change*

Visual or instrumental determination of colour change shall be used as agreed by the interested parties.

NOTE – The term "colour change" includes not only true fading by the destruction of colouring matter, but also changes in hue, depth, brightness or any combination of these characteristics.

6.5.2.1 VISUAL DETERMINATION

Visual determination of colour change shall be carried out by comparing the contrast between exposed and comparison specimens with the steps of the grey scale. The comparison is usually made indoors in a good north light.

The degree of colour change is the number of the grey scale step which shows similar contrast to that between the exposed and comparison specimens.

If the contrast lies between two steps of the grey scale, an intermediate rating shall be given; for example, a rating 3 to 4 indicates that at the stated exposure stage the contrast between the exposed specimen and the comparison specimen was greater than grey scale 4 but less than grey scale 3.

The nature of the colour change shall be recorded in addition to the grey scale rating.

6.5.2.2 INSTRUMENTAL DETERMINATION

Instrumental determination of colour change shall be made on exposed and comparison specimens at each specified exposure stage (see 6.4.1).

The procedure used shall be in accordance with the relevant International Standards.

NOTE – The unexposed comparison specimen may show an alteration in colour over a period with some materials. Where means of colour measurement are used which are sufficiently free from drift over the period concerned, any colour change in the stored comparison specimen may be determined and reported. In this case, the colour change in the exposed specimen may also be determined and reported in relation to the original material.

6.5.3 *Determination of other visible changes*

In addition to the preceding determinations of colour change, any other visible changes in the exposed specimens shall be determined in accordance with relevant International Standards or a note made of visual assessment. Particular examples of visible changes are :

– variation in gloss;

– variation in transparency of transparent or translucent materials;

– appearance of surface defects (for example, marbled appearance, exudation, efflorescence, cracking).

6.5.4 *Determination of changes in mechanical and other properties*

Exposure to light may alter the properties of the specimens, particularly in the surface layer, often causing brittleness. The tests more frequently used are those for tensile properties (particularly elongation at break) and impact properties. Tests for other properties shall be selected as appropriate.

In all cases the test conditions shall be chosen so that the results provide a significant criterion of change in the property concerned, i.e. the test result must be sensitive to the change in property which is to be detected in the exposed test specimen.

It is recommended that sufficient test specimens be prepared in advance for all the exposure stages to be used. When necessary, it is permissible to expose the material, in sheet form for example, and to cut the test specimens after exposure; the exposed surface affecting the results must not be removed.

Unless otherwise specified, test specimens shall be conditioned after exposure and before testing in one of the atmospheres defined in ISO/R 291. The particular atmosphere chosen shall be agreed between the interested parties. Whenever a set of exposed specimens is tested, it is recommended that a comparison set, which has been stored in the dark to minimize changes in properties, be tested. The purpose of this step is to check on any change in the test procedure or equipment which may have occurred during the time of the exposure.

With some materials, changes in properties may take place over a period in the comparison sets of specimens. These changes may be determined and reported, but it is essential to make sure that apparent changes are not due to variations over a period in the test procedure or equipment.

With some tests, the results depend upon which side of the test specimen is exposed. In bending tests, for example, different results are obtained according to whether the exposed surface or the unexposed surface of the test specimen is placed under tension.

The properties of the exposed test specimens shall be expressed as a percentage of the original value as follows :

$$R = \frac{B}{A} \times 100$$

where

R is the percentage of the original value retained;

A is the value obtained on the unexposed specimens;

B is the value obtained on the exposed test specimens.

7 TEST REPORT

The test report shall include the following particulars :

a) the complete identification of the material tested including form, test specimen preparation and thickness;

b) the location of the exposure site and the angle of exposure, if other than 45°;

c) the month and the year in which exposure commenced;

d) the exposure stages used, and their method of determination;

e) if determined, the colour change and other changes in appearance at each exposure stage used, and the methods of assessment;

f) if determined, the changes in mechanical or other properties at each exposure stage, and the test methods and specimen conditioning used;

g) if determined, the changes in the comparison specimens.

Dimensions in millimetres

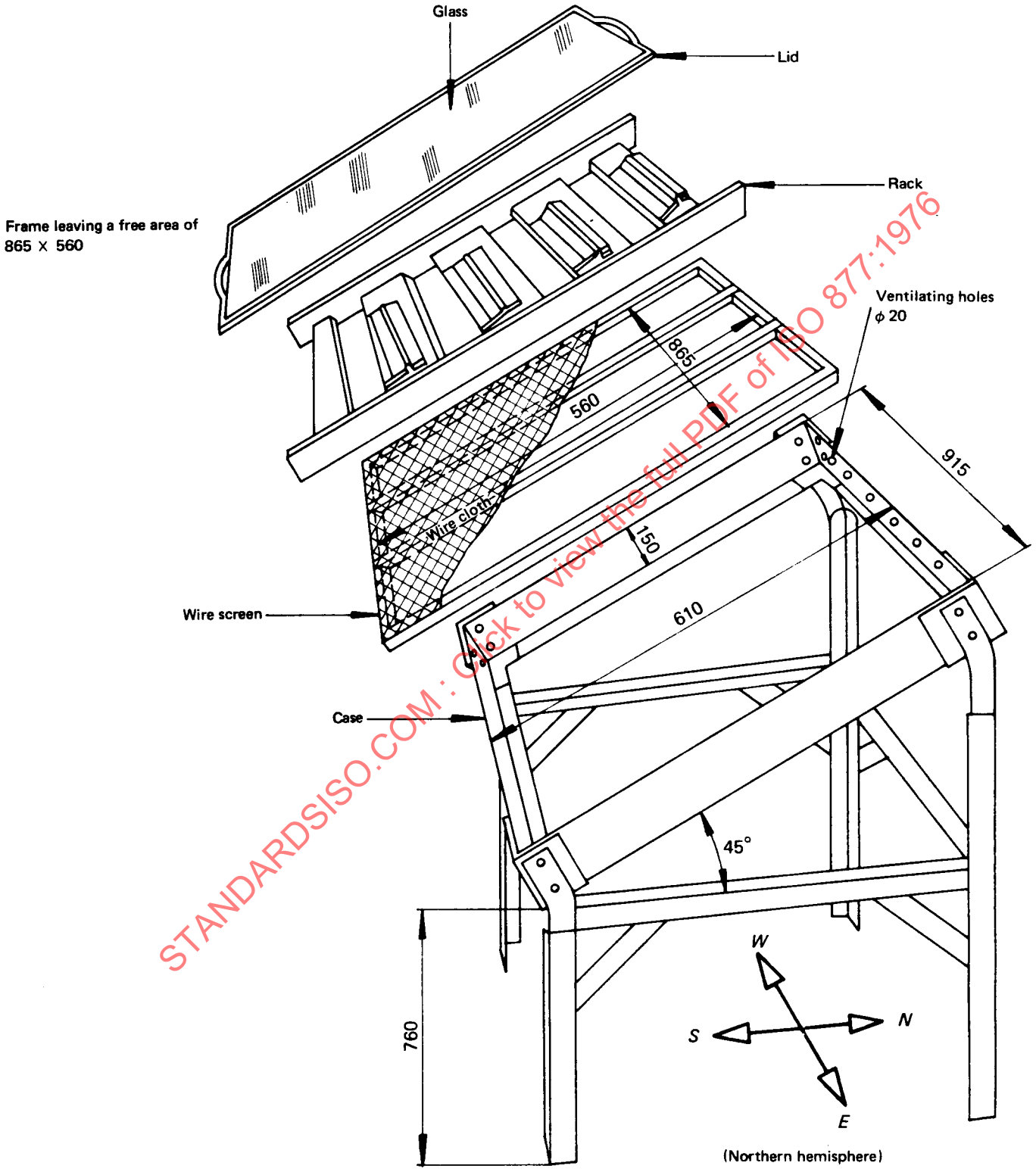

FIGURE 1 — **Exposure case**

Dimensions in millimetres

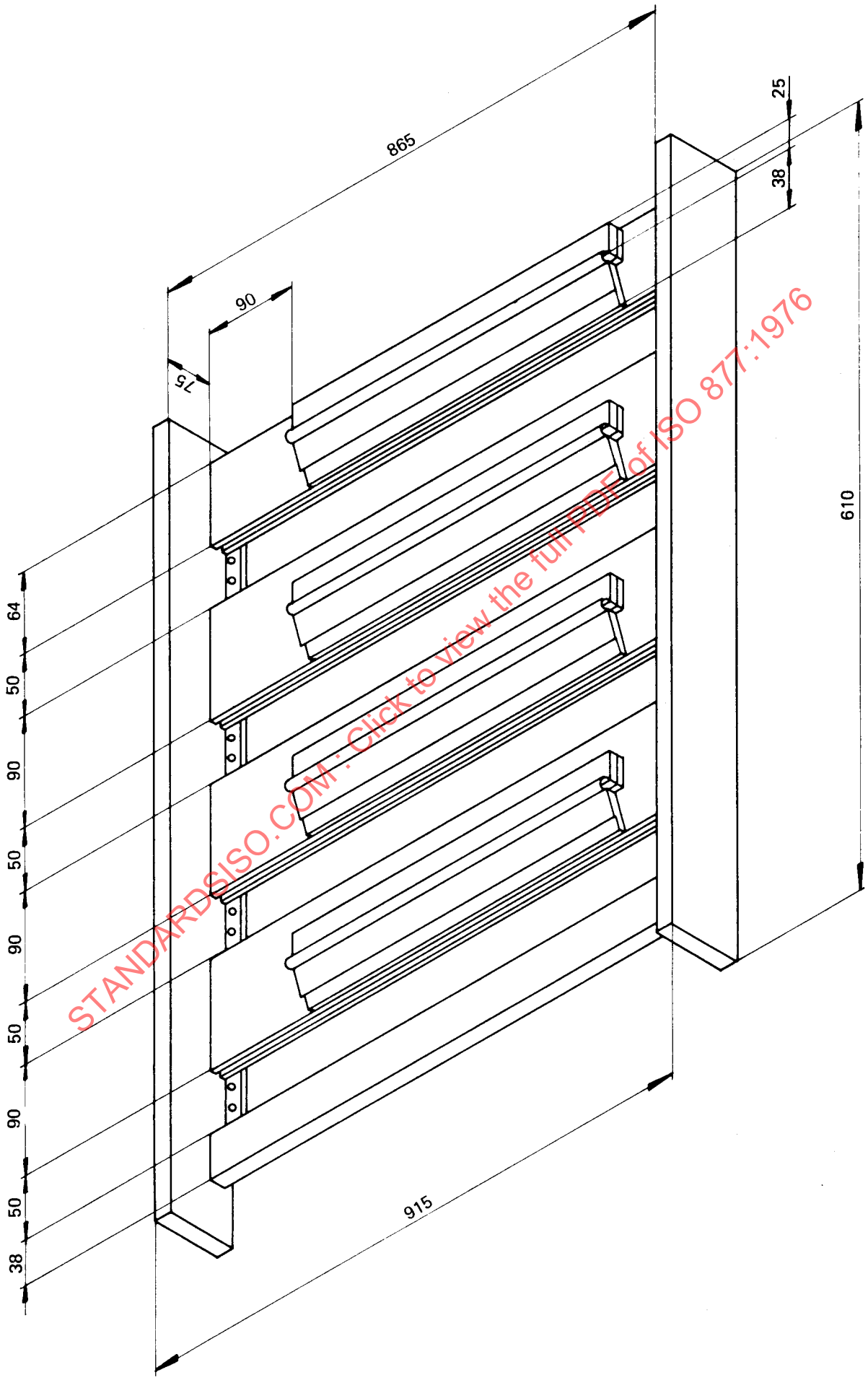

FIGURE 2 – Rack