INTERNATIONAL STANDARD 543

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Cinematography — Motion-picture safety film — Definition, testing and marking

Cinématographie — Film cinématographique de sécurité — Définition, essais et marquage

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

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.

Prior to 1972, the results of the work of the Technical Committees were published as ISO Recommendations; these documents are now in the process of being transformed into International Standards. As part of this process, Technical Committee ISO/TC 36 has reviewed ISO Recommendation R 543 and found it suitable for transformation. International Standard ISO 543 therefore replaces ISO Recommendation R 543-1966.

ISO Recommendation R 543 was approved by the Member Bodies of the following countries :

Belgium	France	Romania
Brazil	Germany	Spain
Bulgaria	Greece	Sweden
Canada	Hungary	Switzerland
Chile	Italy	United Kingdom
Colombia	Japan	U.S.A.
Czechoslovakia	Netherlands	U.S.S.R.
Denmark	New Zealand	

The Member Body of the following country has subsequently approved this Recommendation :

South Africa, Rep. of

No Member Body expressed disapproval of the Recommendation.

No Member Body disapproved the transformation of ISO/R 543 into an International Standard.

Printed in Switzerland

Cinematography – Motion-picture safety film – Definition, testing and marking

1 SCOPE AND FIELD OF APPLICATION

1.1 This International Standard defines safety film intended for motion-picture use, and specifies tests and the marking.

1.2 The term "safety film" as used in this International Standard includes all perforated film used in the motion-picture industry. Specifically included are leaders, including unperforated leaders; sensitized stock based on the silver halide, dye transfer, vesicular or other image-producing systems; raw and processed stock; and magnetically coated perforated film.

1.3 Motion-picture films are classified as safety film if they are difficult to ignite, slow burning and low in nitrate nitrogen content as specified in this International Standard.

2 IGNITION TIME

2.1 Definition

Motion-picture films are classified as difficult to ignite when the ignition time is greater than 10 min at the temperature specified below.

2.2 Method of measurement

2.2.1 *Preparation of test sample*

Cut a sample 35 mm (1.38 in) long and 8 mm (0.32 in) wide from the film to be tested. The sample shall be free of perforations as far as is practicable. Condition the sample for at least 4 h at a temperature of 20 ± 2 °C (68 ± 4 °F) and a relative humidity of 50 ± 5 %.

2.2.2 *Procedure*

Make the test in an electric resistance oven, the interior of which is in the form of a vertical cylinder (preferably with a rounded bottom), having a diameter of 70 mm (2 3/4 in) and a mean height of 70 mm. The top of the oven shall be closed by means of a closely overlapping lid having two holes of 7 mm (0.28 in) and of 15 mm (0.59 in) respectively, the centres being at a distance of about 15 mm from each other. Introduce a thermocouple through the smaller opening, the connecting wires having a porcelain coating fitted tightly into the hole. Alternatively, the temperature in the cylinder may be measured by means of a mercury thermometer protected from rising heat by means of a cork disk lying a little above the lid.

2.2.2.1 TEMPERATURE OF TESTS

Bring the oven to, and maintain it at, a temperature of 300 ± 3 °C (572 ± 5 °F). When this temperature is reached, attach the sample to a thin U-shaped wire hook and introduce it through the larger opening. Fix the thermocouple (or the thermometer) and the sample in such a way that the thermojunction (or the mercury bulb) and the centre of the sample are at an equal depth of about 35 mm (1.38 in).

2.2.2.2 PREPARATION FOR TESTS

Between tests, thoroughly air the oven.

2.2.3 *Expression of results*

Record the time interval from the insertion of the sample to the ignition of the sample as the ignition time.

3 BURNING TIME

The burning time may be determined by either of the two methods specified.

3.1 First method of measurement

3.1.1 *Principle*

Motion-picture films having a thickness equal to or greater than 0,08 mm (0.003 in) are classified as slow burning when the burning time is not less than 45 s. Motion-picture films having a thickness less than 0,08 mm (0.003 in) are classified as slow burning when the burning time is not less than 30 s.

3.1.2 *Preparation of test samples*

Cut three samples each 40 cm (15.7 in) long and 35 mm (1.38 in) wide from the film to be tested. If only films narrower than 35 mm are available, samples 40 cm (15.7 in) long and their full width may be tested.[1] Mark each sample at a point 5 cm (2 in) from each end. If the sample is not already perforated, perforate it with holes 3 mm (0.12 in) in diameter along both edges, at intervals of not more than 20 mm (0.8 in). Condition the sample for at least 4 h at a temperature of 20 ± 2 °C (68 ± 4 °F) and a relative humidity of 50 ± 5 %.[2]

3.1.3 *Procedure*

Measure the burning time of motion-picture films as follows : thread a wire having a diameter of not more than 0,5 mm (0.02 in) through the perforations on one side so that the sample is supported at points not more than 20 mm (0.8 in) apart. With the wire stretched horizontally and the sample hanging vertically from it, ignite the bottom corner of one end.

3.1.4 *Test conditions*

Make the test in a room free from draughts. Carry out at least three tests.

3.1.5 *Expression of results*

Record the time which elapses from the moment the flame reaches the first mark until it reaches the second mark as the burning time. If the sample does not ignite or if the flame does not reach the second mark, classify the film as slow burning.

3.2 Alternative method of measurement

3.2.1 *Principle*

Motion-picture films are classified as slow burning if each of six samples fulfils one of the following conditions :

a) the sample fails to burn beyond the specified mark;

b) a period of not less than 120 s elapses from the time of ignition of the alcohol to the time at which the flame reaches the specified mark.

3.2.2 *Preparation of test samples*

Take the test samples from either end or both ends of the continuous length of film which is to be examined. For the purpose of the burning test, take six samples, each of a length of 533 mm (21 in) for both 35 mm and 16 mm film. Test the samples in the condition in which they are cut from the continuous length without removal of protective or magnetic coatings, stripes or emulsion. Condition the samples for at least 4 h at a temperature of 20 ± 2 °C (68 ± 4 °F) and a relative humidity of 50 ± 5 %.[2]

NOTE — It is important to observe that the whole of the samples for both methods of test shall be taken from the same continuous length, and that if the roll of film to be examined contains splices, then each individual continuous length shall be examined separately. The object of taking six samples for the burning test is to obtain accurate results in the test and not to confirm the homogeneity of the film; the samples may therefore be taken consecutively.

3.2.3 *Apparatus for 35 mm film*

Test samples of 35 mm film on an apparatus complying with the following requirements :

The apparatus shall consist essentially of two semicircular supports, each L-shaped in cross-section, curved to a radius of 178 mm (7 in), spaced apart at a suitable distance for supporting the film within the angles, and structurally completed by a base-plate tying the two ends together (see figure 1).

The two supports shall be made of mild steel, about 1,2 mm (0.05 in) thick, and shall be spaced so that their inner edges are 25,4 mm (1 in) apart, the spacers being of wire, shaped as shown in figure 2.

The film sample shall be held in position over the semicircular supports by two strips of spring steel, 4,8 mm wide by 0,12 mm thick (3/16 in by 0.005 in), each of which is riveted at one end to a support (see figure 3). The other ends of the two steel strips shall be connected, at the appropriate distance apart, by a thin steel crossbar (see figure 4). At the igniting end there shall be, between the supports, a flat platform of heat insulating material (mica, asbestos, etc.) on which a small alcohol cup may be placed. The upper surface of the platform shall be 25 mm (about 1 in) above the base-plate and shall be 20 mm (0.8 in) long by 10 mm (0.4 in) wide.

The apparatus for 16 mm film is similar in general design.

The alcohol cup shall be of copper and shall have the dimensions shown in figure 5.

One curved support shall carry two register lines or marks, as shown in figure 1, which shall be clearly visible when the film sample is in position, and which shall be marked A and B respectively.

The mark A shall be 38 mm (1.5 in) above the base-plate at the igniting end. The mark B shall represent the position which would be occupied by the end of a piece of film 457 mm (18 in) long, whose other end coincides with the mark A.

1) Motion-picture films, when tested by this method, have similar flame propagation characteristics and about the same burning times, regardless of whether the width of the sample tested is 16 mm or 35 mm.

2) Experience has shown that safety film will meet the requirements for burning time when conditioned to any relative humidity in the range of 10 to 70 %. The more stringent range of 50 ± 5 % of this test method is specified in the interest of obtaining strictly comparable results. Likewise, the 4 h conditioning time is not critical and may be reduced to 1 h minimum if the urgency of the test makes this desirable.

3.2.4 *Procedure for 35 mm film*

Place the 533 mm (21 in) film sample in the trough formed by the two L-section supports, with its end in line with the mark A. Draw the steel strips over and hold them by a small spring which clips on to the crossbar which joins them at their free end (see figure 4). Thus the film is securely held by a narrow portion at each side and the centre portion of approximately 25 mm (about 1 in) of the film is in free air. If the sample to be tested is a coated film, place the sample with the coating upwards. Place the copper cup on the platform centrally below the film; place 0,3 ml of alcohol (not less than 95 %) in it and ignite.

3.2.5 *Apparatus for 16 mm film*

The apparatus is similar in general form to that specified above for the testing of 35 mm film. The circular supports are curved to a radius of 229 mm (9 in). They shall be made of mild steel about 0,9 mm (0.035 in) thick, formed to the dimensions shown in figure 7, and shall be spaced so that their inner edges are 12 mm (0.47 in) apart, the spacers being of wire shaped as shown in figure 7. The film sample shall be held in position by steel strips, similar to those for the test of 35 mm film. The upper surface of the platform of heat insulating material shall be 25 mm (about 1 in) above the base-plate and shall be 10 mm (0.40 in) square. The alcohol cup shall be of copper and of the dimensions shown in figure 6. The mark A shall be 38 mm (1.5 in) above the base-plate at the igniting end. The mark B represents the position which would be occupied by the end of a piece of film 457 mm (18 in) long, whose other end coincides with the mark A.

3.2.6 *Procedure for 16 mm film*

The method of carrying out the test shall be similar to that specified for 35 mm film. The length of the 16 mm film sample shall be 533 mm (21 in) and 0,3 ml of alcohol shall be placed in the metal cup.

3.2.7 *Expression of results*

Record the time which elapses from the time of ignition until the flame reaches Mark B as the burning time. If, for each of six samples, the sample does not ignite or if the flame does not reach Mark B within 120 s, classify the film as slow burning.

4 NITRATE NITROGEN CONTENT

4.1 Definition

Motion-picture films which have a nitrate nitrogen content of not more than a certain percentage by mass, depending on the method used, are classified as having a low nitrogen content. This percentage is 0,40 % when the De Varda method is used, whereby the error in nitrogen content owing to the presence of the gelatin layer is taken into account. The percentage is 0,36 % when the Schulze-Tiemann method is used.

4.2 First method of measurement — De Varda method

4.2.1 *Preparation of test sample*

Condition the test sample for at least 4 h at a temperature of 20 ± 2 °C (68 ± 4 °F) and a relative humidity of 50 ± 5 %.

4.2.2 *Procedure*

Cut 5 g (11 grains) of the film into small pieces (25 mm (about 1 in) by 6 mm (0.24 in)) and place them in an 800 ml Kjeldahl flask. Add 90 ml of 30 % sodium hydroxide solution and 10 ml of ethyl alcohol.[1] Connect the flask with a rubber stopper to a vertical cooler. Heat on a steam bath or over an open flame at 30 to 40 °C (86 to 104 °F) and add 25 ml of 30 % hydrogen peroxide slowly, with agitation. Boil slowly until the hydrogen peroxide is reacted. If necessary, add another 25 ml portion of hydrogen peroxide and continue the boiling until it is reacted. Boil for 15 min until the reaction is completed.

Then adjust the contents of the flask to approximately 200 ml using distilled water. (If desired, the test may be conveniently held over for the night at this point). Then evaporate the solution over a small flame to about 75 ml in order to remove any traces of ammonia, after which cool it to room temperature.

Dilute the solution to 350 ml with distilled water.[2] Add 2,5 g (36 grains) of De Varda's alloy and quickly connect the flask to the Kjeldahl apparatus. Make this addition through a funnelled tube, so that no alloy clings to the flask neck. Leave the mixture for 1 h and then distil with great care. Collect approximately 150 ml of distillate in a 500 ml receiving flask containing about 50 ml of approximately 4 % boric acid solution. Titrate the contents of the flask with 0,1 N sulphuric acid, using methyl red as indicator.

4.2.3 *Expression of results*

Carry out a blank determination on the reagents, using the same quantities as are used in the actual determination. Calculate the percentage of nitrate nitrogen by the formula

$$\frac{(A - B) \times 0{,}1 \times 0{,}014 \times 100}{5} = (A - B) \times 0{,}028$$

where

A is the amount, in millilitres, of 0,1 N sulphuric acid used for the sample;

B is the amount, in millilitres, of 0,1 N sulphuric acid used for the blank determination.

1) A denatured ethyl alcohol may be used which does not contain nitrogen compounds.

2) The volume at this point shall be controlled within ± 10 ml, because of the influence of alkali dilution upon the rate of reaction of De Varda's alloy.

4.3 Alternative method of measurement — Schulze-Tiemann method

4.3.1 *Preparation of test sample*

Take the sample from either end or both ends of the continuous length of film which is to be examined. For the purposes of this test for nitrate nitrogen content, take three samples, each of a length 152 mm (6 in) for 35 mm film and 305 mm (12 in) for 16 mm film. Condition the samples for at least 4 h at a temperature of 20 ± 2 °C (68 ± 4 °F) and a relative humidity of 50 ± 5 %.

4.3.2 *Procedure*

Cut the film into strips approximately 6,35 mm (1/4 in) wide by 25 mm (about 1 in) long. Weigh about 10 g of the film into the flask A (capacity about 250 ml) and add about 50 ml of water to cover the film, ensuring that no film is stuck to the sides of the flask. Replace the rubber bung fitted with the delivery tube and filling tube (see figure 8). Turn on the water supply to the tube jacket of the eudiometer; raise the levelling arm B, open taps C and D and pour 24 % sodium hydroxide solution into cup E until the eudiometer tube is full, taking care that there are no air bubbles enclosed. Close taps C and D. Close spring clip F on the delivery tube of the apparatus and fully open clip G. Light a burner under the flask and bring the water to a boil. Allow to boil for 30 s. Continue boiling and, without removing the burner, close clip G and open clip F at the same time. Pour 45 ml of aqueous saturated iron(II) chloride solution into the boiling tube H. When steam issues from the end of the delivery tube J, place this under the sodium hydroxide in cup K. Close clip F and open clip G simultaneously. The steam from the flask now passes through the iron(II) chloride solution, boiling it. Continue boiling until most of the water in the flask has been boiled away and no more air bubbles pass up through the iron(II) chloride solution.

Remove the burner and close clip G. Gently lift the eudiometer tube jacket off the rubber stopper L, and slip the lower end of the eudiometer over the end of the delivery tube J, clamping the tube jacket in this position. Pour about 5 ml of the 24 % sodium hydroxide solution into the cup E at the upper end of the eudiometer.

A vacuum will have formed in the reaction flask A. Slowly open clip G and allow the iron(II) chloride solution to run slowly into the flask. Close clip G just before the last of the iron(II) chloride has run out. Pour 45 ml of concentrated hydrochloric acid into the boiling tube and, by opening clip G, allow the whole of this, except the last 1 ml or so, to be drawn into the flask. Close clip G. Pour 5 ml of iron(II) chloride solution into the boiling tube. Replace the burner under the reaction flask and gradually bring the contents of the flask to a boil, keeping one hand on clip G and the other on clip F. Open clip G slightly, so that iron(II) chloride just drips into the flask.

As decomposition of the nitrogen compound proceeds, pressure will gradually develop in the flask and a point will be reached at which the gas evolved will begin to drive the iron(II) chloride back into the boiling tube (for greater accuracy, use a capillary tube), i.e. when the flask has attained atmospheric pressure. As soon as the drop of iron(II) chloride on the end of the tube begins to recede, close clip G and open clip F simultaneously. Slide clip F off the rubber tube and allow it to rest on the lower part of the delivery tube against cup K.

Boil the contents of the flask until no more gas collects in the eudiometer, agitating the flask fairly vigorously in the later stages of the reaction. When this agitation no longer produces gas bubbles, remove the burner and close the delivery tube with clip F.

Support the eudiometer tube jacket with one hand, slacken the supporting clamp with the other and carefully replace the bottom of the eudiometer tube on the rubber bung L. Fill the cup at the top of the eudiometer with 24 % sodium hydroxide solution. Open tap C and lower the levelling tube until the level of the sodium hydroxide in it is well below the level of the sodium hydroxide in the eudiometer. Partially open tap D and allow the bulk of the sodium hydroxide in the cup to be drawn into the eudiometer. Close tap D and raise the levelling tube B until the sodium hydroxide in B and in the eudiometer are at the same level. Clamp B in this position.

When the temperature of the gas in the eudiometer is constant, as shown by the thermometer in the overflow tube of the eudiometer jacket, readjust the sodium hydroxide in B and in the eudiometer to the same level and read the volume of the gas collected; correct this according to the correction chart for the eudiometer used. Note the temperature of the gas. Read the barometer.

Carry out a blank determination using the correct amounts of reagents with no film present. Subtract this blank from the volume of nitric oxide collected after both volumes have been corrected to normal temperature and pressure. A Farmer gas calculator, which can be obtained at the usual laboratory stockists, simplifies the calculation considerably.

4.3.3 *Method of calculation*

The percentage nitrogen is given by the formula

$$V \times \frac{273}{(273 + t)} \times \frac{(p - P)}{760} \times \frac{100}{m} \times \frac{14{,}01}{22{,}41} \times \frac{1}{1\,000} =$$

$$\frac{V \times (p - P)}{(273 + t) \times m} \times F$$

where

F is a constant ($\log F = \bar{2}{,}351\,4$);

m is the mass, in grams, of sample taken;

V is the volume, in millilitres, of gas collected;

t is the temperature of the gas collected, in degrees Celsius;

p is the barometric pressure at the time of the determination, in millimetres of mercury;

P is the vapour pressure of 24 % sodium hydroxide solution at t °C, in millimetres of mercury.

5 FIELD TEST

5.1 Principle

The following test method may be used for quickly identifying whether most motion-picture films are of the safety or of the nitrate variety, without technical equipment or the expenditure of large amounts of specimen film. However, it does not determine compliance of a film with this International Standard.

5.2 Preparation of test sample

Cut a piece of film approximately 16 mm (0.63 mm) wide and 35 mm (1.38 in) long. Bend the film lengthwise and crease it sufficiently so that when released it will stand upright.

5.3 Procedure

Stand the film sample (with the crease vertical) on a flat surface, such as an ashtray, glass plate, concrete floor, etc. This shall be done at a safe distance from all film stocks. With a match flame, ignite one of the top corners of the film.

Anyone unfamiliar with the burning of safety and nitrate photographic films should first conduct this test on samples of both types of film, the identities of which are known.

5.4 Expression of results

If the film ignites easily, burns downward rapidly and vigorously with a bright yellow flame, and is completely consumed in less than 15 s, it probably contains dangerous quantities of cellulose nitrate and probably will not pass the tests of this International Standard for safety film. If the film sample ignites with difficulty and burns only partially or if it burns completely in a time not under 15 s, it is likely but not assured that the sample will pass the tests of this International Standard.

6 MARKING

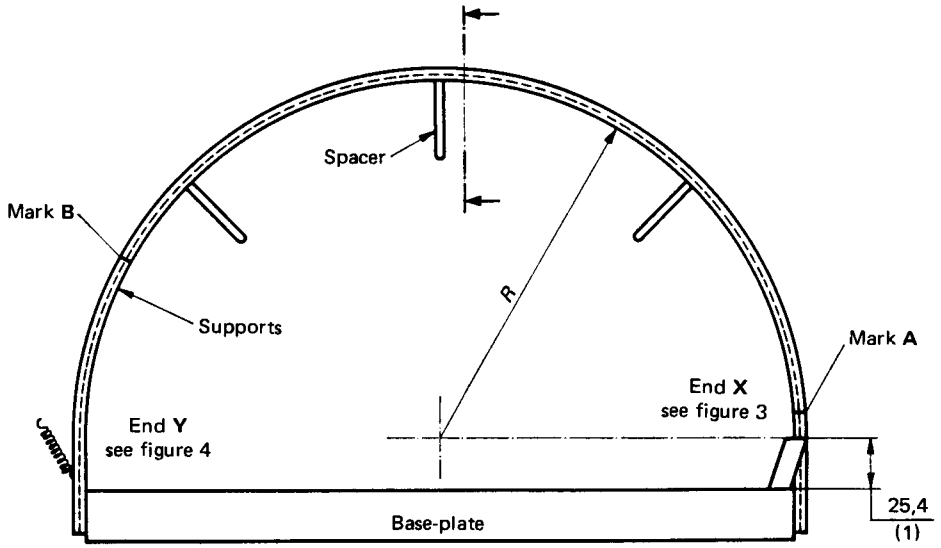
Motion-picture film on safety base shall be suitably marked as such[1]. This does not apply to film having only a magnetic coating.

1) a) In some countries, markings between perforations or along the edge of the film comprising *S* or SAFETY have been used.

b) An alternative or supplementary way of marking is by means of a fluorescent compound in or on the film base.

National regulations may require these or other markings.

Dimensions in millimetres (Inch values in parentheses)



	35 mm	16 mm
R	178 (7)	229 (9)

FIGURE 1 – **General arrangement of apparatus for flammability test of safety film**

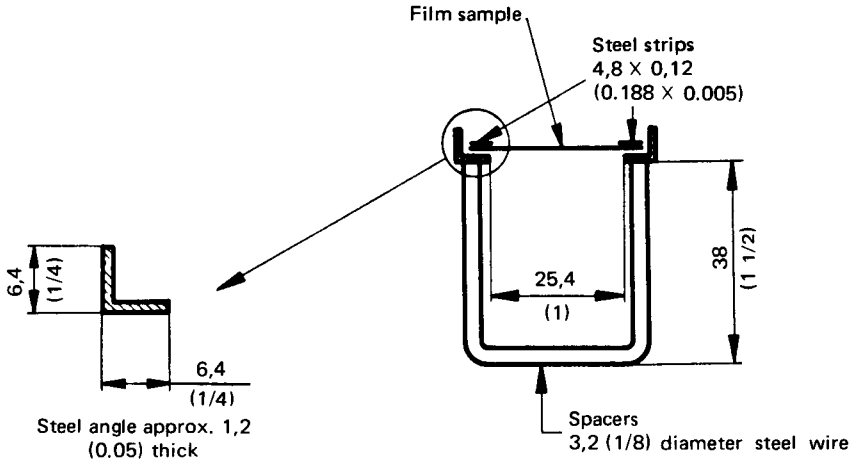


FIGURE 2 – **Section through supports showing wire spacers for 35 mm film apparatus**

Dimensions in millimetres (Inch values in parentheses)

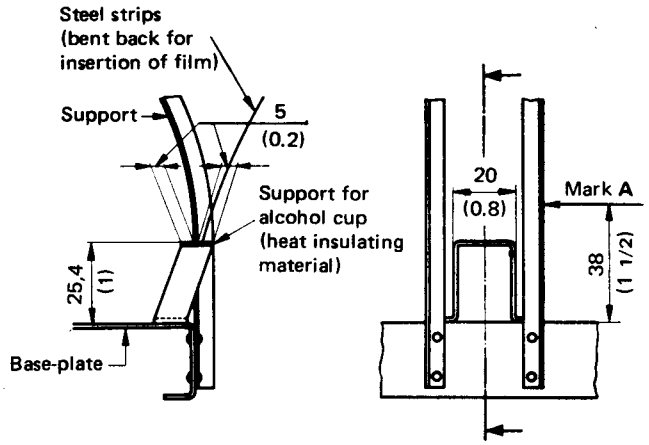


FIGURE 3 – **Detail of end X for 35 mm film apparatus**

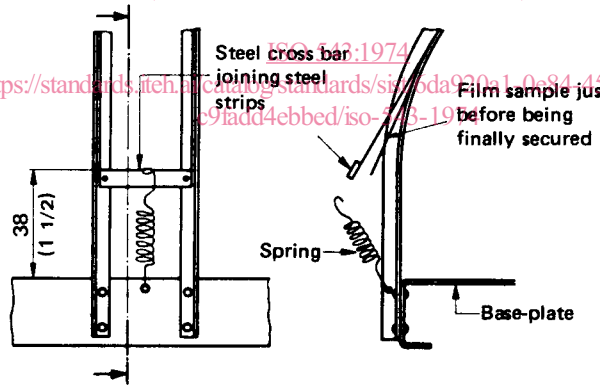


FIGURE 4 – **Detail of end Y for 35 mm film apparatus**

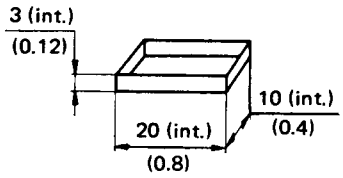


FIGURE 5 – **Alcohol cup for 35 mm film apparatus**