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Photography — Photographic film — Determination of folding endurance

Photographie — Film photographique — Détermination de la résistance au pliage

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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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8776 was prepared by Technical Committee ISO/TC 42, *Photography*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

The annex of this International Standard is for information only.

Photography — Photographic film — Determination of folding endurance

0 Introduction

Photographic film should have sufficient folding endurance to permit satisfactory performance when used in the equipment for which it is intended under the atmospheric conditions likely to be encountered in practice. Folding endurance is a measure of fatigue resistance in multiple flexing. Photographic film is essentially a laminate of two or more different materials, generally a plastics support and the photosensitive emulsion. The latter is usually made of image forming chemicals suspended in gelatin or other polymeric binder.

The folding endurance of photographic film is affected adversely by both reduced temperature and reduced relative humidity. In most applications, folding endurance loss at low relative humidity is encountered more frequently than loss at low temperature. Moreover, a marked change in film flexibility may occur with only a very small change in relative humidity below a level of about 25 %. This means that folding endurance tests on photographic film should be carried out only in an atmosphere which is accurately controlled with respect to both temperature and relative humidity.

The folding endurance of film is very dependent on the sample thickness, decreasing with an increase in thickness of either base or emulsion. For this reason, the thickness of the film layers have to be considered when comparing the behaviour of different films. The temperatures and relative humidities to which the film has been subjected between manufacture and testing may also affect the folding endurance even though the sample is reconditioned to a standard temperature and humidity. Gelatin is generally more brittle than film base, so that photographic film having a gelatin layer on only one side is usually more brittle if bent with the gelatin-side out (that is, gelatin under tension). This can affect the following endurance, depending on the direction of the first fold.

The folding endurance of photographic film may vary in different directions if the base is oriented more in one direction than another. There is generally no directional effect in the emulsion.

This International Standard covers the MIT folding endurance test in which the film is subjected to a rapid and repeated folding action until it breaks. This test is used in ISO 4331 which specifies the requirements for silver-gelatin type archival film on cellulose base and ISO 8225 which covers the stability requirements for diazo film.

Different types of failure occur when film is flexed. Failure may consist of very fine cracks in the emulsion (without a break in the support) which are objectionable when the photograph is viewed. Failure may also consist of cracks in the support or a complete break. The wedge brittleness test, standardized in ISO 6077, can generally detect the presence of emulsion cracks after a single flex. However, emulsion cracks are not visible during the MIT test. They may occur after relatively few flexes and result in subsequent flexing of only the film base itself with consequent higher folding endurance. For this reason, the MIT fold test may not necessarily be in agreement with ISO 6077. The two tests may also disagree because the apparent brittleness (or lack of flexibility) and fatigue resistance can also be dependent upon the manner in which the photographic film is mechanically treated, with respect to both the degree and the speed of straining. There are a number of folding endurance tests in addition to the MIT folding endurance test, as described in ISO 5626. Films may be rated differently by the different tests.

1 Scope and field of application

This International Standard specifies a method for determining and expressing quantitatively the folding endurance of photographic film.[1] It is an analytical test and is not intended to simulate practical use conditions.

This International Standard is applicable to film with or without a gelatin backing, and may also be applied to either raw or processed film, although the flexibility level of a given film may be quite different after processing.

Equipment similar to that described in this International Standard may be used provided that a correlation has been established between the results obtained using such equipment and the results obtained using the equipment described.

2 References

ISO 5626, *Paper — Determination of folding endurance.*

ISO 6077, *Photography — Determination of brittleness of photographic film — Wedge brittleness test.*

1) The method is based on the MIT folding endurance tester described in the annex.

3 Principle

Folding backwards and forwards in a standardized manner of a sample of film subjected to a longitudinal stress, until it breaks.

4 Apparatus

4.1 Test chamber

An air-conditioned cabinet or walk-in room shall be used for both conditioning and testing. The temperature shall be controlled to within ± 1 °C and the relative humidity to within ± 1 % at relative humidities below 30 % and to within ± 2 % at higher humidities. The linear air velocity shall be at least 150 mm/s. If a walk-in conditioned room is used, the air velocity shall be adequate to maintain the conditions specified. The number of personnel permitted in the room during testing shall be limited and precautions taken to prevent the operator's breath reaching the film.

4.2 Test apparatus

The instrument used (see the figure) shall hold the sample in a vertical position under a predetermined tension between two clamps. The upper clamp is stationary and the lower clamp oscillates through an angle of 135° ± 5° to both the right and left of the vertical position. This oscillation is at a frequency of 175 ± 25 cycles, or double folds, per minute. Each of the two folding surfaces, over which the sample is bent in the lower jaw, has a radius of curvature of 0,38 mm ± 0,03 mm. The machine is provided with a counter to register the total number of double folds required to break the sample. The apparatus is described in more detail in the annex.

5 Sampling

5.1 Preparation of samples

Film samples shall be cut in an atmosphere of approximately 23 °C and 50 % relative humidity.[1] The sample cutter shall be of a precision type and shall be kept sharp so that the sample edges are smooth and free of nicks. Rubber gloves shall be worn by the operator in handling the samples, both in their preparation and testing.[2]

5.2 Selection of samples

A set of at least ten samples shall be prepared for each test. Where film size permits, one set of samples should be cut in the machine direction and a second set in the transverse (cross) direction. If the film has a discrete backing layer, a separate set of samples shall be cut in at least one of the two principal directions to enable the film to be tested with both the emulsion-side and the reverse-side in tension on the first fold.[3]

5.3 Size of samples

The standard film samples shall be 120 mm long and 15 to 16 mm wide.

6 Conditioning

6.1 Conditioning of samples

Samples shall be conditioned in the test chamber (4.1) until practical moisture equilibrium has been reached. This may be determined by weighing samples at regular intervals and determining the time at which further conditioning does not appreciably change the weight. In many instances this time will be in the vicinity of 4 h, but actual times will vary due to access of the conditioning air, and the type and thickness of the material. The conditioning time should not exceed 24 h. The film shall be held in racks permitting free circulation of air around the samples.

6.2 Testing conditions

The recommended relative humidity for testing shall be 15 % when the contribution of an emulsion or backing gelatin layer to folding endurance is of interest. A relative humidity of 50 % is more useful for evaluating the contribution of the support.[4] The standard temperature for testing shall be 23 °C. However, other temperatures may be used where the effect of temperature is to be investigated.

The film samples shall not be removed from the conditioning atmosphere for testing except at temperatures of 0 °C or below. For testing film at 0 °C or below, the samples shall be conditioned at the desired relative humidity at 23 °C, sealed in small taped cans, cooled long enough to reach the test temperature, and then removed, one at a time, for testing.[5]

7 Procedure

Level the instrument (4.2) and turn the oscillating folding head so that the sample slot is vertical. Place the film sample in the machine so that the emulsion is in tension on the first fold.[3] The direction in which the lower clamp starts to rotate can be regulated by manually turning the knurled flywheel on the drive shaft in the same direction as the instrument operates. If the

1) If the samples are cut at low relative humidities, it may be difficult to obtain smooth edges. Handling under these conditions can also cause emulsion cracking which will affect the subsequent folding endurance. Exposure to high relative humidities can permanently alter the subsequent brittleness behaviour of the film.

2) Rubber gloves are specified in order to avoid moisture transfer from the operator to the sample.

3) In the MIT folding endurance tester, the same film may give different results depending on the direction of the first fold.

4) The folding endurance of polyethylene terephthalate (polyester) base films is so high that an MIT folding endurance test is impracticable.

5) Direct control of relative humidity at temperatures of 0 °C or below is impracticable, but once film is conditioned, the rate of gain or loss of moisture is much lower at low temperatures.

film has a discrete backing layer, two tests shall be run, one with the emulsion under tension on the first fold and one with the backing under tension on the first fold. Adjust the tension on the sample to 9,81 N. Read the number of folds from the counter when the sample breaks. Perforated film may be tested by positioning the sample in the jaws so that the fold is made between successive perforations.

8 Interpretation of results

For films approximately 0,15 mm thick, an average MIT folding endurance value of 20 or more double folds indicates a reasonably acceptable film at the conditions under which the test was made. A value of 3 or less denotes a very brittle or fatigue-prone film. These ranges differ for films which are either thicker or thinner. An average difference between two films of less than 3 MIT double folds is not believed to be significant. If the adhesion between the emulsion (or backing) and the support is weak, separation may occur during the folding test at the bending area. This may be determined by testing additional samples and stopping the machine prior to sample breakage to permit visual inspection. When this happens, the test is not valid.

9 Test report

The test report shall include the following particulars:

a) reference to this International Standard;

b) the average number of double folds required to break the samples in each manner tested; for example, lengthwise, widthwise, started with emulsion in tension, or started with backing in tension;

c) the temperature and relative humidity during the test;

d) the average thickness of the base emulsion and backing layer.

Annex

Description of MIT folding endurance tester

(This annex does not form part of the standard.)

A.1 Spring-loaded clamp, constrained to move vertically without horizontal rotation above the axis of rotation of a folding head located about 60 mm below its tip. The gripping surfaces of this clamp are in the plane of this axis, and a pivot above the gripping surfaces permits the clamp as a whole to swing in this plane. The load is applied by a spring attached to the clamp assembly and is adjustable to provide any desired tension on the test piece from a range of at least 4,9 to 14,7 N. The loaded deflection of the spring is at least 17 mm/9,81 N, which is achieved by using a weight of 1 kg mass.

A.2 Oscillating folding head, having a slot to accommodate the test piece and surfaces parallel to, and symmetrically placed with respect to, its axis of rotation. Each end of the surfaces forming the slot has a radius of curvature of 0,38 mm ± 0,03 mm and a width of not less than 19 mm.

The opening of the slot is great enough to allow the test piece to fall freely within it but with a clearance of not more than 0,25 mm. Accordingly, folding heads with several slot widths are available. A clamp is situated in the slot with its nearest edge 9,5 mm below the centre of rotation.

A.3 Means of producing 175 ± 10 complete oscillations of the folding head per minute through an angle of 135° ± 2° on each side of the vertical line.

A.4 Counter, to register the number of double folds, which stops automatically when the test piece breaks.

Bibliography

SNYDER, L.W. and CARSON, F.T. A study of the MIT paper folding tester. *Paper Trade Journal*, **96**, 1933, pp. 40 to 44.

ISO 4331, *Photography — Processed photographic black-and-white film for archival records — Silver-gelatin type on cellulose ester base — Specifications.*

ISO 8225, *Photography — Ammonia processed diazo photographic film — Specification for stability.*

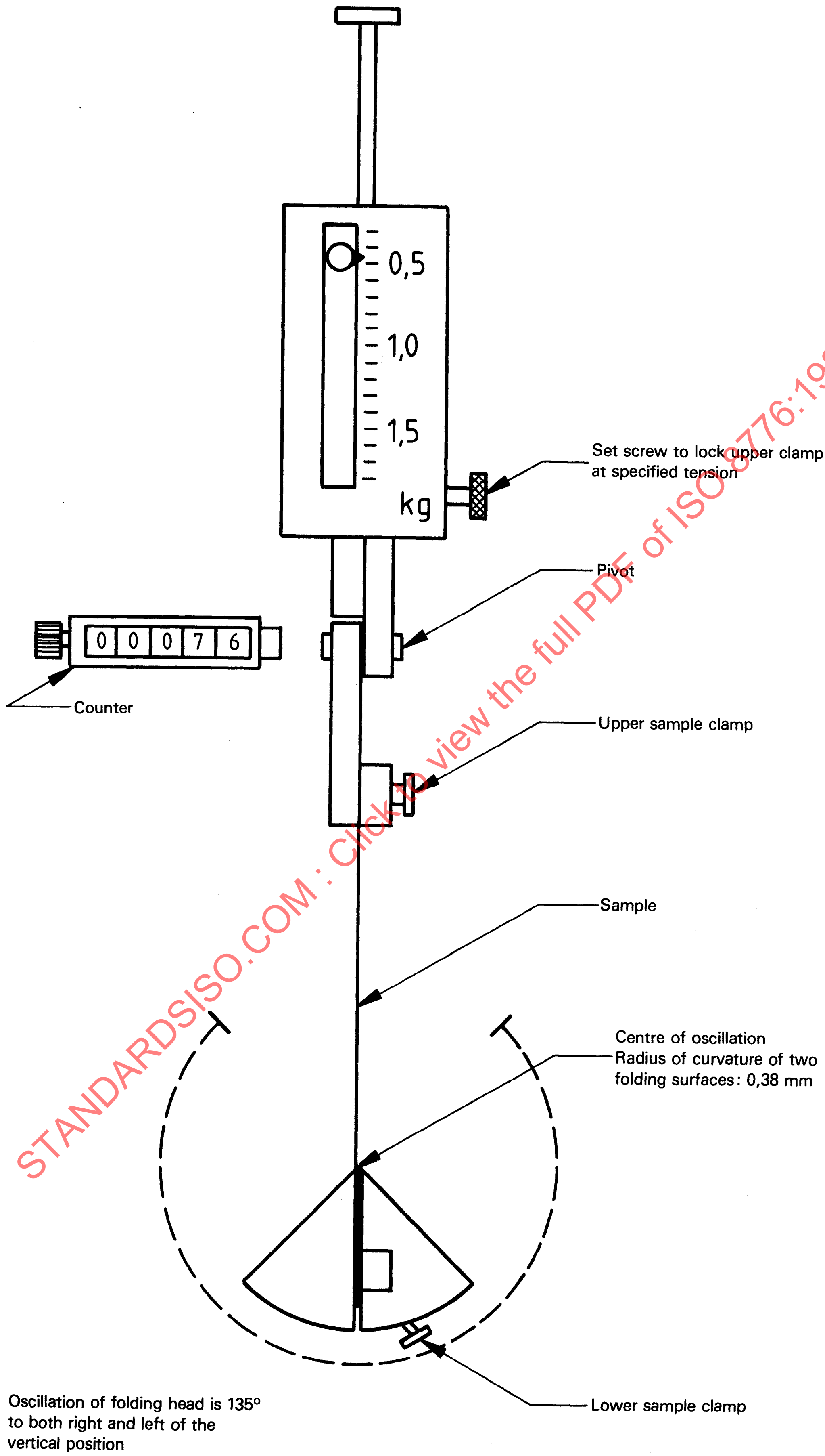

Figure — Operating mechanism of the MIT folding endurance tester