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**Imaging materials - Photographic film and paper -
Determination of curl**

影像材料 照相胶片和相纸 卷曲度的测定

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1 Scope

The standard lays down the method of measuring, and of expressing in figures, the curl of

photographic film and paper in sheet, roll or strip form, before and after processing.

Three measurement methods are laid down. Method A measures curl with the specimen held vertically; methods B and C hold the specimen horizontally. Because the specimens differ in shape and in size, the values from the three methods cannot be compared with one another.

None of the methods can be used to determine the curl of a photosensitive material during processing or drying.

A note states that curl is a physical property of imaging materials, and that the numbering scheme of the International Standards bearing on the physical properties and the stability of imaging materials is given in Annex A.

2 Terms and definitions

2.1 Curl is the degree of departure from physical flatness, expressed by the curl direction (L, T, D or C), the curl sign (plus or minus) and the curl value. The flatness defect is plainly caused by the tendency of the film or paper to roll into a cylinder.

2.2 Curl direction is expressed with the letters L, T, D or C, which denote the direction in which the specimen curls about a particular axis corresponding to a direction of the sample; Figure 1 illustrates it. The notes explain the letters. L denotes longitudinal curl, whose axis is perpendicular to the longitudinal or machine direction of a roll specimen, or to the long edge of a sheet specimen; where the machine direction is not known, an alternative is to take the notch in the film as the reference for fixing the curl direction. T denotes transverse curl, whose axis is parallel to the length or machine direction of the specimen. D denotes diagonal curl, that is curl of the specimen about its diagonal. C denotes cockle, where all four corners of the specimen lift and bend towards its centre.

2.3 The curl sign is the mathematical sign, plus or minus, that expresses the direction of curl: curl towards the emulsion, that is the photosensitive side, with the emulsion on the inside, is plus; curl towards the back, with the emulsion on the outside, is minus. A note adds that for a material carrying a photosensitive layer on both sides the sign is always positive.

Figure 1 carries a key of six entries: the cross-machine or width direction; the machine or length direction; transverse curl, that is T curl; longitudinal curl, that is L curl; diagonal curl, that is D curl; and cockle, that is C curl.

3 Sampling and conditioning

3.1 The material used for the curl test is to represent the whole sample to be tested, to carry no obvious physical defect and to be processed in the same way as in actual use, uniformly. Where different materials are to be compared, their relative humidity histories are

to be the same and the times close to one another. Where the machine direction is known, it is to be marked with a wax pencil or an ink pen.

3.2 Specimens are prepared under controlled relative humidity and then divided into groups and subjected to differing atmospheric conditions. Cotton or other suitable gloves, or tongs, are used when handling them; moisture from the hand or the fingers lowers the accuracy of the test data, and the operator is to avoid breathing towards the specimen.

3.3 Specimens are conditioned at the chosen relative humidity until actual moisture equilibrium is reached. In most cases that takes about 2 h for photographic film, 1 d for ordinary photographic paper and 7 d for resin coated paper. At relative humidity of 70 % and above, film and paper sometimes undergo an irreversible change of curl with time, so the conditioning time is to be standardized if results are to be compared; and an over-long conditioning time may weaken the curl through relaxation. A hole is punched in one side of the specimen near the centre and a hook or a hanging rod passed through it so that the specimen hangs free; the specimens are kept fully separated and out of contact with one another, and a square specimen is hung with its curl axis vertical so that it does not twist. The alternative is to lay the specimens flat on a mesh rack, spaced so that air circulates freely.

3.4 The temperature laid down is 23 °C +/- 2 °C. Relative humidity values of 15 %, 30 %, 50 %, 70 % and 85 % are recommended but not made obligatory. The test may be carried out in a glove box or in an air-conditioned room, the room being preferable because humidity can be held better in it. The curl value may be affected by the humidity history of the material, which can be standardized by an initial pre-treatment step at 50 % relative humidity.

4 Test method A

4.1 The method applies mainly to sheet or roll film or paper samples that do not cockle and that curl in the L, T or D direction only.

4.2 From each sample to be tested, at least three square specimens of 50 mm by 50 mm up to 100 mm by 100 mm are cut. Circular specimens of 50 mm to 100 mm diameter may also be used. Where it can be done, the machine direction is marked. For analysis, or for specimens that cockle or that curl to differing degrees along the length and the width, specimens of 50 mm by 5 mm may be cut in the L and the T directions separately.

4.3 The curl value is expressed as the reciprocal of R, where R is the radius of curvature in metres.

4.4.1 The curl measuring template carries curves drawn to correspond to different reciprocals of the radius, and may take one of several forms, shown in Figure 2. In the first form the edge of the film is held in a clamp whose clamping line is perpendicular to the standard curves on the template, and the curves may be calculated as described in 4.3.

The key to the second form lists a transparent template, a base plate, the specimen, the specimen clamp and a vertical support.

4.4.2 The specimen clamp is made up of two vertical clamping bars, the one facing the concave side of the specimen having a radius of about 3 mm; in no case is that radius to exceed the curl radius of the specimen.

4.5 After conditioning, and within the conditioning environment, each specimen is clamped by the bars above or below the template so that its curl axis stands vertical, with at least 10 mm of the film gripped in the bars. Film of low stiffness needs a larger clamped area so that it does not sag under gravity. The curl value recorded is that of the curve which comes closest to the curl of the specimen.

5 Test method B

5.1 The method applies to long rolls of film and offers a way of measuring the curl that appears in use. Only transverse curl is measured. It is a practical measurement and cannot be used to tell which factors caused the curl.

5.2 Specimens are taken in standard widths, 8 mm, 16 mm, 32 mm, 35 mm, 70 mm and 105 mm among them, at least three from each sample to be tested. The specimen length is at least six times the width of the film.

5.3 The apparatus is a suitable depth gauge or height gauge graduated in millimetres, able to read off the curl at the edge of the film strip; Figure 3 shows the two instruments in use.

5.4 After conditioning, and within the conditioning environment, the strip to be tested is laid on a horizontal surface and, where needed, held down at both ends. The curl at the edge is measured with the depth or height gauge. The accuracy the method calls for depends on the width of the film: as a guide, 35 mm film can be read to 0.20 mm, 16 mm film to 0.04 mm and 8 mm film to 0.02 mm, and the standard notes that 8 mm film is less sensitive than wider film and that reading it to 0.02 mm is very difficult.

5.4 Depending on the type of device used, transverse curl may be measured with the concave side up or with the convex side up. The height gauge shown in the figure can measure film of any shape, whereas the depth gauge is limited to film measured concave side up. The measurements may be converted trigonometrically into curl values expressed as the reciprocal of the radius. The standard gives the relationship between the height of the edge curl, the radius and the width of the film, defining R as the radius, W as the film width, the Greek letter π as the ratio of circumference to diameter and H as the height of the edge curl, and stating that the cosine is taken in degrees; the printed equation is not reproduced here, because the radius appears on both sides of it as printed. For small curl values the standard adds an approximate form, the reciprocal of R being about eight times H divided by the square of W .