July 1985 (reapproved and improved version of 1966)

Determination of the puncture resistance of corrugated fibreboard

1 Scope

To define the apparatus and test procedure use to determine the puncture resistance of corrugated fibreboard used in packing cases bearing the manufacturer's certificate. The test is applicable to all kinds of corrugated fibreboard.

2 References

FEFCO testing method n° 1 : sampling procedure.

EN 20 187 : paper, board and pulps - Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples.

3 Principle

A representative sample of corrugated fibreboard is subjected to puncture by a triangular pyramid puncture head attached to a pendulum.

The energy required to force the puncture head completely through the sample i.e. - to make the initial puncture, and to tear and bend open the fibreboard - is measured in J (N.m).

4 Apparatus

4.1. *Type of puncture tester*

The instrument to be used produces an impact by means of a pendulum. The bed plate of the frame of the instrument must be firmly attached to a strong base to prevent energy losses. The instrument must be accurately levelled, and it must not vibrate during the test.

The instrument must be so designed that the energy contained in the pendulum in each of the measuring ranges corresponds to the respective scale. This condition is the responsibility of the instrument manufacturer to whom appeal shall be made if there is any doubt as to the accuracy of the instrument, particularly if it is suspected that changes have occurred in the distribution of the pendulum, including the supplementary weights.

4.2. *Pendulum and puncture head*

The pendulum shall be fitted with an arm, having the shape of a 90° circular arc, to which the puncture head is attached. Both pendulum and arm must be strong enough to preclude deformation and to minimise vibration when the test is carried out.

The puncture head shall be a triangular, height 25.0 ± 0.7 mm the edges of which, meeting at the vertex, form right angles. All edges between sides are to be rounded off, radius = 1 mm.

One of the edges of the base of the pyramid shall be parallel to the axis of rotation of the pendulum, and the opposite corner of the base shall point towards the axis of rotation.

The axis through the effective point of the puncture head shall be vertical when its mid-point passes through the horizontal plane through the axis of the pendulum. [1].

At release point the pendulum shall be in the horizontal position, which is determined by measuring through an angle of 90° from the pendulum with its centre of gravity at rest.

4.3. *Measuring ranges*

By the use of interchangeable weights which can be attached to the pendulum, several ranges of energy are to be provided.

The range selected should be such that the test result will be between 20 % and 80 % of the maximum value of the corresponding scale.

4.4. *Release mechanism*

A safety catch must be provided to prevent accidental release of the pendulum. The release mechanism must not impart any acceleration or deceleration to the pendulum.

4.5. *Collar*

The neck of the puncture head shall be fitted with a close fitting collar designed so as to slip off its seating and to keep open the aperture in the test specimen after the puncture head has passed through.

This is to prevent the fibreboard from springing back on the arm and braking the pendulum, thus altering the test result.

The loss of energy due to friction when the collar is forced off its seating shall be measurable and shall not exceed 0.25 J. This loss of energy shall be compensated for in the reported test result.

4.6. *Clamping device*

To hold the test specimen, two horizontal clamping plates shall be provided, the upper plate being fixed. The lower face of the upper clamping plate -which contacts the test specimen- shall be on the horizontal plane through the axis of the pendulum, or up to 7 mm above it.

Both clamping plates must be sufficiently rigid to withstand the clamping forces employed, without deformation.

[1] To permit the use of existing instruments, the axis through the effective point of the puncture head may be vertical when its mid-points is within ± 12.5 mm of the horizontal plane through the axis of the pendulum.

The effective clamping dimensions of the clamping plates shall be not less than 175 mm x 175 mm.

The upper clamping plate shall have a centrally positioned regular triangular aperture with sides 100 mm ± 2 mm in length. Whilst it is recommended that the aperture in the lower plate should be identical and coincident with that in the upper plate, a centrally positioned circular aperture, with a diameter 90 mm ± 2 mm, is permissible. [2].

4.7. *Clamping force*

The force holding the test specimen between the clamping plates shall be at least 400 N and not more than 1000 N. If the instrument has no device for measuring the clamping force, the force applied must in any case be sufficient to ensure that the test specimen does not slip when the test is carried out.

4.8. *Indication of the measured result*

The test result shall be indicated by a peak-indicator, e.g. a friction loaded pointer operating over a dial on which the several scales, corresponding to the energy ranges, are engraved. The scale divisions should be calibrated in J (N.m).

In case of a friction loaded pointer, the friction mounting of the pointer should be sufficient to ensure smooth operation without over-run.

4.9. *Adjustment of the instrument*

For all measuring ranges the effective point of the puncture head shall be within ± 5 mm of the horizontal plane through the axis of rotation of the pendulum, when the centre of gravity of the pendulum is at its lowest point.

4.10. *Instrument checks*

No compensation for loss of energy due to friction should be made in the calibration of the measuring scales.

Energy loss due to friction in the bearings of the pendulum and air resistance must not exceed 1 % of the measuring scale.

To measure energy loss due to collar friction a slip-off device must be provided which catches the collar when the pendulum is allowed to swing freely from the release point.

Energy losses due to pointer friction shall be determined by allowing the pendulum to make two free swings from the release position. The first swing should carry the pointer close to the scale zero. The second free swing, made without resetting the pointer, should carry the pointer nearer to the zero reading. The difference between the two readings will represent the energy loss due to pointer friction.

When making readjustments to the settings of the measuring scales the following checks should be made:

Allow the pendulum to come to rest, with its centre of gravity at the lowest point, then move the pointer towards the maximum scale value. If, in the position, the drive pin of the pendulum just touches the pointer, the setting is correct. An analogous check should be carried out with the pendulum in the horizontal position, 180° from the release point, when the pointer should indicate zero.

5 Sampling

Sample in accordance with FEFCO Testing Method N° 1.

[2] To permit the use of certain existing types of instruments, the lower plate may have a centrally positioned circular aperture with a diameter up to 100 mm.

6 Conditioning

Samples shall be conditioned in accordance with EN 20 187 (i.e. 23°C ± 1°C, 50 % ± 2 % r.h.).

7 Preparation of test pieces

Test specimens with minimum dimensions 175 mm x 175 mm shall be prepared from a representative sample of the corrugated fibreboard to be tested. These test specimens must be free from conversion machine marks, irregularities, or damage. In no instance shall the puncture area be less than 60 mm from the edge of the sample, or from any crease, score, or printed area. If for some reason a printed area is used for the test, then this must be clearly stated in the test report.

8 Procedure

The testing shall be carried out in the standard atmosphere defined in clause 6.

The test specimen will be placed between the clamping plates and clamped with a constant force which should be recorded if the instrument is equipped with a clamping force measuring device.

The pendulum mass shall be adjusted, using the supplementary weights as necessary, to operate over the energy range which will contain the expected test result within 20 % and 80 % of its maximum value.

The release mechanism shall then be operated and the puncture head will completely pierce and pass through the test specimen.

The amount of energy used, representing the work in puncturing the test specimen is to be read from the appropriate scale. Scale readings should be to the nearest 0.1. J for the measuring ranges up to 12 J, and to the nearest 0.2 J for measuring ranges above 12 J.

The test result shall then be compensated for predetermined energy losses caused by friction in the apparatus (pointer friction, forcing off the pyramid collar, etc).

Unless otherwise stipulated, ten replicate tests are to be made from each side of the corrugated fibreboard ; five tests from each side with the flutes parallel with the axis of rotation of the pendulum ; and five tests from each side with the flutes at right angles to the axis of rotation of the pendulum.

9 Test report

The test report will contain the following information :

- a *Date and place of testing*
- b *Description and identification of the material tested*
- c *Number of replicate tests carried out*
- d *Arithmetic mean of all the replicate test results in J (N.m)*
- e *Standard deviation of the arithmetic mean in J (N.m)*
- f *Clamping force in N*
- g *Details of any deviation from this testing method*
- h *Any other information which may assist in the interpretation of the test results.*

10 Note

Interlaboratory tests showed, that the puncture resistance of corrugated boards tested in different laboratories may be assumed to be identical with a high degree of probability if the difference of the arithmetic mean is less than ca. 7 ... 8%.