

Introduction to the development of FEFCO Testing Methods for corrugated board and boxes

The Testing Methods n° 1 - 7 were officially issued following the approval by national organisations, by the FEFCO General Assembly at the Vienna Congress on 29th April 1966. Since then new Testing Methods were introduced in 1968, 1971 and 1973.

The Standards Committee of FEFCO proposed in 1982 to the FEFCO Board to follow several organisations in changing the testing conditions from 20°C and 65 % RH into 23°C and 50 % RH as being a world-wide standard. The approval of the proposal by the Board of FEFCO in 1983 meant consequently that the Testing Methods had to be revised.

Doing this the Standards Committee took the opportunity to improve several Testing Methods to a better working level based on the experience with the methods during the past years.

Since 1990 some of the Testing Methods have been amended again in order to be in line with the ISO and EN test methods as these cover the same purpose and have been internationally accepted.

Altogether this leads to a complete new publication of the Testing Methods. FEFCO intends to pursue its responsibility for improving and developing Testing Methods both on corrugated board and corrugated cases.

It is intended that these Testing Methods should be selectively applied, either singly or in combination with others in the series, as may be called for in the FEFCO Classification and/or in National Specifications and Regulations.

Regular checking to improve method and instruments will be part of the FEFCO Test Round with the national laboratories. The application of these Testing Methods with the standardisation of instruments and processes to be used in individual laboratory tests will contribute towards providing an ever improving guarantee of the specific characteristics of corrugated board and containers and will engender increasing confidence in the employment of such material in the packaging field throughout Europe. ■

Sampling procedure

1 Scope

To define a procedure for sampling from a batch of corrugated fibreboard in sheets, or from corrugated containers, for the purpose of obtaining a representative sample for testing. The test is applicable to all kinds of corrugated fibreboard.

2 References

From each batch a number of bundles or pallets will be selected at random. Random means that any item shall have an equal chance of being selected as part of the **sample**. From each of the bundles or pallets a specified number of **individual samples** will be picked. From individual samples the **test specimens** for the various tests will be cut with adequate dimensions.

A **batch** is a quantity of corrugated fibreboard of one sort or type which may be considered homogeneous, and may consist of one or several bundles or pallets.

A **sample** is the total number of individual samples from one batch.

An **individual sample** is a sheet of corrugated fibreboard, or a case, taken from a bundle or pallet.

A **test specimen** is a piece of corrugated board cut from an individual sample.

3 Principle

3.1. Determination of the total number of individual samples

The number of individual samples to be taken, as a minimum, from a batch will be determined by the formula :

$$n = \sqrt[3]{N}$$

Where:

n = total number of individual samples, and

N = total number of sheets or cases in the batch.

For convenience, the following table may be used:

N	n
1,000 or less	10
1,001 to 5,000	15
5,001 to 10,000	20
10,001 to 20,000	25
20,001 to 30,000	30
30,001 or more	40

(the minimum in any case will thus be 10, and the maximum 40).

3.2. Selection of individual samples

Each of the bundles or pallets selected according to Clause 3 will be handled as follows :

After removal of the wrapping or strapping materials at least five topmost sheets or cases will be eliminated. Thereupon, so many individual samples will be picked at random from the bundles or pallets that the total number of individual samples thus obtained from the batch will equal « n » as defined in Clause 3.1. An approximately equal number of individual samples shall be taken from each bundle or pallet selected.

3.3. Handling of individual samples

Keep the samples flat, without compression, and protect them from direct sunlight, liquids, or anything liable to alter their condition.

3.4. Marking of samples

Individual samples will be marked in a corner in such a manner as to ensure perfect identification.

3.5. Repeated sampling

If repeated sampling is necessary, it will be done in accordance with the method. Unless it is otherwise specified, and if it is possible, samples shall not be taken from bundles or pallets which have been used for the first sampling.

4 Report

The report will contain the following information :

- a Date and place of sampling
- b Inspector's name
- c Manufacturer's name
- d Size of batch
- e Number and type of bundles or pallets
- f Number of individual samples pursuant to clause 3.1.
- g Identification marks on the samples
- h Details of any deviation from this sampling method
- i Any other information which may assist in the evaluation of the sample.

Determination of the basis weight of corrugated fibreboard

1 Scope

To define the apparatus and procedure used to determine the basis weight of corrugated fibreboard for 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

Test specimens of given area, taken from a representative sample of corrugated fibreboard, are brought into equilibrium with a standard atmosphere and are then weighed on a suitable accurate balance.

Test results (basis weights) are expressed in g/m².

4 Apparatus

A balance with sensitivity of 0.5 g, or better, over the entire measuring range, shall be used to make the determinations.

5 Sampling

Sample in accordance with FEFCO Testing Method N° 1.

6 Conditioning

The 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

Representative samples from corrugated fibreboard to be tested shall be large enough to permit the cutting of test specimens of 500 cm² area (200 mm ± 0.5 mm x 250 mm ± 0.5 mm).

Test specimens shall be free from machine marks and other irregularities ; the surface must be free from printing or other treatments which may affect the weight ; and the edges must be cut clean and square.

8 Procedure

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

Each test specimen will be separately weighed and the weight recorded to the nearest 0.5 g.

Unless otherwise stipulated, at least ten determinations are to be made.

9 Calculation of basis weight

For each determination the basis weight will be calculated by the formula:

$$G = \frac{g \times 10^6}{a \times b}$$

Where :

G = basis weight in g/m²

g = weight of test specimen in g

a = length of test specimen in mm

b = width of test specimen in mm

10 Test report

The test report will contain the following details :

- a** *Date and place of testing*
- b** *Description and identification of the product tested*
- c** *Results of individual tests to the nearest g/m²*
- d** *Arithmetic mean and standard deviation of all the replicate tests*
- e** *Details of any deviation from this testing method*
- f** *Any other information which may assist in the interpretation of the test results.*

Determination of the thickness (calliper) of corrugated fibreboard

1 Scope

To define the apparatus and test procedure to measure the thickness (calliper) of corrugated fibreboard used in packing cases bearing the manufacturer's certificate. The test is applicable to all kinds of corrugated fibreboard. This method is applicable to all types 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

The thickness (calliper) of corrugated fibreboard is the distance in millimetres measured between two plane parallel faces of a micrometer, between which the test specimen is subjected to a specified pressure.

4 Apparatus

The measuring apparatus shall be a dead-weight dial gauge micrometer with a plane circular anvil and a concentric plane plunger. The area of the anvil and of the plunger shall be $10 \text{ cm}^2 \pm 0.2 \text{ cm}^2$.

The measuring surfaces shall be parallel within 0.001 of their diameter, and the dead-weight loading of the plunger shall be $20 \pm 0.5 \text{ kPa}$.

The instrument shall be sufficiently accurate to permit measurement to be made to the nearest 0.05 mm.

5 Sampling

Sample in accordance with FEFCO Testing Method N° 1.

6 Conditioning

Samples shall be conditioned accordance with EN 20 187 (i.e. $23^\circ \text{ C} \pm 1^\circ \text{ C}$, $50 \% \pm 2 \% \text{ r.h.}$).

7 Preparation of test pieces

Individual samples selected from the batch must be large enough to permit the cutting of test specimens with an area of 500 cm^2 ($200 \text{ mm} \times 250 \text{ mm}$). Test specimens must be free from converting machine marks, damage, or other irregularities.

8 Procedure

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

The plunger is to be lowered slowly, without impact.

Two measurements are to be made on each test specimen, at least 50 mm from an edge, and at least ten test specimens shall be measured.

9 Test report

The test report will provide the following information :

- a** *Date and place of testing*
- b** *Description and identification of the material tested*
- c** *Number of individual measurements*
- d** *Arithmetic mean of all measurements in millimeters*
- e** *Details of any deviation from this testing method*
- f** *Any other information which may assist in the interpretation of the test results ; in particular whether any areas compressed by printing or converting machines are involved.*

Recommendations : the measuring capacity of the dead-weight dial gauge micrometer should be at least 20 mm.

The depth of throat of the micrometer should be not less than 50 mm.

Determination of the bursting strength of corrugated fibreboard

1 Scope

To define the apparatus and test procedure used to determine the bursting strength of corrugated fibreboard. 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

The test specimen of corrugated fibreboard is firmly clamped between annular surfaces and uniformly increasing pressure is applied to one side, by pumping liquid under a flexible diaphragm, over a circular free testing area, until the specimen bursts.

The maximum pressure sustained by the specimen is recorded.

4 Apparatus

4.1. Type of Burst Tester

A hydraulic motor-driven burst tester shall be used.

4.2. Clamping Device

The burst tester must be fitted with a clamping device in which test specimens can be held without damage, other than crushing of the flutes, and without slippage, whilst the test is carried out. The clamping pressure shall be measurable.

4.3. Clamping Rings

The internal diameter of the upper and lower clamping rings shall be 31.5 mm ± 0.1. mm.

The edges of the clamping surfaces shall be slightly rounded. The rings shall be strong enough to withstand the clamping stresses without deformation.

The internal edge at the lower face of the lower clamping ring shall be rounded, to prevent damage to the diaphragm.

The clamping surfaces must be flat and should have circular or spiral grooves 0,2 mm to 0,5 mm deep to increase clamping efficiency.

The clamping rings must be mounted parallel, and accurately centred.

4.4. Diaphragm

The diaphragm shall be made of highly elastic material, should be clamped securely with its upper surface about 5.5 mm below the top plane of the lower clamping plate and have the following distension / load properties :

Bulge height	Pressure range
10 mm	170 to 220 kPa
18 mm	250 to 350 kPa

4.5. Pumping rate

The pressure under the diaphragm shall be produced by an electro-hydraulic pump delivering technically pure, air-free glycerine, or other suitable liquid with analogous properties, at a rate of 170 ± 15 ml per minute.

4.6. Pressure measurement

The total measuring capacity shall extend from 0 to 5000 kPa.

Pressure measuring devices shall be fitted with the means to record maximum value.

Those devices shall be calibrated

5 Sampling

Sample in accordance with FEFCO Testing Method N° 1.

6 Conditioning

The 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

A sufficient number of representative samples of the corrugated fibreboard to be tested shall be available to permit the stipulated number of replicate tests to be carried out without overlap of the clamped areas. For convenience of handling, the board may be cut into specimens 150 mm x 250 mm ; this will allow one test from each side of each specimen.

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

The specimen is placed in the clamping device and clamped with a pressure not less than 700 kPa.

The maximum reading device is set to zero and the tester operated until the specimen bursts.

Test results should be recorded to 3 significant figures.

Unless otherwise stipulated, 10 tests are to be made from each side of the corrugated fibreboard.

The test report should contain at least the following points :

- a** *Date and place of testing*
- b** *Reference to this FEFCO testing method*
- c** *Description and identification of the product tested*
- d** *Value of each test*
- e** *Arithmetic mean and standard deviation of all replicate test results*
- f** *Clamping pressure in kilopascal*
- g** *Details of any deviation from this testing method*
- h** *Any other information which may help in the interpretation of the test results*
- i** *Name and signature of the operator.*

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%.

Determination of the flat crush resistance of corrugated fibreboard

1 Scope

To define the apparatus and test procedure used to determine the flat crush resistance of corrugated fibreboard used for packing cases bearing the manufacturer's certificate.

The test may be carried out on single face and double face (single wall) corrugated fibreboard. It is not suitable for testing the flat crush resistance of double-double face (double wall) board.

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 test specimen of corrugated fibreboard is subjected to a uniformity increasing force applied perpendicularly to the surface by a compression tester having two flat and parallel platens, until the fluting collapses.

The maximum force sustained by the specimen is recorded.

4 Apparatus

4.1. Type of flat crush tester

A motor-driven type compression tester shall be used.

If the tester operates on the principle of beam deflection the beam shall be such that the test results will occur within 20 % to 80 % of the normal range of deflection.

4.2. Platens

The platens must meet the following conditions :

- deviation from parallel not greater than 1:1000
- lateral play not exceeding 0.05 mm
- size : 120 mm x120 mm to take 100 cm² or 50 cm² specimens.

Note : the preferable size for beam tester is 50 cm².

4.3. Relative speed and force

The relative speed between the two platens shall be 12.5 mm ± 2.5 mm per minute (with testers operating on the principle of beam deflection this is equivalent to an increment of force of 67 ± 23 N per second when the platens are in contact with each other).

4.4. Cutting instrument

An instrument having a circularly guided knife to cut specimens with area of 100 cm² (diameter 112.8 ± 0.5 mm), or an area of 50 cm² (diameter 79.80 ± 0.5 mm) shall be used. The cut edges must be clean and perpendicular to the facings of the board.

5 Sampling

Sample in accordance with FEFCO Testing Method N° 1.

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

Unless otherwise stipulated, at least ten specimens of the board shall be tested. They shall be free from converting machine marks, printing, or damage.

8 Procedure

The testing shall be carried out in the standard atmosphere defined above in clause 6 unless otherwise stipulated.

The test specimen shall be placed centrally on the lower platen, and the tester operated until the fluting collapses.

The maximum pressure sustained by the specimen before collapse of the fluting will be recorded to the nearest 10 kPa (kN/m²).

9 Test report

The test report will contain the following details :

- a) Date and place of testing
- b) Description and identification of the product tested
- c) Results of individual tests to the nearest 10 kPa (kN/m²)
- d) Arithmetic mean and standard deviation of all the replicate test results
- e) Number of specimens with leaning flutes
- f) Details of any deviation from this testing method
- g) Any other information which may assist in the interpretation of the test results.

Determination of water absorptiveness of corrugated fibreboard (Cobb test)

1 Scope

This testing method specifies the apparatus and the procedure for determining the water absorptiveness of corrugated fibreboard in 30 minutes (1800 sec.). The method is applicable to all types of corrugated fibreboard. For paper the EN 20 535 testing method should be used.

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.

EN 20 535 : paper and board - Determination of water absorptiveness - Cobb Method.

3 Principle

One specified side and a specified area of a corrugated fibreboard test piece is exposed to a defined column of water for 30 minutes.

Its water absorptiveness is deducted from the difference of weightings immediately before and immediately after exposure to water.

4 Reagent and material

Freshly distilled or deionized water at a temperature of 23 °C ± 2°C.

Soft blotting paper 250 g/m² ± 25 g/m² grammage.

5 Apparatus

- 5.1. Rigid smooth finished cylindrical tank of either 100 cm² or 50 cm² internal cross sectional area, of sufficient depth to provide a head of at least 3 mm of water.

When necessary to form an effective seal, the cylindrical tank, with its base possibly covered by a non-absorbent rubber ring of the same cross sectional area, may be fitted with a means of lightly clamping to the corrugated fibreboard test piece.

- 5.2. Smooth stainless metal roller, 200 mm wide, 90 mm ± 10 mm diameter, 10 kg ± 0,5 kg mass.
- 5.3. Analytical balance sensitive to 1 mg.
- 5.4. Stop watch readable in seconds.
- 5.5. Glass measuring cylinder to prepare aliquots of water.

6 Sampling

Sample in accordance with FEFCO Testing Method N° 1.

7 Conditioning

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

8 Preparation of test pieces

Prepare the test pieces in the same atmosphere as for conditioning the samples. From representative and undamaged areas of the samples, cut at least 3 test pieces for each specified condition (test on inner liner, or test on outer liner, unprinted or printed areas, etc.) with dimensions 10 mm greater than the external cross sectional area of the cylindrical tank. Avoid contact of bare hands on test pieces.

9 Procedure

Carry out the tests in the same atmosphere as for conditioning the samples.

Ensure before each test that the cylindrical tank is dry.

Weigh the test piece to the nearest 1 mg (m₁).

Apply the tank cylinder to the specified side and the specified area of the test piece.

Pour the specified water in the cylindrical tank to form a head of at least 3 mm of water upon the test area of the test piece and start the stop watch immediately.

After 30 minutes of exposure to water, quickly pour out the water, remove the cylindrical tank, place the blotting paper on the tested area of the test piece, roll the metal roller once forwards and once backwards with its axis parallel to the flutes, and weigh again the test piece to the nearest 1 mg (m₂).

Renew the water and the blotting paper for the subsequent test pieces.

10 Expression of test results

The water absorptiveness value A to the nearest g/m² of each test piece is :

$$A = \frac{m_2 - m_1}{S}$$

where :

m₁ : mass of the test piece before exposure to water in g

m₂ : mass of the test piece after exposure to water in g

S : nominal cross sectional area of the cylindrical tank in m²

For each test condition, calculate the arithmetic mean of the replicate test results to the nearest g/m².

The test report shall contain at least the following informations :

- a** *Date and place of the testing*
- b** *Reference to this FEFCO testing method*
- c** *Complete identification and description of the material tested*
- d** *Duration of exposure to water; if not 30 minutes*
- e** *Nominal cross sectional area of the cylindrical tank*
- f** *Number of replicate test for each test condition*
- g** *Replicate test results and arithmetic mean for each test condition*
- h** *Details of any deviation from this testing method*
- i** *Any information which may assist in the interpretation of the test results*
- j** *Name and signature of the operator*

Edgewise crush resistance of corrugated fibreboard

1 Definition

The edgewise crush resistance of corrugated fibreboard is the maximum compressive force that a test piece will sustain before being crushed, the test piece standing on one edge and the force being applied to the opposite edge under specified conditions.

The edgewise crush resistance of corrugated fibreboard can be very much affected by conversion of board into packaging. It is also affected when the packaging is in use. It is therefore important that the origin of the sample being tested is fully identified under 10. Test report.

2 Scope

To define the apparatus and test procedure used to determine the edgewise crush resistance of corrugated fibreboard. This method is applicable to all types of corrugated fibreboard.

3 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.

4 Principle

A rectangular specimen of the corrugated fibreboard is placed between the platens of a crush tester with the flutes perpendicular to the platens, and is subjected to an increasing compressive force until failure occurs.

The maximum force sustained by the specimen is recorded and the edgewise crush resistance calculated.

5 Apparatus

5.1. Crush tester

A power driven crush testing machine with horizontal platens designed to measure compressive force, shall be used.

For testing machines operating on the principle of beam deflection, see note.

5.2. Platens

The platens must meet the following conditions :

- size large enough to take test specimens of 100 mm length
- deviation from parallel not greater than 1:1000
- lateral play not exceeding 0.05 mm
- flat with at most 0.1 mm deviation from the median plane.

5.3. Compression speed

The tester operates with one fixed platen, the other having a direct positive drive, the rate at which the platens approach each other shall be 12.5 mm/mn \pm 2.5 mm/min.

5.4. Cutting equipment

Cutting equipment designed to give rectangular test pieces with parallel, clean, straight edges.

The cutting shall be done perpendicularly to the flutes in one operation for instance by single bevelled knives which have a thickness of about 0.5 mm, used not more than 50 times or by a high speed rotary saw.

5.5. Guide blocks

Two rectangular, smooth finished, metal blocks, 20 mm x 20 mm, and at least 100 mm in length, to support the test piece and keep it perpendicular to the platens.

6 Sampling

Sample in accordance with FEFCO Testing Method N° 1.

7 Conditioning

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

The corrugated board has to be conditioned before cutting, and to be kept conditioned throughout the test.

8 Preparation of test pieces

8.1. From the corrugated board to be tested, strips 100 mm \pm 0.5 mm wide will be cut in the direction of the glue lines.

8.2. Out of these strips, perpendicularly to the glue lines, test pieces of 25 mm \pm 0.5 mm nominal height will be cut. The maximum difference between any two dimensions having the same nominal value must not exceed 0.2 mm.

8.3. Unless otherwise stipulated, 10 test pieces of the board shall be tested.

8.4. When converted board is tested, test pieces should be free from converting machine marks, printing and any damaged areas.

9 Procedure

The test piece shall be placed centrally on the platen with its shorter edges perpendicular to the platens and supported by the guide blocks.

By operating the tester, the load is increased until the test piece collapses. The maximum load sustained is rounded to the nearest 10 N.

Calculate the edgewise crush resistance R, in kilonewtons per metre according to the equation below, where F is the maximum load, in newtons. L is the length of the test piece in millimetres (here L = 100).

$$R = \frac{F}{L} \text{ kN/m}$$

10 Test report

The test report shall contain the following details :

- a** *Date and place of testing*
- b** *Reference to this FEFCO Method*
- c** *Description and identification of the product tested*
- d** *Results of individual tests to be stated in kN/m*
- e** *Arithmetic mean and standard deviation of all the replicate test results*
- f** *A specific statement that a testing machine working on the principle of beam deflection has been used if relevant*
- g** *Details of any deviation from this testing method*
- h** *Any other information which may assist in the interpretation of the test results*
- i** *Name and signature of the operator*

Note: when a tester operating on the principle of beam deflection is used, results are valid only if they occur between 20 % and 80 % of the maximum range of deflection, that can be measured with the beam and dial in question.

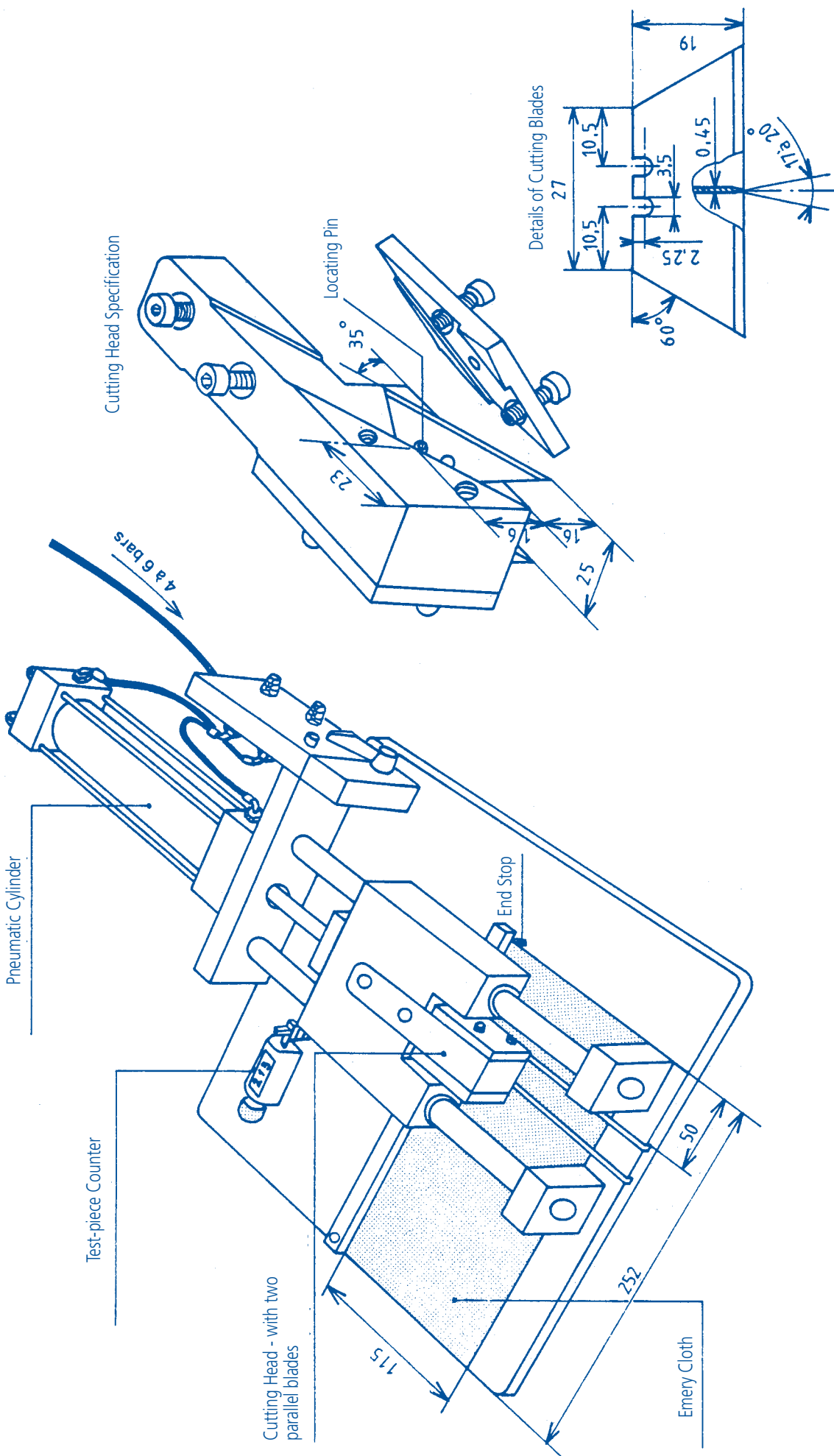


Fig. 1
Edge Crush Sample Cutter

Determination of the water resistance of the glue bond of corrugated fibreboard by immersion

1 Scope

To define the apparatus and test procedure used to determine the water resistance of the glue lines of corrugated board. This method is applicable to all types of corrugated board for which a high degree of bond strength is required to resist the influence of wet conditions.

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

The water resistance of the glue of corrugated fibreboard is expressed by the length of time during which a predetermined combination of glue lines, immersed in water, resists the pull of a suspended weight in the plane vertical axis of the board, at a right angle to the glue lines.

4 Apparatus

4.1. A water tank, preferably glass, for easy observation, large enough for the free suspension of the required number of test specimens. The depth of the tank shall be at least 25 cm. The bottom of a glass tank may be lined with a rubber sheet to prevent damage.

4.2. A number of rods or bars with hooks. These to be placed across the tank for suspension of the test specimens. Means for proper identification of test specimens shall be provided.

4.3. A soft rubber stamp to mark the sample corrugated board with outlines and other details for cutting the test specimens. The design to be imprinted on the corrugated board is shown in fig.1.

4.4. A knife with a sharp, thin blade.

4.5. A straight edge.

4.6. Punch pliers.

4.7. Eyelet pliers, and eyelets.

4.8. A 250 g copper weight for each test specimen. Each of these weights shall be provided with a hook.

4.9. A time control device.

5 Sampling

Sample in accordance with FEFCO Testing Method N° 1.

6 Conditioning

The 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

7.1. Sample

Individual samples must be large enough to permit the cutting of test pieces, size 20 mm ± 1 mm by 150 mm approximately, with the flutes at right angles to the length of the specimen. Except for routine production control tests, the corrugated board to be tested should generally be at least three days old to allow it to develop its water resistance properties. The time will be dependent on temperature and adhesive formulation.

7.2. Test specimens

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

To guide the operator in preparing the test pieces, the corrugated board sample will be marked by means of the rubber stamp (clause 4.3.).

The specimens to be tested are picked at least 50 mm away from a crease, edges and finger lines and also from small local defects in the paper. Not more than one specimen should be cut out of an area approx. 1/2m².

Unless otherwise specified test pieces have to be free from all irregularities or damage, especially by water, mechanical stress (e.g. finger lines).

Two holes shall be punched into the pieces, their centres being at a distance of 10 mm from either end and side, respectively.

Eyelets are inserted into these holes and clenched.

Alternatively a suitable clamp may be used to suspend the test specimen from the rod. A cooper clamp may be used at the lower end to suspend the weight. This clamp and any additional copper weight shall not exceed a total of 250 g.

7.3. Determination of the glue lines to be tested

The shearing stress is concentrated on five lines to be tested within zone M (see fig. 1). These glue lines shall be isolated by cuts through the components as may be necessary to achieve this object, as exemplified in fig. 2 for single wall, fig. 3 for double wall board.

8 Procedure

Five test pieces of each set of glue lines to be tested (standard number), with their ends loaded with weight (see 4.8), are suspended in the tank, which be filled with neutral water (distilled, deionized, demineralized, hydrant) that all M zones (clause 7.3.) of the specimens remain immersed 25 mm below the surface of the water throughout the test period. Care should be taken to avoid the inclusion of air bubbles in the flutes.

Individual test pieces will not be used to test more than one set of five glue lines between the selected lines and its fluting.

8.1. Test temperature

The temperature of the water shall be $23^{\circ}\text{C} \pm 1^{\circ}\text{C}$.

8.2. Timing

The immersed specimens will be checked for failure at 24 hour or such shorter intervals as may be suitable. An automatic time control device is recommendable.

8.3. Failure

Failure of a specimen is shown by complete separation of the five bonds on the same liner side, which will cause the weight to drop.

9 Test report

The test report will contain the following details :

- a) *Date and place of testing*
- b) *Description and identification of the product tested*
- c) *Identification of each specimen tested*
- d) *Number of specimens tested and number of failures at each set glue lines at the chosen test intervals. State intervals.*
- e) *Statement whether after rupture :*
 - * *fibres adhere to the glue*
 - * *glue predominates on the fibre surface.*
- f) *Details of any deviation from this testing method*
- g) *Any other information which may assist in the interpretation of the test results.*

10 Interpretation of the test results

The board can be considered as « water resistant » :

- *if for every test specimen the time of resistance is at least 24 hours without a dropped weight (standard : 5 test pieces of each cutting type).*
- *should there be one early failure per sample type within a period of 24 hours under load, the test will have to be repeated with the corresponding sample type with the full number of specimens (standard : 5 test pieces).*

In this case the test will also be considered as successful, if in the repeated test all specimens remain resistant for at least 24 hours.

- *in all other cases (more than one early failure per sample below 24 hours in the first test round, as well as one more early failure in the repeated testing), then the test will be considered as not successful.*

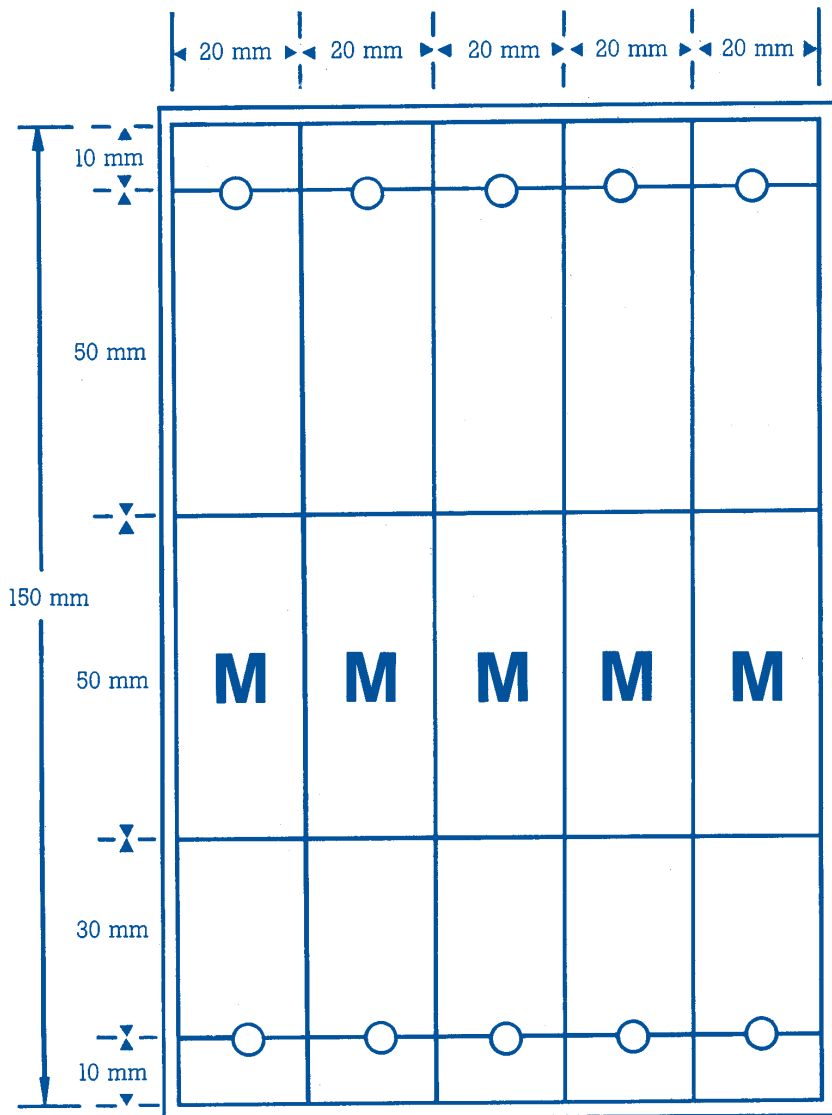
Sporadic weak spots in the paper being technically unavoidable, are not taken into consideration in respect to moisture-proof bonding. (Sporadic impurities do not influence the acceptance but systematical ones in the paper may be a reason for rejection).

11 Notes

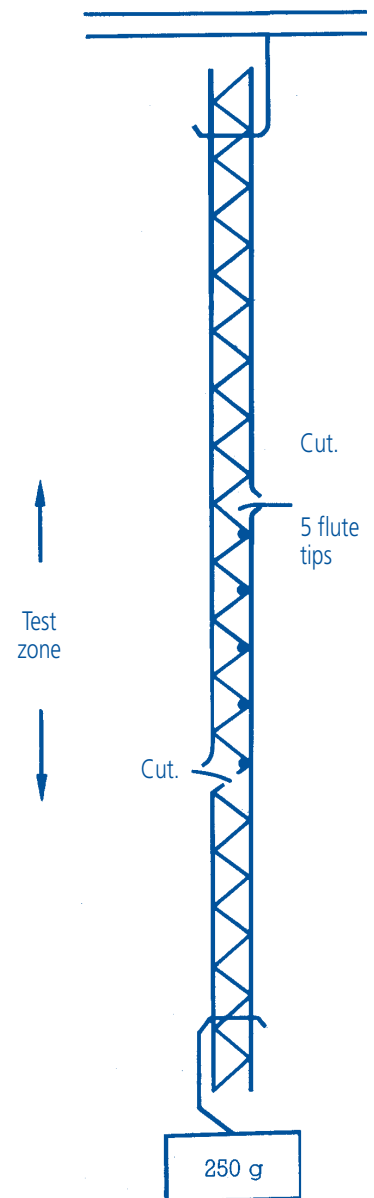
Water resistance of the manufacturer's joint of a box. (Only valid for joints, made with an adhesive or taping band, which can be reactivated with water).

This is also a very good method to test the water resistance of the manufacturer's joint of a box. In this case 2 cm wide strip cuts across the manufacturer's joint are tested according the prescribed method for ordinary board specimens. The whole glued zone has to remain under water. The evaluation of test results has to be done as described in clause 10.

Diagrams



*Fig.1
Rubber stamp*



*Fig.2
Diagram showing suspension
arrangement and typical cuts
in s.w. board*

Diagrams showing typical cuts in D.W.
board to isolate the five glue lines, to be tested

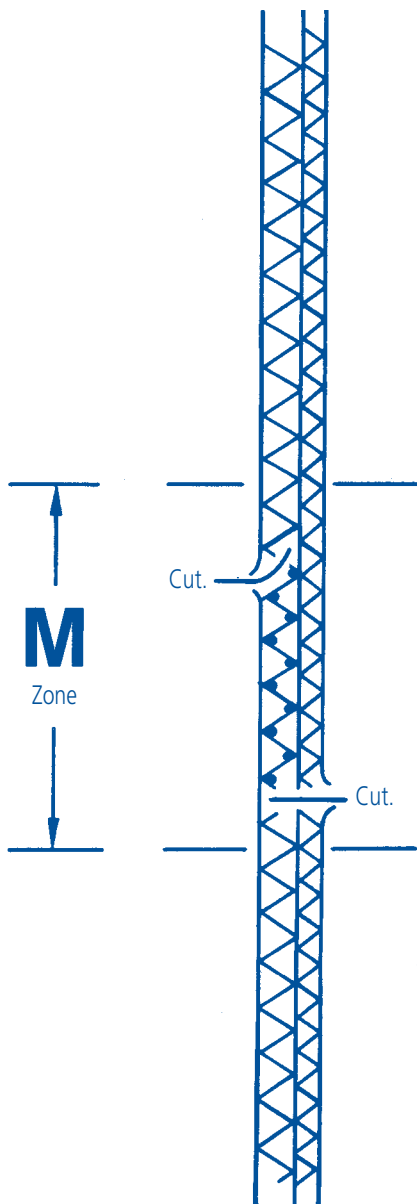


Fig. 3
"A" "A"
flute/liner flute/centre

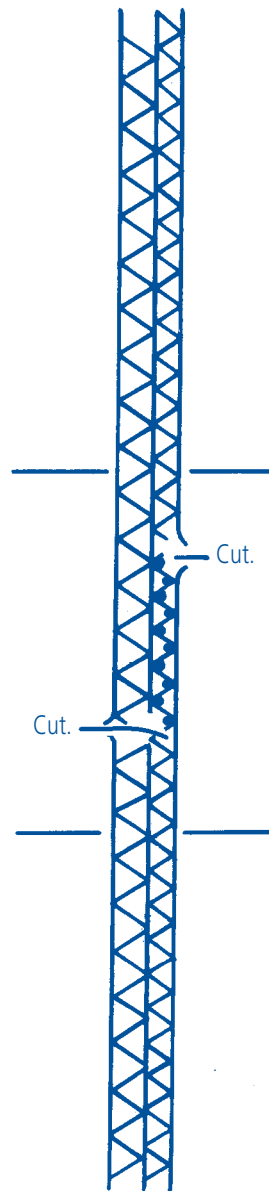


Fig. 4
"B" "B"
flute/liner flute/centre

Determination of the basis weight of the component papers of corrugated fibreboard after separation

1 Scope

To define the apparatus and procedure used to determine the basis weight of the individual papers from which corrugated fibreboard has been made. This method is applicable to all types 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.

EN ISO 536 : paper and board - Determination of grammage

FEFCO testing method n° 6 : Determination of the flat crush resistance of corrugated fibreboard.

3 Principle

Test specimens of corrugated fibreboard are treated so that the individual components can be separated. The component papers are then dried and conditioned, and subsequently used for the determination of their basis, in accordance with EN ISO 536.

4 Apparatus

4.1. A tank of sufficient size for immersion of the board specimens, to contain cold or hot water.

4.2. Means for drying the test specimens when separated, to contain cold or hot water.

4.3. A cutting instrument having a circularly guided knife to cut test pieces with an area of 100 cm² (diameter 113 mm ± 0.5 mm) shall preferably be used. (see FEFCO Test Method N° 6, para 4.4.). Alternatively a sharp knife and straight edge may be used.

4.4. A balance with sensitivity of 0.01 g or better over the entire measuring range (this will make it possible to determine from test pieces of 100 cm² area their grammage to a precision of 1 g/m²).

5 Sampling

Sample in accordance with FEFCO Testing Method N° 1.

6 Conditioning

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

7 Preparation of test pieces

Individual samples of board of sufficient size to provide the test pieces shall be cut from the corrugated fibreboard to be tested. The surfaces of the fibreboard shall be free from any damage which may affect the results. Test specimens shall preferably be taken from nonprinted and noncoated board.

After conditioning the test specimens, cut test pieces of board, each of 100 cm² area minimum using cutting device specified at 4.3. The cut edges shall be clean and perpendicular to the faces of the board.

8 Procedure

8.1. Separation of components papers

Test specimens shall be immersed long enough in water to cause the component sheets of paper to separate spontaneously or with an extremely light pull. Care shall be taken, in separating the papers that no fibres be removed from a surface and adhere to the adjoining one. To accelerate the process, and to separate corrugated board whose glue bond is more or less moisture resistant, hot water may be used.

8.2. Removal of adhesive showing on the surface of the paper

Adhesive which has not been absorbed by the paper may be removed, while wet, by lightly scraping the surface.

Complete removal of the absorbed adhesive cannot be expected.

8.3. Drying of the separated papers

The individual papers shall be dried in a temperature not exceeding 125°C and conditioned.

8.4. Weighing fluting medium

After cleaning and conditioning the fluting medium shall be flattened and recut to give an area of 100 cm².

8.5. Individual tests

The weighing shall be carried out in the standard atmosphere (specified at Clause 6). Each specimen of component papers is to be weighed individually to the nearest 0.01 g.

8.6. Number of individual determinations

Unless otherwise specified, the component papers of five specimens of corrugated board shall be tested.

9

Test report

The report will contain the following details :

- a** *Date and place of testing*
- b** *Description and identification of the corrugated board tested*
- c** *Description and identification of the individual papers*
- d** *Number of test pieces*
- e** *Results of the individual tests in g/m²*
- f** *Arithmetic mean of the individual tests*
- g** *Details of any deviation from this FEFCO Testing Method*
- h** *Any other information which may be essential for the interpretation of the results.*

Determination of the adhesion strength of the glue bonds of corrugated fibreboard (pin method)

1 Scope

To define the apparatus and procedure to be used to determine the strength of the adhesion between the flutes and liners of corrugated board. This method is applicable to all types 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

Two assemblies of metal pins are introduced into spaces between the flutes of the adhesive joints to be tested, in such a way that by means of a holder and a crush tester the sets of joints are separated by the application of a force applied perpendicularly to the surface of the board. The force needed to separate the liner from the fluting is measured and reported.

4 Apparatus

4.1. Crush tester [1]

A power-driven type crush tester shall be used. (When a tester operating on the principle of beam deflection is used, results are valid only if they occur between 20 % and 80 % of the normal range of deflection).

4.1.1. Platens

The platens must meet the following conditions :

- deviation from parallel not greater than 1:1000
- lateral play not exceeding 0.05 mm
- minimum size large enough to take test specimens of 100 mm length.

4.1.2. Compression speed

The relative speed of the two platens shall be 12.5 mm ± 2.5 mm per minute (with testers working on the principle of beam deflection this is equivalent to an increment of force of 67 N/s ± 23 N/s when the platens are in contact with each other).

[1] As an alternative to the crush tester specified at 4.1., other suitable apparatus operating at the speed given at 4.1.2. and meeting the requirements of clause 3 may be used. Full particulars of alternative apparatus used shall be reported under 9.

4.2. Cutting equipment

This shall ensure that the cut edges are clean, straight and perpendicular to the facings of the board.

4.2.1. A bandsaw or knife and cutting jig may be used.

4.3. Pin holder assemblies

The apparatus to be used shall be of any suitable type permitting the perpendicular force to be applied selectively to the liner/flute lines to be tested. Annexe 1 shows the points at which the pins shall be inserted to enable the test to be effected on the selected liner and fluting.

The pins shall be sufficiently rigid so that they are not bent during the test and of a diameter and arrangements that will not distort or deform the flute profiles of the board tested. Unless otherwise specified it is recommended that a combination of 6 and 7 pins shall be used.

The following pin diameters are normally suitable :

A flute = 3 mm

B flute = 2 mm

C flute = 2.5 mm

Note: Flute distance may vary with corrugator manufacturer. Thus, to make appropriate apparatus use pin diameter and tolerance for each flute size, and adjust pin spacing (distance between pins).

5 Sampling

Sample in accordance with FEFCO Testing Method N° 1.

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

7.1. Sample

The samples must be taken from board of sufficient area to permit the cutting of the required number of test specimens which shall be free from machine marks, or other damage.

7.2. Test specimens

Test pieces shall be cut from the samples, avoiding finger lines.

They shall be rectangular, with a dimension parallel to the flute tips of 30 mm unless otherwise specified. The length of the test pieces shall be $N \times Y$ where N equals the number of pins employed plus one and Y equals the distance between the glue line centres.

Glue lines in a test piece in excess of the required amount shall be carefully cut along the fluting at approximately the middle of the flute walls before testing.

7.2.1. Unless otherwise specified, at least ten specimens for each set of lines to be tested shall be used.

8 Procedure

The tests shall be carried out in the standard atmosphere specified above.

After introducing the sets of pins in the required positions in the test piece and assembling the test set described in 4.3., the latter is placed in position centrally on the crush tester platen. The machine is then operated to apply force to the test until separation of the liner/fluting occurs. The force needed to separate the liner from the fluting of the test piece is recorded to the nearest 5N (or 0.5 kgf) [2].

The Pin Adhesion Strength is calculated according to the formula:

$$\text{PAT} = \frac{F}{L}$$

where:

PAT = Pin Adhesion Strength in N/m

F = Force for separation in N

L = total length of the glue lines in m [eq. (number of pressure pins) x 2 x (width of the sample)]

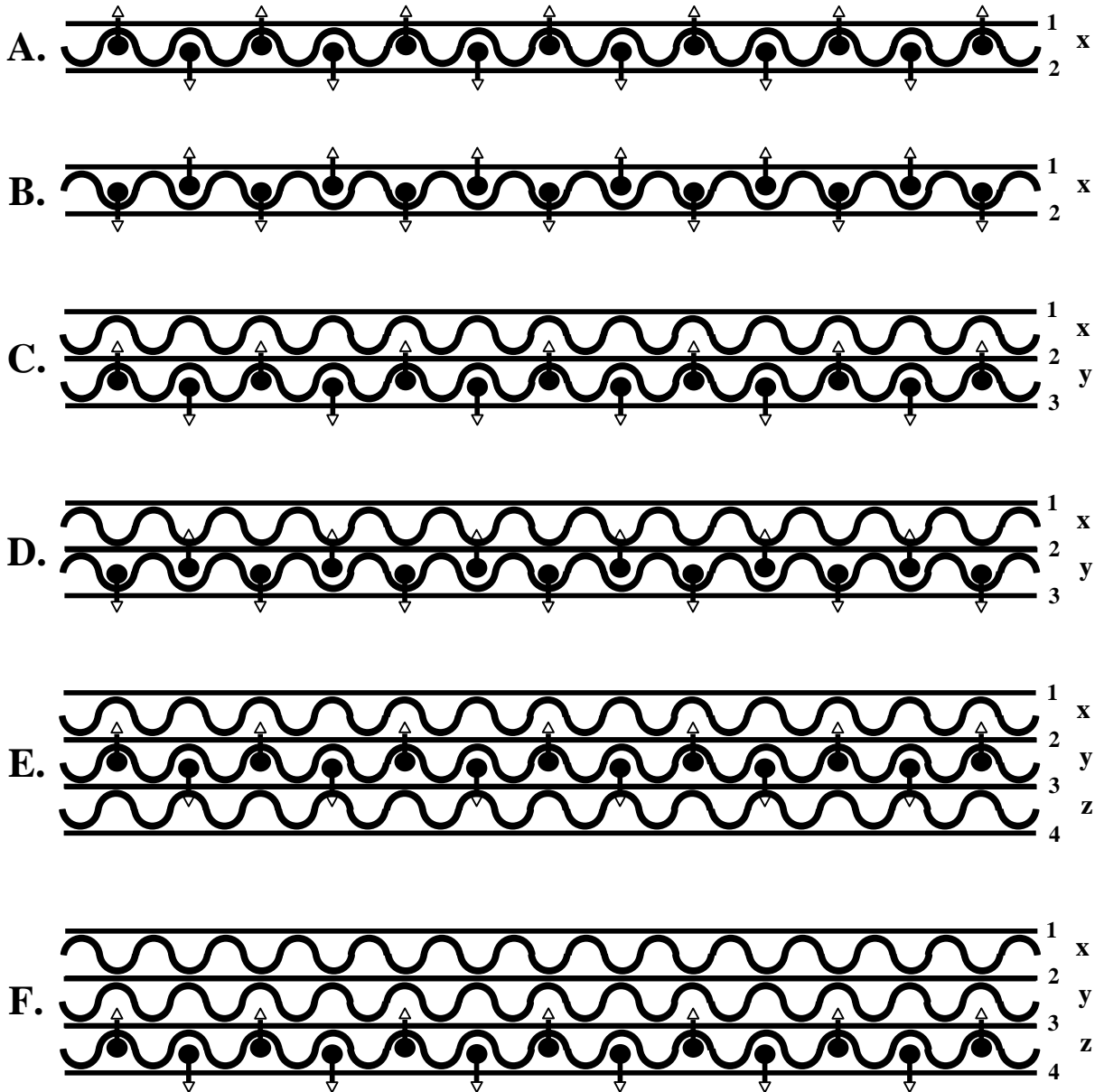
9 Test report

The test report shall contain the following details :

- a) *Date and place of test*
- b) *Description and identification of the material tested*
- c) *Number of individual tests stating liner/flute bond tested*
- d) *Number of pins employed*
- e) *Total length of glue lines tested on each test piece*
- f) *Results in N/m (or kgf) [2] per m for each test piece*
- g) *Arithmetic mean and standard deviation of the results*
- h) *The extent of fibre tear expressed as a percentage of the total glue line length*
- i) *Details of any deviation from this test method*
- j) *Any other information which may assist in the interpretation of the test results.*

[2] 1 N = 0.1019 kgf

DIAGRAMS



FEFCO TEST N. 11

Diagrams illustrating the placing of pins between flutes to test the glue bonds of selected liners/fluting of corrugated board.

- | | |
|-------------------------------------------|-------------------------------------------|
| a) To test the bond between liner 2 and X | d) To test the bond between liner 2 and Y |
| b) To test the bond between liner 1 and X | e) To test the bond between liner 3 and Y |
| c) To test the bond between liner 3 and Y | f) To test the bond between liner 4 and Z |

Note : Normally Liner 1 = single facer liner.

Determination of the Compression Resistance of corrugated fibreboard containers

1

Scope

This testing method specifies the procedure for determining the resistance to compression of empty corrugated fibreboard packagings, with or without interior fittings, using a compression testing machine.

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.

EN 22 206 : packaging - complete, filled transport packages - identification of parts when testing.

EN 22 233 : packaging - complete filled transport packages - conditioning for testing.

3

Principle

Placing the test packaging between the platens of a compression testing machine and subjecting it to a crushing force.

The force and platens displacement are recorded during the test.

4

Apparatus

4.1 Motorised compression testing machine, platen type, capable of applying a force through uniform movement of one or both platens at a relative speed in the range of 12.5 mm/min \pm 2.5 mm/min.

Note: compression testing machines with relative platen speeds outside the specified range may be used but their speed must be indicated in the test report, as it may influence the result.

The platens shall be :

- horizontal and rigidly mounted
- flat, with at most 1 mm deviation from the median plane, local fixing bolts recessed excepted
- dimensioned so as to extend over the whole area of the packaging
- parallel within 2 : 1000
- rigid, so as not to deform \sim y more than 2 mm at any point when the compression testing machine applies a force of 75 % of its maximum rating to a centrally placed 100 x 100 x 100 mm block having sufficient strength to withstand this force.

The lower platen may bear markings to facilitate the centering of the test packaging prior to testing.

4.2 Device for recording forces with at most 2 % error and platen displacements, with at most 1 mm or 5 % error, whichever is greater.

5

Sampling

Sample in accordance with FEFCO Testing Method N° 1.

6

Conditioning

Unless otherwise specified, containers shall be conditioned in accordance with EN 20187 (i.e. *noe* \pm 1°C. 50 % \pm 2% r.h.).

Note: In case other conditions are used, preference should be given to the conditions mentioned in EN 22233.

7

Preparation of the Packaging

Erect the packaging by direct folding and if necessary, assemble it according to the procedure agreed upon by the interested parties and compress it in the agreed direction.

8

Procedure

Wherever possible the test shall be carried out in the same atmospheric conditions as used for conditioning. In other circumstances, the test shall be carried out immediately after conditioning, with indication of the elapsed time in the test report.

- 8.1 Place the test packaging centrally on the lower platen of the compression testing machine, in the pre-determined attitude.
- 8.2 Start the compression testing machine and continue compressing until complete collapse of the packaging.
- 8.3 Note the maximum resistance of the packaging in N to three significant figures.
- 8.4 Unless otherwise specified, the deflection shall be measured on the force/deflection CUNE from a pre-load datum point of 5 % of the maximum resistance of the packaging, with a maximum of 200 N, see figure.
- 8.5 Unless otherwise specified, test at least 10 replicate packagings.

The precision is based on a round robin test carried out by FEFCO in 2001 with 14 laboratories.

The test specimens consisted of B, C, and BC flute regular slotted boxes (FEFCO 0201).

The precision calculated according to ISO 5725-2 is the following:

<i>Relative Standard Deviation(%)</i>	
<i>in repeatability conditions (r.s.d. = 100.s_r/general mean)</i>	<i>in reproducibility conditions (r.s.d. = 100.s_R/general mean)</i>
4.4	8.0

See examples in Appendix 2

s_r : repeatability

s_R : reproducibility

The test report shall at least include:

- a. Date and place of the testing
- b. Reference to this FEFCO testing method
- c. Number of replicate packagings tested
- d. Full description of the packaging, including dimensions, structural and material specifications of the packaging and its fittings
- e. Temperature, relative humidity
- f. The particulars of preparation of the packaging covered by a special agreement, and attitude in which the packaging was tested using the method of identification given in EN 22 206
- g. Conformance of the compression testing machine, including the relative speed of the platens
- h. Measurements of the maximum resistance to compression of the packaging in N to three significant figures; and if requested, associated deflections, or force/deflection recordings
- i. Arithmetic mean and standard deviation of the results
- j. Any deviation from the procedure specified in this testing method
- k. Any observation which may assist in the correct interpretation of the results
- l. Name and signature of the operator

For packaging made up of several pieces each contributing to the overall resistance (i.e. full telescopic boxes, packaging with internal fitments, etc.), it may be useful to separately determine the resistance of its components according to this procedure and then to compare the resistance of the packaging to the sum of the resistances of its components.

Force (N)

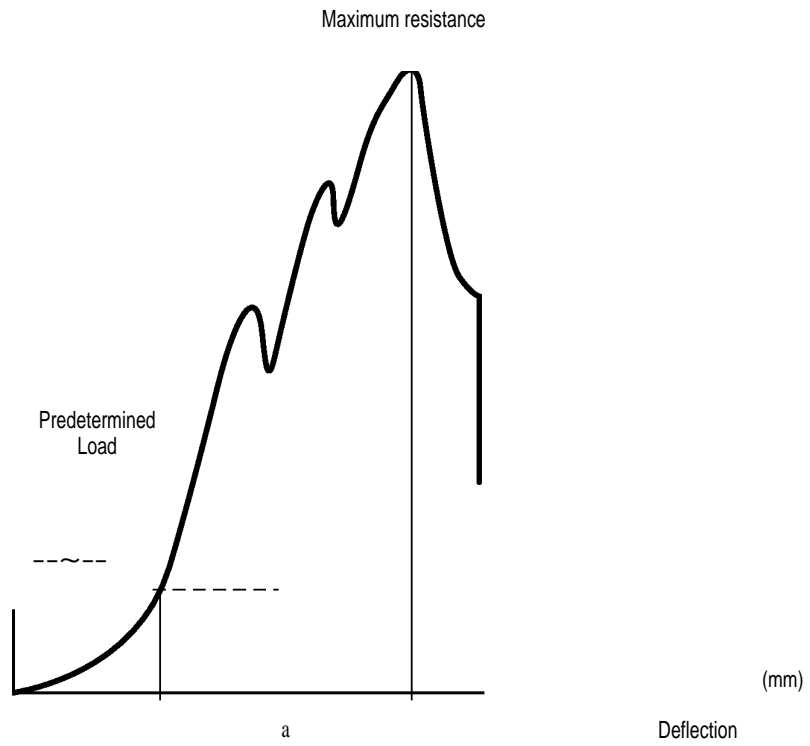


Fig.
1

Appendix 2

Calculation of the Critical Difference between measurements from Repeatability (s_r) and from Reproducibility (s_R) along ISO 5725

Examples

1 – Two series of n_1 and n_2 measurements in one laboratory

$$C.D = 2,77 \cdot s_r \sqrt{\frac{1}{2n_1} + \frac{1}{2n_2}}$$

Knowing $r.s.d = 100 S_r / level$

then

$$C.D = 2,77 \cdot \frac{r.s.d \times level}{100} \sqrt{\frac{1}{2n_1} + \frac{1}{2n_2}}$$

- $n_1 = n_2 = 1$ (Comparison of measurements)

$$C.D = 2,77 \cdot \frac{r.s.d \times level}{100}$$

ex.

$$level = 300 \text{ daN}$$

$$r.s.d = 4,4 \%$$

$$C.D = 2,77 \times 4,4 \times 300 / 100 = 37 \text{ daN}$$

- $n_1 = n_2 = 10$ (Comparison of means)

$$C.D = 2,77 \cdot \frac{r.s.d \times level}{100} \sqrt{\frac{1}{20} + \frac{1}{20}}$$

ex.

$$level = 300 \text{ daN}$$

$$r.s.d = 4,4 \%$$

$$C.D. = \frac{2,77 \times 4,4 \times 300}{100 \times \sqrt{10}} = 12 \text{ daN}$$

2 – Two series of n_1 and n_2 measurements in two laboratories

$$C.D = \sqrt{(2,77 s_R)^2 - (2,77 s_r)^2 \left(1 - \frac{1}{2n_1} - \frac{1}{2n_2}\right)}$$

Knowing $r.s.d = 100 S/level$

then

$$C.D = \sqrt{\left(2,77 \frac{r.s.d_R \times level}{100}\right)^2 - \left(2,77 \frac{r.s.d_r \times level}{100}\right)^2 \left(1 - \frac{1}{2n_1} - \frac{1}{2n_2}\right)}$$

- $n_1 = n_2 = 1$ (Comparison of measurements)

$$C.D = 2,77 \cdot \frac{r.s.d_R \times level}{100}$$

ex.

$level = 300 daN$

$r.s.d_R = 8,0 \%$

$$C.D = 2,77 \times 8,0 \times 300/100 = 67 daN$$

- $n_1 = n_2 = 10$ (Comparison of means)

ex.

$level = 300 daN$

$r.s.d_r = 4,4 \%$

$r.s.d_R = 8,0 \%$

$$C.D = \sqrt{\left(2,77 \frac{8,0 \times 300}{100}\right)^2 - \left(2,77 \frac{4,4 \times 300}{100}\right)^2 \left(1 - \frac{1}{20} - \frac{1}{20}\right)}$$

$$C.D = 57 daN$$

Filled corrugated fibreboard containers - Vertical impact test by dropping

This test is one of a series of performance tests for corrugated fibreboard containers and may be selectively applied as specified, either singly, or in combination with other tests.

1 Object

To define the apparatus and test procedure to be used to determine the ability of complete filled corrugated fibreboard containers to withstand vertical impacts (caused by drops, handling etc) and to assess the protection provided for the contents by the packaging.

2 Scope

The test is applicable to all types of corrugated containers, complete with internal fitments and the actual or dummy contents.

3 Normative references

EN 22 206 : Packaging - Complete, filled transport packages - identification of parts when testing.

EN 22 233 : Packaging - Complete, filled transport packages - Conditioning for testing.

4 Principle

A specimen container complete with actual or dummy contents is caused to fall freely, in a predetermined attitude and from a specified drop height on to a solid plane, horizontal surface⁽¹⁾. On completion of the test cycle, which may consist of a number of drops with the container in differing attitudes, the specimen and its contents are examined and reported on.

Dummy contents : where the use of the actual contents is prohibitive because of excessive cost or danger, or for other reasons, an artificial load may be used provided that it has similar dimensions, centre of gravity, moment of inertia, etc, and adequately represents the item it replaces.

Drop height : the vertical distance from the impacting surface to the lowest corner, edge, or face of the specimen, as appropriate, when positioned for dropping.

Attitudes : for the purpose of specifying the attitude in which the specimen is dropped the faces should be identified according to EN 22206 as follows :

Facing one end (with the manufacturers' joint vertical on the right side) the top of the container is numbered as 1, the right side 2, the bottom 3, the left side as 4, the near end 5, and the far end 6 (see fig. 1).

Containers not having or having more than one manufacturers' joint will be dealt with on the same principle by arbitrarily selecting one end as face 5.

Thus, the edges will be identified by the numbers of the two faces which make the edge and corners by the numbers of the three faces which meet to form the corner e.g. 2-3-5 will designate the corner at the bottom of the manufacturers' joint in fig. 1.

5 Apparatus

This shall consist of :

- 5.1.** Means of suspending or supporting the test specimen in the required attitude at the specified drop height.
- 5.2.** A release mechanism which shall not impart acceleration, rotational or side wise forces, nor interfere with the free fall of the test specimen.
- 5.3.** A horizontal⁽¹⁾, concrete or steel plane surface which shall be solid and of sufficient mass to withstand the impact energy without significant deflection or movement.

6 Conditioning

The test containers, with any internal fitments, shall be conditioned prior to filling in accordance with EN 22233. Unless otherwise specified, condition 'G' (23°C ± 2°C, 50 % rh ± 3 % rh) shall be used.

Note : For packaging tests, FEFCO recommends 23°C ± 2°C, 50 % rh ± 3 % rh, but draws the attention that ISO sets ± 2 % rh, which is quite strict for plants that cannot condition a big room.

7 Procedure

- 7.1.** A test specimen shall consist of a container, with normal or dummy contents, filled, closed and sealed in the manner intended for normal usage. The faces should be numbered for identification.
- 7.2.** The test should be carried out in the same atmosphere used for conditioning. Alternatively the test should be commenced within 5 minutes of removal of a specimen from the conditioning atmosphere.

If specified, the contents may be conditioned before filling the container which shall be retained in the conditioned atmosphere during filling, closing and testing.

7.3. Individual tests : the test container shall be suspended or supported by means of the apparatus, in the required attitude at the specified drop height and the release mechanism operated to permit free fall of the specimen on to the impact surface.

Drop testing of individual specimens shall be repeated as specified, unless there is evidence of severe damage necessitating termination of the test sequence.

7.4. Number of tests : unless otherwise specified, a minimum of three containers shall be tested.

8 Test report

The test report shall contain the following :

- a** *date and place of testing*
- b** *description, (including internal fitments and contents) identification and quantity of specimens tested.*
- c** *test climate used (if other than 23°C 50 % rh).*
- d** *description of the apparatus employed.*
- e** *description of the test sequence carried out on each specimen.*
- f** *if the drop testing is carried out as part of a series of tests, reference to that series.*
- g** *observations for each specimen indicating :*
 - 1) damage sustained by the container and fitments*
 - 2) damage to and/or loss of contents*
 - 3) whether the test sequence was completed, and if not, the point at which it was terminated.*
- h** *details of any deviation from this testing method*
- i** *any other information which may assist in the interpretation of the test results.*

(1) A plane surface inclined at 10° from the horizontal may be substituted.

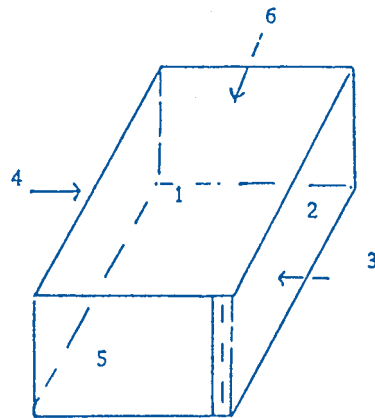


Figure 1

Filled corrugated fibreboard containers - Vibration test at fixed low frequency

This test is one of a series of performance tests for filled corrugated fibreboard containers and may be selectively applied as specified, either singly, or in combination with other tests.

1 Object

To define the apparatus and test procedure to be used to determine the ability of a complete filled corrugated fibreboard container or a stack of complete filled corrugated containers with or without a superimposed load, to withstand vibration within the stated range.

2 Scope

The test is applicable to all types of corrugated fibreboard containers, complete with internal fittings and the actual or dummy contents, or a stack of filled containers.

3 Normative references

EN 22 206 : Packaging – complete, filled transport packages – identification of parts when testing.

EN 22 233 : packaging - complete, filled transport packages, conditioning for testing.

4 Principle

The test provides an accelerated simulation of transportation vibration effects.

A specimen container or a stack of containers with actual or dummy contents is subjected to controlled vibration for a specified period of time or until a defined failure occurs.

Dummy contents : where the use of the actual contents is prohibitive, because of excessive cost or danger, or for other reasons, an artificial load may be used provided that it has similar dimensions, centre of gravity, etc, and adequately represents the item it replaces.

Amplitude : the amplitude is the maximum distance in mm, which the table of the vibration tester makes in the direction of vibration measured from the zero position of the table.

Attitudes : for the purpose of specifying the attitude in which the specimen is tested the faces should be identified according to EN 22 206 as follows :

Facing one end (with the manufacturers' joint vertical on the right side) the top of the container is numbered as 1, the right side 2, the bottom 3, the left side as 4, the near end 5, and the far end 6 (see fig. 1).

Containers not having or having more than one manufacturers' joint will be dealt with on the same principle by arbitrarily selecting one end as face 5.

Thus, the edges will be identified by the numbers of the two faces which make the edge and corners by the numbers of the three faces which meet to form the corner e.g. 2-3-5 will designate the corner at the bottom of the manufacturers' joint in fig. 1.

5 Apparatus

5.1. Type of vibration tester : a motorised and movement controlled table type vibration tester shall be used.

5.2. Table : the table shall be a rigid, horizontal plane surface of adequate weight-carrying capacity with dimensions to accept test specimens without overhang. The table shall be supported on a mechanism that will maintain the surface horizontal during vibration.

The table may be equipped with :

5.2.1. Low fences to restrict sideways and endways movement during testing.

5.2.2. High fences or other means of maintaining a superimposed load in position on the package during testing.

5.2.3. A device to enable a superimposed load to be applied to the specimens throughout the test.

5.3. Mechanism : the mechanism on which the table is supported shall be designed to vibrate the table with a vertical component motion which is approximately sinusoidal. A rotary movement of the table is acceptable. Existing apparatus, not complying with this clause, may be used but the type of motion and the maximum acceleration applied shall be stated in the report.

5.4. Weight capacity : the functional weight-carrying capacity of the apparatus shall exceed the weight of the test specimen plus any additional superimposed loading which may be specified for the test.

5.5. Frequency and amplitude : the vibration frequency shall be adjustable over the range 2 Hz to 7 Hz, and the amplitude shall be adjustable over the range 5 mm to 12,5 mm (total throw = 2x amplitude). The amplitude will vary with frequency ; see clause 7.3.

- 5.6.** Calibration : an accelerometer should be fixed securely to the table in the area where the test specimen is to be placed, and the frequency then varied until the required acceleration is indicated.

The acceleration head should be placed in this sensitive direction parallel to the direction of motion. When there is a combined motion, acceleration heads shall be used perpendicular to each other and parallel to directions of motion to be measured.

6 Conditioning

The packages to be tested shall be conditioned in accordance with one of the conditions specified in EN ISO 22 33. Unless otherwise specified condition "G" (23°C ± 2°C, 50 % rh ± 3 % rh) shall be used.

Note : For packaging tests, FEFCO recommends 23°C ± 2°C, 50 % rh ± 3 % rh, but draws the attention that ISO sets ± 2 % rh, which is quite strict for plants that cannot condition a big room.

7 Procedure

- 7.1.** Test specimen : a test specimen shall consist of a representative container or a stack consisting of a given number of containers with actual or dummy contents, closed and sealed in the manner intended for shipment.

- 7.2.** The test should be carried out in the same atmosphere used for conditioning. Alternatively the test should be commenced within 5 minutes of removal of a specimen from the conditioning atmosphere.

- 7.3.** Individual tests : the test specimen or a stack of test specimens, with or without additional top loading, is placed on the table and the fences put in position.

To avoid overloading, start the apparatus at a low frequency. Then increase it at a steady rate as quickly as possible so that the acceleration of specified G value is attained.

The acceleration factor (G) is dependent on frequency as well as amplitude. Theoretically this is given in the following formula :

$$G = x \cdot \omega^2 = \text{actual acceleration in m/s}^2$$

x = amplitude in m

$$\omega = 2 \cdot \pi \cdot f$$

f = frequency in Hz

$$(G) = \frac{\text{actual acceleration}}{g} = \text{acceleration factor}$$

$$g = 9.81 \text{ m/s}^2 = \text{gravity acceleration}$$

For tests in excess of acceleration factor 1.0 - 1.1 g, the required acceleration shall be determined, using an accelerometer capable of sensing up to 2.0 g under the required conditions.

Continue the test for the specified period of time or, if so specified, until failure occurs. When the specification requires testing to failure, it must give a clear definition of failure.

- 7.4.** Number of tests : unless otherwise specified a minimum of three identical tests shall be carried out.

8 Test report

The test report shall contain the following :

- a** date and place of testing
- b** description and identification of the specimens tested, including internal fitments and contents.
- c** test climate used (if other than 23°C 50 % rh).
- d** relative humidity, temperature and duration of conditioning and the atmospheric conditions during test.
- e** angle of motion relative to the horizontal ; frequency and amplitude, applied.
- f** if the vibration test is carried out as part of a series of tests, reference to that series.
- g** duration of test
- h** observations for each test specimen indicating as necessary :
 - 1) damage sustained by the container and fitments and other packaging material
 - 2) damage to contents
- i** details of any deviation from this testing method or apparatus used
- j** any other information which may assist in the interpretation of the test results.

Filled corrugated fibreboard containers - Horizontal impact test (inclined plane test)

This test is one of a series of performance tests for corrugated fibreboard containers and may be selectively applied as specified, either singly, or in combination with other tests.

1 Object

To define the apparatus and test procedure to be used to determine the ability of complete filled corrugated fibreboard containers to withstand horizontal impact stresses and to assess the protection provided for the contents by the packaging.

2 Scope

The test is applicable to all types of corrugated fibreboard containers complete with internal fitments and the actual or dummy contents.

3 Normative references

EN 22 206 : Packaging - Complete, filled transport packages - Identification of parts when testing.

EN 22 233 : Packaging - Complete, filled transport packages - conditioning for testing.

4 Principle

A specimen container complete with actual or dummy contents is placed on a carriage mounted on inclined rails. The loaded carriage is released and allowed to run freely down the incline causing the specimen to impact against a rigid flat plane surface mounted at 90° to the inclined plane.

On completion of the specified test cycle, which may consist of a number of impacts from varying distances and with the specimen in differing attitudes, the specimen container and its contents are examined and reported on.

Dummy contents : where the use of the actual contents is prohibitive, because of excessive cost or danger, or for other reasons, an artificial load may be used provided that it has similar dimensions, centre of gravity, etc, and adequately represents the item it replaces.

Attitudes : for the purpose of specifying the attitude in which the specimen is impacted the faces should be identified according to EN 22 206 as follows : Facing one end (with the manufacturer's joint vertical on the right side) the top of the container is numbered as 1, the right side 2, the bottom 3, the left side as 4, the near end 5, and the far end 6 (see fig. 1).

Containers not having or having more than one manufacturer's joint will be dealt with on the same principle by arbitrarily selecting one end as face 5.

Thus, the edges will be identified by the numbers of the two faces which make the edge ; and corners by the numbers of the three faces which meet to form the corner e.g. 2-3-5 will designate the corner at the bottom of the manufacturer's joint in fig. 1.

5 Apparatus

The principal apparatus shall consist of :

5.1. A track consisting of two parallel steel rails inclined at an angle of 10° to the horizontal rigidly supported and braced to minimise deflection when loaded.

5.2. A flat, smooth, rigid impact surface integral with the main structure at the lower end of the incline. The plane of the impact surface shall be at 90° to the plane of the track and to its direction.

The impact surface shall be adequately reinforced to withstand the impact energy, without significant deflection or movement.

The dimensions of the impact surface shall be greater than those of the impacting face of the test specimen.

5.3. A sturdily constructed flat-bed carriage with four steel wheels with roller bearings.

Note : four steel guide wheels may be additionally used.

The surface of the carriage, normally of wood, must be flat, smooth, and free from bolt or nail heads and other projections, and must be parallel to the plane of the track.

The friction between the test specimen and the carriage shall be sufficient to maintain its position during the run.

The dimensions of the carriage shall be sufficient to accommodate the test specimen without overhang.

5.4. A graduated scale with convenient increments e.g. 5cm increments- along the inclined plane to permit accurate control of the distance of travel before impact.

- 5.5.** A motorised or manually operated mechanism to elevate the loaded carriage, and an automatic tripping device to release the carriage at predetermined distances from the impact face.

The apparatus may also be fitted with an automatic counting device to record each passage of the carriage down the incline.

Note : figure 2 shows a diagram of the main features of the apparatus with some typical dimensions suitable for most purposes.

- 5.6.** Calibration : the apparatus shall be calibrated so that the velocity at the point of impact is known in metres per second. The calibration shall be made with an empty carriage using an electric timing device. The average velocity shall be calculated from the known distance of travel and the elapsed time. The velocity at impact shall be taken as twice the average velocity.

A chart or graph shall be prepared from the calibration values and this will be used to determine the distance of travel required to produce the desired velocity at impact.

It is necessary, when calibrating the apparatus, and when carrying out tests, that the carriage wheels and the track shall be generously lubricated to minimise friction.

6 Conditioning

The specimen containers, with any internal fitments, shall be conditioned prior to filling in accordance with EN ISO 22 33. Unless otherwise specified, condition 'G' ($23^{\circ}\text{C} \pm 2^{\circ}\text{C}$, $50\% \text{ rh} \pm 3\% \text{ rh}$) shall be used.

Note : For packaging tests, FEFCO recommends $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$, $50\% \text{ rh} \pm 3\% \text{ rh}$, but draws the attention that ISO sets $\pm 2\% \text{ rh}$, which is quite strict for plants that cannot condition a big room.

7 Procedure

- 7.1.** Test specimen : a test specimen shall consist of a container, with actual or dummy contents, filled, closed and sealed in the manner intended for normal usage. The faces should be numbered for identification in accordance with clause 4.

- 7.2.** The test should be carried out in the same atmosphere used for conditioning . Alternatively the test should be commenced within 5 minutes of removal of specimen from the conditioning atmosphere.

If specified the contents may be conditioned before filling the container, which shall be retained in the conditioned atmosphere during filling, closing and testing.

- 7.3.** Individual tests : the test specimen shall be placed on the carriage in the specified attitude with the face or edge to be impacted coincident with the lower edge of the carriage flat-bed (see fig. 2).

The carriage will then be elevated and released at the predetermined point required to give the specified impact velocity.

Impact testing shall be repeated as specified unless there is evidence of severe damage necessitating termination of the test sequence.

- 7.4.** Number of tests : unless otherwise specified a minimum of three containers shall be tested.

8 Test report

The test report shall contain the following :

- a** date and place of testing
- b** description, including internal fitments and contents, identification and quantity of specimens tests.
- c** test climate used (if other than 23°C 50 % rh)
- d** a statement whether the contents have been conditioned
- e** description of the apparatus employed
- f** description of the test sequence carried out on each specimen
- g** if impact testing is carried out as part of a series of tests - reference to that series
- h** observations for each specimen indicating :
 - 1) damage sustained by the container fitments
 - 2) damage to and/or loss of contents
 - 3) whether the test sequence was completed and if not, the point at which it was terminated.
- i** details of any deviations from this testing method, conditioning etc
- j** any other information which may assist in the interpretation of the test result.

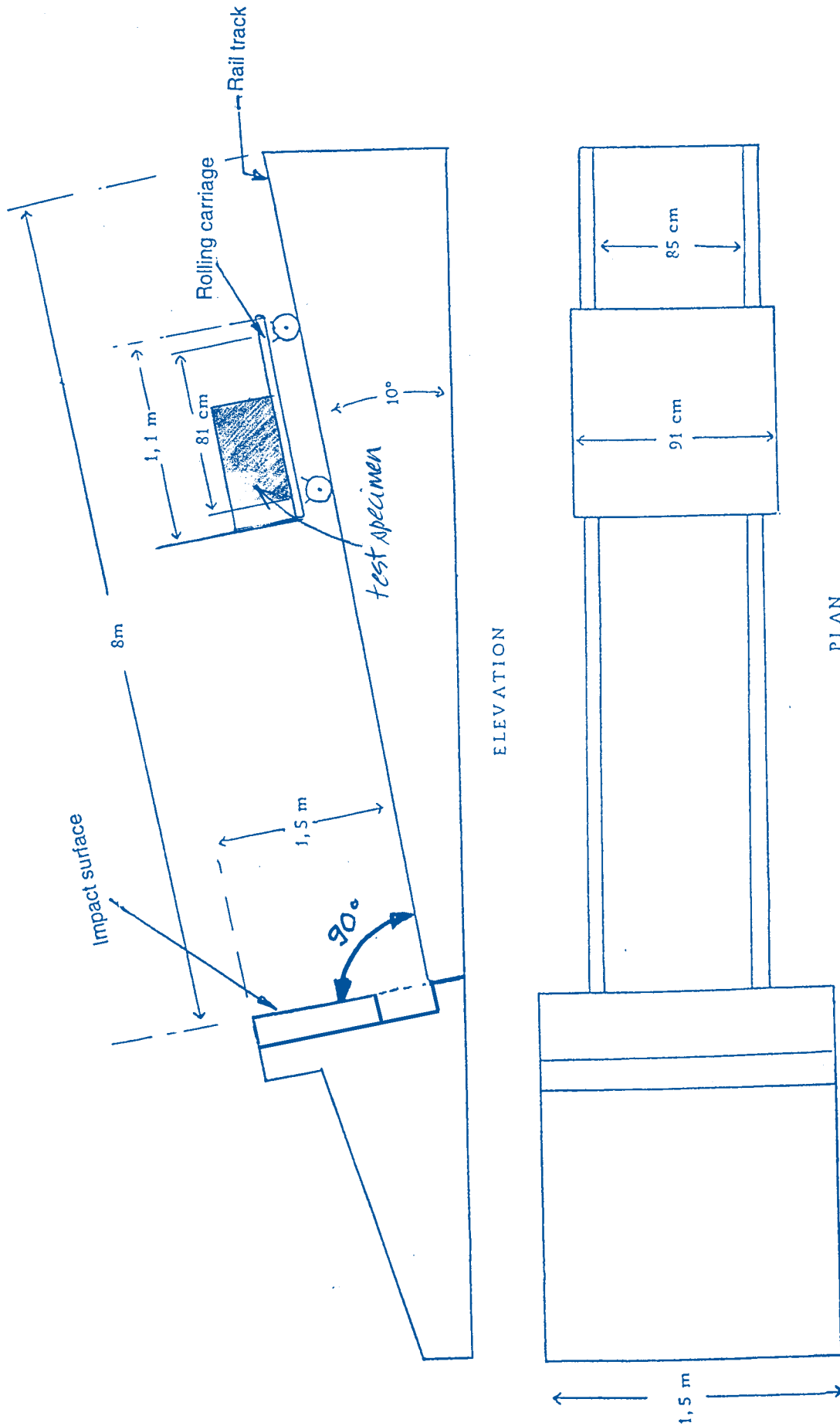


Figure 1

Determination of the strength of the manufacturers' joint of corrugated fibreboard containers (compression method)

This is one of a series of performance tests for corrugated fibreboard containers and may be selectively applied, as specified, either singly or in combination with other tests.

1 Object

To define the apparatus and test procedure to be used to determine the strength of a section of the manufacturers' joint taken from a corrugated fibreboard container.

2 Scope

The test is applicable to all types of manufacturers' joints made at the edges of corrugated fibreboard containers.

3 Normative references

EN 22 233 : Packaging – Complete, filled transport packages – conditioning for testing.

4 Principle

A section of the board containing the manufacturers' joint and adjacent panels is cut from the container and clamped in a test assembly. The test assembly is then placed between the platens of a compression tester, and is subjected to compressive action until the specified value is obtained or rupture of the joint occurs.

5 Apparatus

5.1. Type of compression tester : a suitable motor driven, mechanical or hydraulic, platen type tester shall be used.

5.1.1. Compression speed : load shall be applied through uniform movement of one or both platens at a relative speed of 12,5 mm/min \pm 2,5 mm/min. Some existing testers operate outside this range and when one of these is used, the actual relative speed shall be stated in the test report.

5.1.2. Recording device : the compression tester shall be equipped with an autographic load/deflection recording device with zero setting adjustment.

5.1.3. Calibration : the rate of loading shall be maintained within the specified limits and checked by direct measurement of the relative movement of the platens in a measured period of time. The recording of load shall be within a total tolerance range of 2 % checked by applying weights, or with a load cell or other appropriate means. Calibration correction factors shall be applied, where necessary to comply with the specified accuracy for load recording.

5.2. Test assembly

5.2.1. A typical test assembly is shown at fig 1. This consists of a rigid metal frame, fitted with clamps at each side to secure the free ends of the test piece parallel to the manufacturers' joint and a movable shaft, fitted with a radiused V shaped pressure head (see fig.1). Load is applied to the test piece by vertical movement of the platen acting on the pressure head assembly.

5.2.2. To prevent slippage, the clamping surfaces of the assembly shall be faced with emery cloth, free of ridges, secured by means of double sided adhesive tape or adhesive. The emery cloth should be replaced when necessary.

5.2.3. To facilitate positioning of the test pieces, the design of the assembly should be such that the upper clamps are removable and can be replaced to ensure positive clamping.

6 Conditioning

6.1. Unless otherwise specified test specimens shall be conditioned in accordance with EN ISO 22 33. Unless otherwise specified, condition 'G' (23°C \pm 2°C, 50 % rh \pm 3% rh) shall be used.

Note : For packaging tests, FEFCO recommends 23°C \pm 2°C, 50 % rh \pm 3 % rh, but draws the attention that ISO sets \pm 2 % rh, which is quite strict for plants that cannot climate a big room.

7 Procedure

7.1. Test specimens

A test specimen shall be a rectangular section cut from a case to provide two equal panels on either side of the angle formed by the manufacturers' joint. The normal crease formed by the joint during manufacture shall not be reversed.

Each of the panels of the test specimen shall be of sufficient length to permit adequate clamping in the test assembly when the test piece suspended below and in line with the centre line of the pressure head forms a 90° angle.

The dimension parallel to the joint shall be, where possible, at least 150 mm and shall not exceed the length of the pressure head.

7.2. The test should be carried out in the standard atmosphere used for conditioning.
Alternatively the test shall be commenced within five minutes of removal of a test specimen from the conditioning atmosphere.

7.3. Individual tests : with the inner facing (liner) of the test piece uppermost, the panels shall be positioned so that the V of the joint forms a 90° angle directly below and in line with the centre line of the pressure head. Ensuring that the test specimen is maintained in this position the free ends shall then be firmly secured in the test assembly clamps.

The test assembly shall be placed centrally on the lower platen of the compression tester and the tester operated until the specified load is obtained or until rupture occurs.

7.4. Number of tests : unless otherwise specified, a minimum of five test specimens shall be tested.

8 Test report

The test report shall contain :

- a** *date and place of testing*
- b** *description and identification of the board*
- c** *length and types of joint (glued, taped, stitched)*
- d** *full particulars of the joint tested, e.g. nature of the adhesive and the width or pattern applied ; width and type of tape ; wire gauge, number of stitches and whether applied in line, parallel to or at an angle with the joint crease.*
- e** *test climate used (if other than 23°C 50% rh)*
- f** *number of replicate tests carried out*
- g** *individual test results as required by the test specification*
 - 1) *load sustained without rupture*
 - 2) *maximum load at rupture in N per m of joint length*
- h** *arithmetic mean and standard deviation where appropriate, of test results*
- i** *details of any variation from this method*
- j** *any other information which may assist in the interpretation of the test results.*

