DETERMINATION OF ELMENDORF TEARING RESISTANCE

These notes are intended as a brief introduction to the subject and are not a definitive procedure. Operators should always follow the procedures prescribed in the relevant national, international or industry standard methods.

Definition

This method is for determining the tearing resistance of paper and light boards or corrugated fluting medium (Not corrugated board) that are within the range of the test instrument. (Elmendorf method - single tear).

Tearing resistance is the mean force needed to tear a single thickness of sample of paper or board that has an initial cut. The tearing force is generated by the release of the quadrant pendulum to which one half of the paper sample is clamped, the other half being attached to the stationary clamp. The Elmendorf tear test exerts a shearing force perpendicular to the surface of the paper, simulating an actual tearing action. A test sample normally comprises a pack of 4 sheets of the same direction torn simultaneously. A cut in the machine direction is a machine direction tear test, a cut in the cross direction is a cross direction tear test. The tear test result units should be millinewtons (mN).

The tear index can be obtained by dividing the tearing resistance by the sample grammage. The result will be millinewton square meters per gram (mNm²/g).

The tear test apparatus

The standard apparatus consists of a frame and pedestal, mounted on a rigid base, carrying a pendulum and pointer assembly. There are two clamps to hold the test sample, a fixed one on the pedestal part of the instrument and one on the pendulum. The dimensions of the clamping surfaces are at least 25 mm wide and 15 mm deep. The pedestal is fitted with a low friction bearing having a horizontal axis upon which the pendulum is allowed to swing. The pointer fits on the same axial spindle as the pendulum, its friction is enough to stop it at the highest point reached by the pendulum when it swings. The pointer stop is adjustable to allow the instrument zero to be set.

The base of the instrument is fitted with the pendulum release and pointer stop mechanisms. The pendulum is held in the initial position and the test is started by the release mechanism. The release mechanism is designed to let the pendulum swing freely without imparting any shock or throw to the pendulum as it is released. A built in knife assembly allows the operator to produce the initial cut. It is adjusted so that the sample tearing length, after the initial cut is 43.0 mm ± 0.5 mm.

Interchangeable pendulums cover the range 8000 to 64000 calibrated in millinewtons (mN).

Digital tear testers have similar geometry to the manual versions but have an electronic rotary transducer to measure the pendulum swing instead of a friction pointer. Calculation of calibration, calculation and data functions are processed electronically. The instruments digital display presents test information including results, number of plies torn, number of tests made, maximum and minimum values and standard deviation etc. The instruments are sometimes fitted with automatic sensing of the pendulum type in use. Interchangeable pendulums are available giving a range of 2000 to 32000 mN. Pneumatic clamping and automated cut and test procedure help overcome possible operator influence.
Checking the apparatus

Before use, the tear tester should be inspected to ensure that the pendulum shaft is not bent, the distance between the clamps is correct i.e. 2.8 mm ± 0.3 mm and that the pointer is properly fitted to the spindle. The initial cut should be checked to ensure it is clean and the remaining tear length is 43 ± 0.5 mm. The instrument should also be checked for level, that zero is correctly adjusted and that pendulum friction and pointer friction are properly set. The specific manufacturer instructions should be followed for these settings, particularly if the instrument is a digital machine.

Preparing the samples

The test pieces should be prepared in the same atmospheric conditions as those used to condition the samples. Do not use material for testing that is close to the edge of the reel or sheet and ensure the test area is free from creases or visible defects. The sides of the test pieces should be identified and kept the same side up. Precision cut four similar pieces with dimensions between 50 ± 2 mm and 76 mm ± 2 mm wide, with the edges parallel to the required test direction and long enough so that after the initial cut (20 mm) has been made there is a tear test length of 43 mm ± 0.5 mm remaining. Depending on the tear tester design the appropriate test sample dimensions are 50 mm wide x 63 mm long; for other testers 76 mm wide x 63 mm long. Each test piece should comprise a pack of four samples. Prepare enough samples to carry out at least 10 valid tests (i.e. total of 40 sheets in each direction.)

Test procedure

The tests should be carried out in the same atmospheric conditions in which the samples were prepared. Check the apparatus as described in the earlier section.

If the apparatus requires calibration refer to the manufacturer's instructions, relevant standard method or contact PTA service. Ensure the correct pendulum selection for the required test range by making a few preliminary tests. (Readings should be between 20 % and 80 % of FSD).

Position the pendulum in the initial start position by raising it clockwise and allowing the release mechanism to secure it. Open both sample clamps and place the 4-ply sample evenly and centrally within both sets of clamp jaws. Tighten the clamps. Depress the integral knife handle to perform the initial cut. Move the pointer so that it is touching its stop.

Press and hold down the pendulum release to perform the test. After the tearing swing, as the pendulum makes its return swing (clockwise), catch it gently, so as not to shift the pointer position, and raise it again to the initial position, securing it with the release mechanism. Record the reading from the scale indicated by the pointer. To avoid parallax error, take the reading from directly in front of the pointer. Read to the nearest indicated scale division of the pendulum capacity. Open the clamps and remove the torn paper.

If the tear has deviated from the direction of the initial cut by more than 10 mm, note this in the test report. If after 10 tests no more than 2 samples have a large deviation, reject the test results and conduct further tests to make up for them. If more than 2 tests out of 10 have the deviation, use the results and state the fact in the test report.

If any of the test papers peel or “skin” instead of tearing cleanly, apply the above instructions regarding deviation of tear direction. Determine the direction of tear as the mean centreline of the torn area. Carry out the rest of the tests for the sample batch, alternately orientating the packs side one and side two at the front.

If the tearing resistance of a pack of four sheets of the test material is too strong or too weak for the available pendulum range and acceptable results cannot be obtained, test fewer of more sheets together but state this fact in the test report.
DETERMINATION OF ELMENDORF TEARING RESISTANCE

Test results calculations.

For each direction tested, the mean scale reading, the tearing resistance and tear index can be calculated using the following equations.

\[ T = \frac{R \times P}{N} \]

\[ I = \frac{T}{G} \]

- \( T \) = The tearing resistance, in millinewtons (mN).
- \( R \) = The mean scale reading, in millinewtons (mN).
- \( P \) = The number of sheets torn simultaneously for the pendulum scale factor in millinewtons (mN).
- Pendulum factors can be 4, 8, 16, 32, 64.
- \( N \) = The number of sheets torn simultaneously (normally four).
- \( I \) = The tear index in millinewton square metres per gram (mN-m²/g).
- \( G \) = The grammage in grams per square metre.

The coefficient of variation of the results is calculated from the individual scale readings.

These notes are intended as a brief introduction to the subject and are not a definitive procedure. Operators should always follow the procedures prescribed in the relevant national, international or industry standard methods.