Adhesive Tape Testing

INTRODUCTION

Satisfying International Standards
180° Peel Testing
90° Peel Testing
Tensile Testing
'Loop' Tack Measurement
Unwind Adhesion
Dynamic Shear

Providing Solutions to New and Different Adhesion Problems
Avery Adhesive Test
Multi-Hole Adhesive Indexing System
Peltier Temperature Control
A selection of typical measurements and special attachments are shown here which are commonly used in adhesive tape testing. Test procedures possible with the texture analyser range include: compression, puncture/penetration, tension, fracture/bending, extrusion (forward and backward), cutting/shearing.

Many parameters that can be quantified with the Stable Micro Systems texture analyser range and its software are not otherwise quantifiable with alternative instruments. Measurements allow the viewing of subtle differences between different formulas, materials, chemical ingredients, and manufacturing processes. For QC/QA production, verification of batch conformity to an existing standard can be checked and a comparison of consistency between batches, shifts and different manufacturing facilities can be made.

Standard test methods according to adhesive tape associations (FINAT, AFERA, PSTC, ASTM) that specify a tensile testing machine are also applicable and incorporated into the software for automatic testing and analysis.

The TA.XT plus and TA.HDplus texture analysers have been used to assess the following typical adhesive products:

- Adhesives/Glues
- Bandages
- Paints, inks etc.
- Hot Melt products
- Packaging
- Labels
- Gums
- Caulkings
- Resins
- Coatings
- Sealants
- Waxes
- Creams/lotions
- Solder paste
- Transdermal patches
- Gels: silicon, medical, cosmetic
- Adhesive tapes:
  - double-sided, duct, electrical, foam-backed, masking, office, packaging

The following focuses on the methods typically used for adhesive tape products.
Satisfying International Standards

180° Peel Testing

Test Procedure:
A strip of tape is applied to a standard test panel (or other surface of interest) with controlled pressure. The tape is peeled from the panel at 180° at a specified rate, during which time the force required to effect peel is measured.

Standard Method according to:
- FINAT test method no. 1: Peel adhesion (180°) at 300mm per minute
- International Harmonised Test Method AFERA 5001 (methods A-F):
  Self adhesive tapes – Measurement of peel adhesion from stainless steel or from its own backing
- FINAT test method no. 3: Low speed release (300mm/min) force for Adhesive Tape/Release Backing
- PSTC 4B: Relative Performance of Release Coating

Method applies to:

Use:
- FINAT 1: This test method is designed to quantify the permanence of adhesion or peelability of self-adhesive (pressure sensitive) materials. Adhesion is measured 20 minutes and 24 hours after application, the latter being considered as “the ultimate adhesion.”
  Note: FINAT 1 can also be performed under the conditions of FINAT 5 (at elevated temperatures) and FINAT 6 (under ultra violet light)
FINAT 3: This test method allows the end user to determine the force required to separate the release backing from the pressure sensitive adhesive coated face material. It may be used in the preliminary evaluation of the conversion aspects of the laminate: very low values may create label fly during conversion or application; high values may produce web break when skeleton stripping die cut labels or dispensing failure during automatic application.

AFERA 5001: These test methods are tools for quality assurance use. Given specific pressure-sensitive tape and a requirement in terms of the minimum or maximum peel value expected for this tape, the data from the test can be used in conjunction with acceptance criteria. These test methods may not provide design information as there is usually no direct relationship between peel adhesion and any functional requirement.

Test Method A: Single-coated Tapes, Peel Adhesion at 180° Angle.
Test Method B: Adhesion to Backing, Single-coated Tapes
Test Method C: Double-Coated Tapes (Face Side and Liner Side Adhesion)
Test Method E: Adhesion of Adhesive Transfer Tapes (Face Side and Liner Side Adhesion)

Test Method A, B, C, or E can show the relative bond strength of a given tape to one or more surfaces (material and texture) as compared to the standard stainless steel panel. Substitution of representative samples of materials in question for the standard steel panel would suffice to do this.

Test Methods A, B, C, or E cannot be used to compare two pressure-sensitive tapes of the same type but of different manufacture for their ability to adhere to a surface. This is because the measured peel force is not normalised for a fixed area of stress. The area under stress varies with backing stiffness and adhesive rheology (firmness). Two different tapes seldom agree in these properties.

Test Method D: Adhesion to Liner
Test Method D can show the amount of force required to remove a liner that covers the adhesive side of a tape at a specified peel rate. The force will be different at other peel rates.
PSTC 4B: This test is designed to compare two main properties of release coatings: (1) Ease of release (as “release force”), and (2) the effect that the coating has upon the adhesive properties of a pressure sensitive tape that has contacted the release surface (“subsequent adhesion”). It is designed for use as a tool in determining relative release levels and consistency.

Analysis:

FINAT 1: Peel adhesion is defined as the force required to remove pressure sensitive coated material, which has been applied to a standard test plate under specified conditions from the plate at a specified angle and speed.

AFERA 5001: The average force, obtained during the peeling of the 50mm following initial 25mm peeling region, is taken as the adhesion value.

FINAT 3: Low speed release force is defined as the force required to separate a pressure sensitive adhesive coated material from its backing or protective sheet (or vice versa) at an angle of 180° and a jaw separation rate of 300mm per minute.

PSTC 4B: Release force is the measure of the force required to separate a unit width of pressure sensitive tape from a release liner at controlled angle and speed.

Subsequent adhesion is the force required to remove a unit width of pressure sensitive adhesive tape, which has been in contact with a release liner for a given period of time, from a standard test panel. The results of this test must be compared with the adhesion of the same tape which has not been in contact with the release liner to determine the degree of loss of adhesion.

The percentage subsequent adhesion is obtained by dividing the subsequent adhesion to steel value by the initial adhesion to steel value and multiplying by 100.
90° Peel Testing

Test Procedure:
Peel adhesion is defined as the force required to remove pressure sensitive coated material, which has been applied to a standard test plate under specified conditions from the plate at a specified speed and approximate angle of 90°.

Standard Method according to:
- FINAT test method no. 2: Peel adhesion (90°) at 300mm per minute
- AFERA test method no. 4015: Quick stick
- AFERA 5001 (Test Method F): Single-coated Tapes: Measurement of peel adhesion from stainless steel or from its own backing

Method applies to:
Pressure Sensitive Adhesive Tapes

Use:
- FINAT 2: This test method differs from FINAT 1 in that it can allow the end user to compare the repositionability of different laminates. Adhesion is measured 20 minutes and 24 hours after application, the latter being considered as the ultimate adhesion. Measuring peel adhesion at 90° normally gives a lower value than at 180 and allows values to be measured for materials normally giving paper tear.

- AFERA 4015: this test method is designed to measure the ability of adhesive tape to adhere to a surface, with the application of a very light pressure.

- AFERA 5001: Test Method F
  Test Method F can show the relative bond strength of a given tape to one or more surfaces (material and texture) as compared to the standard stainless steel panel. Substitution of representative samples of materials in question for the standard steel panel would suffice to do this.

Figure 7: Adhesive Indexing System allows 90° peel tests
Test Method F cannot be used to compare two pressure-sensitive tapes of the same type but of different manufacture for their ability to adhere to a surface. This is because the measured peel force is not normalised for a fixed area of stress. The area under stress varies with backing stiffness and adhesive rheology (firmness). Two different tapes seldom agree in these properties.

Analysis:
■ FINAT 2: Peel adhesion (90) is expressed as the average results for the strips tested in Newtons per 25mm for either 20 minutes or 24 hours application time.

Note: FINAT 2 can also be performed under the conditions of FINAT 5 (at elevated temperatures) and FINAT 6 (under ultra violet light)

■ AFERA 4015: For each test specimen, force measurements are taken at 5 intervals in ascending order and the central value is taken. Similarly, these 5 central values are arranged in ascending order and their central value taken. The results are expressed in Newtons per centimetre widths of tape.

Figure 8: Typical graphs generated from tape tested according to FINAT 2 after 20 minutes and 24 hours of contact with the test plate at 22°C, RH 50%. Peel adhesion (90) is expressed as the average results for the strips tested in Newtons per 25mm for either 20 minutes or 24 hours application time.

Figure 9: Typical graphs comparing two tape types according to AFERA 4015. ‘Quick stick’ is expressed in Newtons per centimetre widths of tape.
Tensile Testing

Test Procedure:
- AFERA 5004: The procedures in this test method describe the measurement of breaking strength, elongation at break, and energy to break, of pressure sensitive tapes.
- AFERA 4014: The test method is designed to measure the elongation of an adhesive tape under a low tension maintained over a relatively short period.

Standard Method according to:
- International Harmonised Test Method AFERA test method no. 5004: Test Method for Breaking Strength and Elongation of Pressure Sensitive Tape
- AFERA 5004 replaces 4004 and 4005, ASTM D 3759M, EN 1940 and EN 1941 and corresponds with PSTC 31
- AFERA 4014 - Elongation of adhesive tape under reduced load

Method applies to:
- AFERA 5004: Test procedure A gives the breaking strength and elongation of tapes having 200% or less elongation, other than filament reinforced tapes.
- AFERA 5004: Test procedure B gives the breaking strength and elongation of filament reinforced tapes.
- AFERA 4014: This test is particularly applicable to tapes based on highly stretchable backings.

Use:
- AFERA 5004: These procedures provide a means of assessing the uniformity of breaking strength and elongation of a given type of pressure-sensitive tape. The assessment may be within a roll of tape, between rolls or between production lots. They may be used in comparing one product with another and can also provide information that can be used in material specification for product design and quality assurance applications. They can be used in comparing different products.
The use of this test method must be related to the purpose for which the test is performed. One purpose is for determining the relative strength of the tape in the size in which it is purchased or used. Another purpose is to identify or characterise a particular backing material.

- **AFERA 4014:** This method is intended to give an indication to the user of the elongation of an adhesive tape under tension in use. The tape is subjected to a relatively light load for a brief but definite period of time under standard test conditions. The elongation of the tape is then measured.

**Analysis:**
- **AFERA 5004:** The tensile value at point of break (which is usually expressed in N/10 mm) and the ultimate elongation (expressed as a %) are determined.

Breaking Energy is an optional calculation and is defined as the area under the stress-strain curve to the point of rupture. (With homogeneous film, foil, or paper backed tapes, this value can be normalised as the energy per unit volume of tape backing based on the initial gauge region of the test specimen. This may be reported in megajoules per cubic meter.) The test result can also be normalised to a tape width under these test conditions. This may be reported in joules per 100mm of width.

- **AFERA 4014:** The results are expressed as the percentage increase in length of the tape.

*Figure 11:* Repeat graphs of a tape tested according to AFERA 5004
The breaking strength in Newtons per 10mm of width (to three significant places), the ultimate elongation in percent (to two significant places) and energy to break (if determined) are reported.
‘Loop’ Tack Measurement

Test Procedure:
The ‘Loop’ tack value of a pressure sensitive material is expressed as the force required to separate, at a specified speed, a loop of material (adhesive outermost) which has been brought into contact with a specified area of a standard surface.

Standard Method according to:
- FINAT test method no. 9

Method applies to:
Pressure Sensitive Adhesive Tapes

Use:
This test method describes a means of assessing probably the most important and yet the hardest to measure property of pressure sensitive materials, the tack. The method described should allow the end user to compare the “initial grab” or “application tack” of different laminates and can be extremely useful to those working with automatic labelling equipment where this property is of particular importance.

Analysis:
The tack force is the maximum force measured at the moment just prior to the tape loop being completely separated from the glass slide. The force exerted by two peel fronts and the centre joint is measured. ‘Quick-Stick’ tack is expressed as the average maximum value (ignoring any initial peaks), tested in Newtons.

Note: FINAT 9 can also be performed under the conditions of FINAT 5 (at elevated temperatures) and FINAT 6 (under ultra violet light).

Figure 12: Loop Test System – for ‘Quick-Stick’ tack measurement

Figure 13: Typical graph comparing two tape types using FINAT 9
‘Quick-Stick’ tack is expressed as the average maximum value tested in Newtons.
Unwind Adhesion

Test Procedure:
The roll of tape is mounted on a mandrel so that it can turn without appreciable friction. The mandrel is fixed in the driven clamp of the tensile testing machine and the free end of the tape is fixed in the other clamp and the unrolling force is measured.

Standard Method according to:
- AFERA test method no. 4013: Unwind adhesion of adhesive tape at low speed (1944) (as issued by AFERA in September 1979 and later revised in September 1989)
- PSTC 8: Unwind Force of Pressure Sensitive tape (as issued by PSTC in September 1955 and most recently revised in June 2000)

Method applies to:
Pressure Sensitive Adhesive Tapes

Use:
The test method is designed to measure the force required to unwind a roll of adhesive tape at low speed under standard test conditions. Unwind adhesion is a quantitative measure of the degree of ease or difficulty in unwinding a roll of tape.

Analysis:
- AFERA 4013: After 25mm peeling, the minimum, maximum and arithmetic mean (i.e. average) of 5 readings of unwinding speed in Newtons per centimetre of width rounded to the nearest Newton are recorded.
- PSTC 8: The maximum unwind adhesion value in pounds per inch width to the nearest 0.1lb, or other suitable unit, is recorded. If other than 1” widths are tested, 1” values are found as the result of dividing the observed value by the specimen width.
Dynamic Shear

Test Procedure:
Dynamic shear is defined as the maximum force per unit width required to remove the adhesive coated label stock from a specified area in the direction parallel to the surface.

Standard Method according to:
■ FINAT test method no. 18: Dynamic Shear

Method applies to:
Adhesive Coated Label Stock

Use:
This test method is designed to determine the resistance of an adhesive coated label stock on a standardised surface, to shear at a constant speed.

Analysis:
The maximum force during the test is recorded and the mode of failure for each test piece individually. The mean value and standard deviation of the maximum forces in Newtons per 12.7mm width (N/12.7mm) are calculated.

Figure 17: Dynamic shear testing using the TA.XTplus Texture Analyser

Figure 18: Typical graph produced from FINAT 18: Dynamic Shear
The maximum force during the test is recorded
Avery Adhesive Test

Over the past years, one objective of the PSA industry has been to identify a single, standard, reproducible test to easily measure the tack of a PSA. As a result, the industry has experimented with probe adhesive testers of various designs. Some of these testers have measured the tack force, that is, the maximum force recorded during the debonding of the probe from the adhesive. Others have suggested measuring the tack as a function of energy dissipation during the debonding process. Because of this ambiguity, the probe tack testers have not provided a better definition of tack than other conventional tack performance tests such as loop tack, rolling ball tack, etc. Another disadvantage is that the data generated by these testers has not been very reproducible due to inconsistent contact areas between the probe and test surfaces or the interference of the face material stiffness with tack measurements. Consequently, these probe tests have not been widely accepted as standard tools for measuring PSA performance.

The Avery Adhesive Test (AAT) has eliminated the disadvantages of the traditional probe testers. Avery Dennison modified an existing concept to develop a new technique. The major concept change involved recording and analysing the entire stress-strain behaviour of a probe test. Earlier methods had reported a single value for tack force or tack energy. The ability to record and analyse the entire adhesive stress-strain behaviour was made possible by improved transducer and motor technologies, coupled with less expensive and faster computers. Other improvements over the traditional testers include the use of a spherical probe to ensure contact consistency and the use of double-side tape to mount the test sample such that the effect of facestock stiffness on test data is minimised.

The advantage of the AAT is that the method can be used to specify adhesive performance by analysing the multiple parameters extracted from the force-distance AAT profile. A second advantage is that the test can then be used for QA/QC by profile pattern recognition software. Finally, the method can also be used for R&D by analysing the relationship between PSA molecular structure and the AAT profile.

Figure 19: 1” Stainless steel Ball probe (Avery Adhesion Test)

Figure 20: Adhesive properties of tape using a 1” ball probe
Multi-hole Adhesive Indexing System

This fixture that has been developed for the testing of adhesive tapes allows the testing of 10 regions along the length of an adhesive tape strip. The strip is applied to the undersurface of the holed plate that is then inserted in a support. This support holds the plate in position during tests to avoid the plate lifting, upon probe withdrawal, due to the adhesive strength of the tape. After each probe test the holed plate is slid along through the support, to the next neighbouring hole which is positioned by an indent, to present itself exactly central to the ball probe above.

The Rotary Adhesive Indexing System provides the same indexing concept as the Linear Indexing System but was developed to allow indexing within a thermal cabinet when adhesive properties need to be measured at sub-zero or elevated temperatures.

Figure 21: Multi-hole Adhesive Indexing System

Figure 22: Comparison of adhesive properties of three adhesive tapes
Peltier Temperature Control

There are many products that are “temperature critical” and which need testing at a specific non-ambient temperature or range of temperatures to provide reproducible comparative results. Such information is far more relevant than ambient testing alone can ever achieve. When used in conjunction with the TA.XTplus Texture Analyser, the Temperature Controlled Peltier Cabinet (XT/PC) and Temperature Controlled Plate (XT/PP) provide highly stable and accurate testing environments/surfaces for many such products.

One such range of products are transdermal delivery systems, in which the active drug is absorbed directly into the blood stream through the skin from an adhesive patch thereby circumventing the metabolic complications that are sometimes associated with orally administered drugs, e.g. estrogens. Transdermal drug delivery as a route for systemic drug administration is currently one of the advancing areas in drug development research for the delivery of such drugs as nitroglycerin for the prophylaxis of angina, nicotine for smoking cessation therapy, testosterone for the correction of male hypogonadism. Drug-in-adhesive systems are characterised by the inclusion of the drug within the skin contacting adhesive. The adhesive not only fulfils the adhesion to skin function, but serves as the formulation foundation containing drug and other excipients.

Skin adhesion and drug compatibility is one of the most critical performance characteristics of a transdermal system. Because drug delivery is directly proportional to the skin contact area, if a patch does not maintain proper skin adhesion, the drug will not be delivered at a constant rate. Peel tests have been performed in the past but for accurate peel strength measurement a constant force application before removal is required and is difficult is regulate. Temperature can also affect adhesion properties and testing at a constant temperature (e.g. 35°C for skin) provides a more accurate measurement.

A TA.XTplus and Exponent software provides a specialist Adhesive Test which allows controlled probe and product contact to assess the adhesive strength of transdermal patches at 35°C. The sample is equilibrated and tested on a Peltier plate which provides a constant controlled testing platform.