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Devices and Methods for Testing Self-Adhesive Materials

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Abstract—This article examines the main quality indicators of self-adhesive materials and methods for determining them. It lists international organizations involved in developing standards in the field of adhesive tape testing and describes the main requirements for devices and testing conditions.

Keywords: self-adhesive materials, adhesive tapes, adhesion, stickiness, shear resistance

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INTRODUCTION

The main quality indicators of self-adhesive materials include adhesion, stickiness, shear under vertical loads, and temperature resistance. To determine these indicators, the specialized organizations have developed test methods at different times, the most widely used of which are the methods of the following organizations:

• FINAT (European association for the self-adhesive label industry) is an international organization the standards of which (FTM for short) are used by manufacturers of self-adhesive labels and markings;

• ISO (International Organization for Standardization), standards that are common among manufacturers of self-adhesive tapes in different regions of the world;

• AFERA (European adhesive tape industry network) is a community of European tape manufacturers, whose standards are widely distributed not only in Europe, but also in Asia;

• ASTM (American Society for Testing and Materials) is an organization that develops and publishes voluntary standards for materials, products, systems, and services in the United States used by manufacturers of self-adhesive tapes around the world;

• PSTC (Pressure Sensitive Tape Council) is an American union of adhesive tape manufacturers;

• TLMI (Tag and Label Manufacturers Institute) is an American association of adhesive tape manufacturers, whose standards are widely used by European manufacturers.

GB and GB/T are national Chinese standards developed by the Standardization Administration of China (SAC), which is part of the Chinese National Committee for ISO and IEC (International Electrotechnical Commission). Some of the standards are mandatory, while others are optional, which can be distinguished by the symbols used. Thus, standards with the symbol GB are mandatory specifications, while those with the symbol GB/T are recommended. The standards developed by SAC used in the field of self-adhesive materials are recommended.

Most of the main standards of the above organizations are harmonized with each other and can be interchanged.

PEEL ADHESION MEASUREMENTS

Adhesion is the spontaneous sticking of two different bodies that are held in contact with each other by chemical and physical forces or both together [1].

Adhesion to standard surfaces (steel or glass) is measured by separation at a peel angle of 90° or 180° using the FTM-1, FTM-2, AFERA 5001, ISO 29862, ASTM D3330/D3330M-04, GB/T 2792, and other methods.

The polished steel panels used in testing of self-adhesive materials, manufactured in accordance with ASTM A666 from grade 302 or 304 steel, shall have a surface roughness requirement of 50 ± 25 nm Ra. The panels shall be cleaned immediately prior to testing using one of the following solvents:

• diacetone alcohol (4-hydroxy-4-methyl-2-pentanone);

• methanol (95%);

• methyl ethyl ketone (MEK);

• n-heptane;

• acetone.

Fig. 1. AR-2000 adhesion tester from the manufacturer ChemInstruments.

Fig. 2. TT-2000 universal tensile testing machine from the manufacturer ChemInstruments.

The dimensions of steel plates used to determine adhesion at a peel angle of 90° or 180° shall be at least 125 mm in length, at least 50 mm in width, and at least 1.1 mm in thickness.

The peel resistance value is affected by the adhesive's composition, peel angle, tape base material, holding time after rolling, peel speed, environmental conditions during conditioning of samples and testing. The measurement methods establish strict limits for the temperature and the environment's relative humidity at which tests must be carried out, so test laboratories must be equipped with a climate control and regulation system or supplied with climatic chambers. For example, the measurement of peel strength from stainless steel according to ISO 29862 Method 1 is carried out at a temperature of 23 ± 1°C and a relative humidity of 50 ±5%. In this case, preliminary preparation is mandatory, which consists of conditioning the samples at a temperature of 23 ± 1°C and a relative humidity of 50 ± 5% [2, 3].

To determine adhesion, the adhesion machines are used that ensure testing at specified angles and speed and with specified accuracy, for example, testing equipment from the manufacturer ChemInstruments: AR-2000 (Fig. 1) or a TT-2000 universal tensile testing machine [4] (Fig. 2).

Testing equipment is also widely used that is manufactured in China, the main distinction of which is its great versatility, with one device being able to combine several tasks and be used to conduct tests using several different methods.

Testing equipment is equipped with various strain gauge sensors. When selecting a strain gauge sensor, the principle must be followed that the expected maximum load on the sensor must not exceed 95% of the nominal load. Testing equipment is designed so that the user can replace the strain gauge sensors and calibrate them independently if necessary. Permissible maximum measurement error must not exceed 2%.

The essence of the adhesion measurement method is to measure the force required to peel off the test sample from the standard surface at a given angle with a given speed. The speed recommended by the methods is 300 mm/min.

The measured adhesion at 90° is typically less than the adhesion at 180°, allowing adhesion to be measured for materials such as paper or thin polyethylene that have lower tensile strength or stretch when force is applied (Figs. 3, 4).

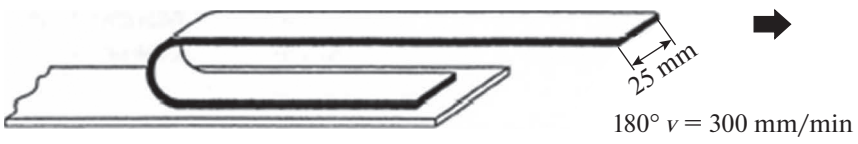

Fig. 3. Measuring adhesion at a peel angle of 180°.

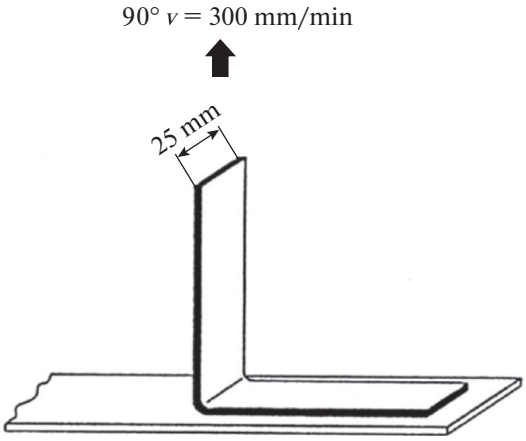

Fig. 4. Measuring adhesion at a peel angle of 90°.

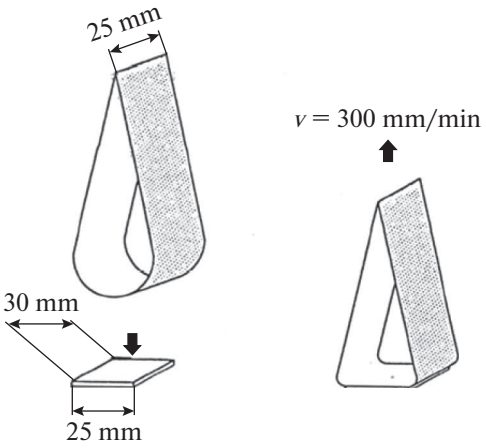

Fig. 6. Measurement of loop stickiness.

Fig. 5. RBT-100 rolling ball tack tester from ChemInstruments complies with PSTC-6 requirements [4].

Fig. 7. Loop Tack 2000 (LT-2000) device is used to determine the loop tack of self-adhesive materials [4].

TACK MEASUREMENTS

Tack is the ability of an adhesive to form a bond with the surface being measured immediately after contact under low pressure.

The methods for measuring tack are as follows.

(1) Quick Stick can be measured as the resistance force of separation of a unit width of tape at an angle of 90° from a standard surface to which this tape has been adhered under a pressure not exceeding its own weight. PSTC-5 or AFERA 4015 are used to determine the instant stickiness.

(2) Tackiness can be measured using a rolling ball (Rolling Ball Tack) according to PSTC-6 or ASTM D3121. This is one of the existing methods for determining the ability of an adhesive to quickly stick to other surfaces. The method's essence is to measure the distance that a steel ball will travel along the adhesive's surface with a given acceleration due to the inclined surface and the ball's mass (Fig. 5).

(3) Loop Tack is the most common method of assessing the tack of self-adhesive tapes and is measured in accordance with FTM-9, PSTC-16, ASTM D6195, GB/T 31125, AFERA 5014, etc. The loop tack value of self-adhesive materials is expressed as the force required to separate a loop of material (with the adhesive facing out) at a given speed, which is brought into contact with a standard surface, over a certain area. The surface to be tested is 25 × 25 mm. It is the loop tack that allows determining the initial pasting of various laminates and is used to assess the quality of labels for automatic equipment (Figs. 6, 7).

TESTING THE STATIC RESISTANCE OF SELF-ADHESIVE TAPES TO SHEAR (SHEAR ADHESION)

Shear adhesion allows determining the ability of tapes to resist vertical shear loads; i.e., it is the ability of self-adhesive tape to remain glued under the influence of a constant force acting parallel to the gluing surface. The sequence of determining shear adhesion is defined in FTM-8, AFERA 5012, ISO 29863,

Fig. 8. Test equipment for determining static shear, including at elevated temperatures, from ChemInstruments SS-OS-30 [4].

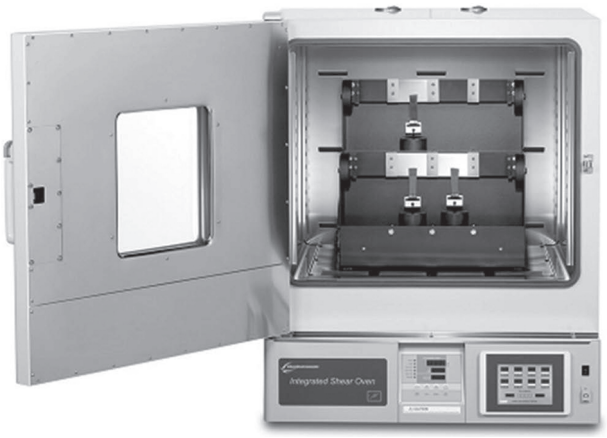

Fig. 9. Shear failure temperature test equipment for self-adhesive tapes from ChemInstruments for simultaneous testing of eight samples of SS-OS-8 [4].

ASTM D3654/D3654M-06, GB/T4851, etc. The method's consists of measuring the time until the samples come off the standard surface under the influence of a vertical load of 1000 g. Polished steel, glass, cardboard, or any other surface that can subsequently be used as a surface for gluing self-adhesive tapes can be used as standard surfaces.

Static shear is determined using stands equipped with time counters. Tests can be carried out directly under standard conditions or at elevated temperature, such as, for example, when testing according to ASTM D3654/D3654M-06 Procedure H, when static shear tests are carried out after holding at elevated temperature for 10 min (Fig. 8).

Fig. 10. Hand roller for rolling samples [4].

DETERMINATION OF SHEAR ADHESION FAILURE TEMPERATURE OF SELF-ADHESIVE TAPES (SHEAR ADHESION FAILURE TEST)

Shear adhesion failure temperature tests are performed in accordance with the AFERA 5013 requirements and the modified versions of ASTM D3654/B3654M-06, ASTM D6463, or PSTC-107. These tests can be used to determine the ability of a tape to withstand static forces applied in the same plane as the substrate at a continually increasing temperatures and, accordingly, determine the temperature range for use of self-adhesive tapes.

As described in the methods, the specimens are assembled in the same manner as for the static shear test, but using a load of 500 g, and are placed in the test chamber. The test is started at 40°C, and the temperature is gradually increased by 0.5°C/min until the specimen is completely detached from the plate. Test equipment should include a heating programming function and operate in the range of 25–200°C (Fig. 9).

AUXILIARY EQUIPMENT—MANUAL AND AUTOMATIC ROLLERS FOR ROLLING SAMPLES

Methods for determining the quality characteristics of self-adhesive materials regulate the use of special equipment for preparing samples for testing, such as a manual or automatic roller for rolling samples directly onto the plates. The use of specialized equipment eliminates additional load on the samples and, thereby, increases the accuracy and convergence of results. The steel rollers used for sample preparation should be 85 ± 2.5 mm in diameter and 45 ± 1.5 mm in width, and the coating should be made of rubber with a hardness of 80 ± 5 Shore A units and a thickness of 6 mm. The mass of rollers should be approximately 2000 g (Fig. 10).

Fig. 11. Automatic device for RD-3000 rolling samples [4].

For automatic rolling of samples, the RD-3000 device from ChemInstruments can be used, which allows simultaneous preparation of up to three samples. The device has a programming function for the following parameters: speed, stroke length, and number of cycles. No part of the device increases the mass of rollers during the rolling process higher than a speed of 10 ± 0.5 mm/s (Fig. 11).

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CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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