4.5 Fabric abrasion resistance

Abrasion is defined as the wearing away of any part of the fabric by rubbing against another surface. Fabrics are subjected to abrasion during their lifetimes and this may result in wear, deterioration, damage and a loss of performance. However, the abrasion resistance is only one of several factors contributing to wear performance or durability. Abrasion can occur in many ways and can include fabric to fabric rubbing when sitting, fabric to ground abrasion during crawling, and sand being rubbed into upholstery fabric, and it is difficult to correlate conditions of abrasion of a textile in wear or use with laboratory tests. This may explain the reason why there are many different types of abrasion testing machines, abradants, testing conditions, testing procedures, methods of evaluation of abrasion resistance and interpretation of results.

The methods used may be described by the equipment, the test head movement or testing device setup. These include (a) inflated diaphragm; (b) flexing and abrasion (i.e. the Stoll Flex Tester); (c) oscillatory cylinder; (d) rotary platform; (e) uniform abrasion; and (f) impeller tumble. Presentations of the fabric to the abradant include in plane (or flat), flex, tumble or edge abrasion or a combination of more than one of these factors.

There are two general approaches for assessment of abrasion resistance: (1) to abrade the sample until a predetermined end-point is reached, such as the breaking of two threads or the generation of a hole, while recording the time or number of cycles to achieve this; and (2) to abrade for a set time or number of cycles and assess the fabric for change in appearance, loss of mass, loss of strength, change in thickness or other relevant property. The length of the test for the first approach is indeterminate and requires the sample to be regularly examined for failure. This need for examination is time consuming as the test may last for a long time. The second approach provides for simpler measurements; however, the change in properties such as mass loss can be slight.

4.5.1 Factors affecting abrasion resistance

A fabric's resistance to abrasion is affected by many factors, such as fibre type, the inherent mechanical properties of the fibres, the dimensions of the fibres, the structure of the yarns, the construction and thickness of the fabrics, and the type and amount of finishing material added to the fibres, yarns or fabrics.

For example, fibres with high elongation, elastic recovery and work of rupture have a good ability to withstand repeated distortion, hence a good degree of abrasion resistance. Nylon is generally considered to have the best abrasion resistance, followed by polyester, polypropylene, wool, cotton and acrylic. Longer fibres incorporated into a fabric confer better abrasion resistance than short fibres because it is harder to liberate them from the fabric structure. Flat plain weave fabrics have better abrasion resistance than other weaves because the yarns are more tightly locked in a plain weave structure and the wear is spread more evenly over all of the yarns in the fabric. Fabrics with a loose structure have a lower abrasion resistance than those with a tight structure.

The resistance to abrasion is also greatly affected by the conditions of the tests, such as the nature of the abradant, variable action of the abradant over the area of specimen abraded, the tension of the specimen, the pressure between the specimen and the abradant, and the condition of the specimen (wet or dry).

Abradants can consist of anything that will cause wear. The most common solid abradants are abrasive wheels (vitreous and resilient), abrasive papers or other fabrics, stones (aluminium oxide or silicon carbide) and metal 'knives'. The nature of abradants and the type of action will control the severity of the test. It is important that the action of the abradant should be constant throughout the test and the tension of the mounted specimen should be reproducible, as this determines the degree of mobility of the sample during abrasion. The pressure between the abradant and the sample affects the severity and rate at which abrasion occurs. Accelerated destruction of test samples through increased pressure or other factors such as heat generation may lead to false conclusions on fabric behaviour.

4.5.2 Methods for testing abrasion resistance

Three methods have been widely used over the years: the Martindale tester, the Taber abrader (rotary platform double-head abrader) and the accelerator.

The Martindale tester

The Martindale tester is designed to give a controlled amount of abrasion between fabric surfaces at comparatively low pressures in continuously changing directions. The results required determine the test and assessment method used. Assessments can include determination of specimen breakdown, mass loss or appearance change.

For the methods applying assessment of specimen breakdown or mass loss, specimens are circular of either 38 mm or 140 mm in diameter. Normally the abradant is silicon carbide paper or woven worsted wool mounted over felt. The small test specimen is sitting on the large abradant and then cycled backwards and forwards in a Lissajous motion producing even wear. A force of either 9 or 12 kPa is applied to the top of the specimen to hold it against the abradant. If assessment of appearance change needs to be carried out, then larger test pieces (140 mm in diameter) are required. The roles are reversed and the abradant is placed in the holder with the specimen as the base platform. The standard abradant should be replaced at the start of each test and after 50 000 cycles if the test is to be continued beyond this number. Behind the abradant is a standard backing felt which is replaced at longer intervals.

For assessment, the specimen is examined at suitable intervals to see whether two threads have broken, mass has changed or appearance has changed. Different fabric structures or components will require different inspection intervals. Some bias may occur if a fabric has a low abrasion resistance. Hosiery may be tested using a modified specimen holder, which stretches the knitted material, thus effectively accelerating the test. A flattened rubber ball is pushed through the sample as the holder is tightened, thus stretching it.

The Taber abrader

The rotary platform abrader (Taber abrader) applies two abrasive wheels (13 mm thick and 51 mm in diameter) under controlled pressure to a circular sample (110 mm in diameter) mounted on a rotating table or platform. The fabric is subjected to the wear action by two abrasive wheels pressing onto a rotating sample. The wheels are arranged at diametrically opposite sides of the sample so that they are rotated in the opposite direction by the rotation of the sample. These are available in different abrasive grain sizes. The load used can be 125, 250, 500 or 1000 g (or 1.23, 2.45, 4.9 or 9.81 N). The test specimen is abraded until damage (broken threads or hole) occurs or there is a visual change in the surface appearance (loss of texture, pile

or surface coating). The number of cycles is recorded when the end point is reached.

The accelerator abrasion tester

The accelerator abrasion tester has an action that is quite different from most other abrasion testers. In the test a free fabric specimen is driven by a rotor inside a circular chamber lined with an abrasive cloth. The specimen suffers abrasion by rubbing against itself as well as the liner. Evaluation is made on the basis of either weight loss of the specimen or the loss in grab strength of the specimen broken at an abraded edge. For evaluation by loss in strength, two specimens measuring 100 mm × 300 mm are used for grab tests. Each specimen is numbered at both ends and then cut in half. One half is used for determining the original grab strength and the other half for determining the grab strength after abrading.

Many different standards are used worldwide for abrasion resistance tests, including:

- ASTM D3884 Standard guide for abrasion resistance of textile fabrics (rotary platform, double-head method)
- ASTM D4966-1998(R04) Standard test method for abrasion resistance of textile fabrics (Martindale abrasion tester method)
- ISO 12947-1-1998 Textiles – Determination of the abrasion resistance of fabrics by the Martindale method – Part 1: Martindale abrasion testing apparatus
- ISO 12947-2-1998 Textiles – Determination of the abrasion resistance of fabrics by the Martindale method – Part 2: Determination of specimen breakdown
- AS 2001.2.25.1-2006 Physical tests – Determination of the abrasion resistance of fabrics by the Martindale method – Martindale abrasion testing apparatus
- AS 2001.2.25.2-2006 Physical tests – Determination of the abrasion resistance of fabrics by the Martindale method – Determination of specimen breakdown
- AS 2001.2.25.3-2006 Physical tests – Determination of the abrasion resistance of fabrics by the Martindale method – Determination of mass loss
- AS 2001.2.25.4-2006 Physical tests – Determination of the abrasion resistance of fabrics by the Martindale method – Assessment of appearance change
- AS 2001.2.26-1990 Physical tests – Determination of flat abrasion resistance of textile fabrics (flexing and abrasion method)