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Application News

No. MT-006

Material Testing System

Compression Testing of Foam Rubbers by ASTM D3574

■ Introduction

On average, people spend many hours a day sitting on chairs, couches, and car seats as well as significant time on mattresses each night. In each of these products, polyurethane foam plays a key role in giving comfort and support. It is important to know how the foam can stand up to extended forces and how it can recover once the person gets up.

Foams undergo testing procedures to quantify the ability of the foam to recover from loads and to withstand repeated forces. One such testing standard is ASTM D3574, which contains a series of tests to characterize the different properties of foam. This includes measurements of foam density, odor, dynamic force responses, aging and mechanical properties.

For the mechanical testing, foams are subjected to compressive and tensile forces and their strain and strength values are measured. Three compression tests, B1, B2, and C, are defined that require control of a multi-segmented mechanical test. Test B1, called the indentation force deflection test, measures the force necessary to produce certain indentations in the foam. The forces are reported as the indentation force deflection (IFD) values and give information on the support of the foam. Test B2, called the indentation residual gage load test, is used to determine the compressed thickness of padding under the average person. The thickness of the foam is measured under various loads and reported as the indentation residual gage load (IRGL) value. Test C, called the compression force deflection test, is used to determine the amount of force necessary to produce a 50% compression over the entire area of a sample.

This article describes an example case in which all three tests are conducted on polyurethane foam.

W. Straka

■ Instrument and Fixtures

The test configuration is shown in Table 1. Measurements were taken on an AGS-X table-top type universal testing instrument using a large circular indenter foot (200 mm diameter) and a perforated, square support plate for the samples (400 mm x 400 mm with 6.5 mm holes 20 mm apart). The perforated support plate allows the air to escape from the foam and allows for more accurate data collection. A 1 kN S-style load cell was used to measure the forces on the foam. Fig. 1 shows the fixtures and Fig. 2 shows the test setup.

Table 1: Equipment Configuration

Universal testing machine	**AGS-X 10 kN**
Load cell	1 kN
Fixture	Compression Test Jig for Foam Rubber
Software	Trapezium X (Control)

Figure 1: Fixtures

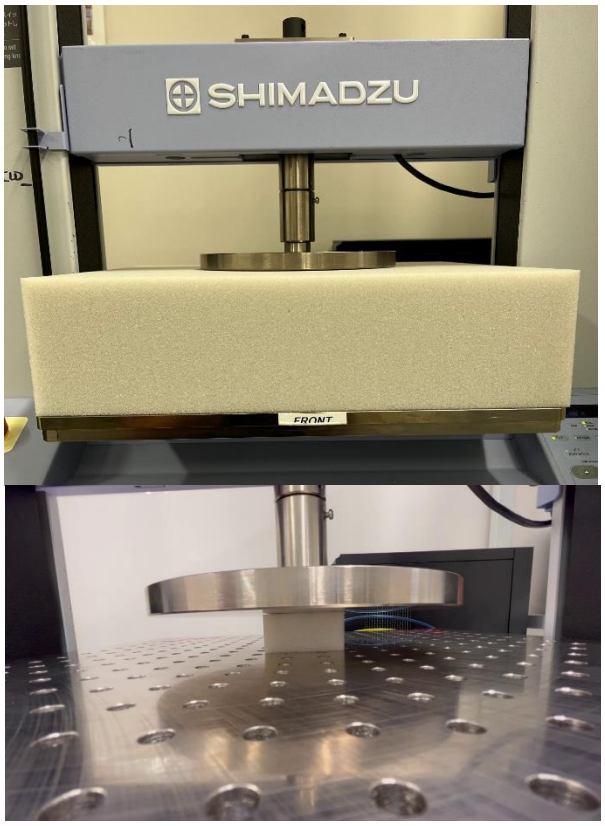

Figure 2: Test setup

■ Samples and Method

Samples for Tests B1 and B2 had dimensions of 400 mm x 400 mm with a thickness of 100 mm. Samples for Test C had dimensions of 50 mm x 50 mm with a thickness of 25 mm. Methods were created using the Shimadzu TrapeziumX Control module, which allows users to program complex multi-step tests to reach specified displacement or force targets.

For each test, the sample was pre-stressed and allowed to rest for six minutes. For Test B1, the sample was then stressed to 4.5 N and the new thickness of the sample was measured. This was used for the calculation of a 25% indentation and a 65% indentation. The compressions were held for 60 seconds each and the force was measured at the end of each 60 second period.

For Test B2, the sample was stressed to 4.5 N after the 6-minute recovery period and held at that force for 60 seconds. The thickness of the sample was measured before moving to 110 N and 220 N, each of which was held for 60 seconds, and their strokes were measured at the end of the waiting period.

For Test C, after pre-stressing the sample, the sample was compressed to a stress of 140 Pascals and its new thickness measured. The sample was then compressed to 50% of this new thickness and held for 60 seconds. The stress on the sample was measured at the end of this 60 seconds. This specific test called for 3 samples to be tested in the batch. The average and standard deviation of their results were also calculated. The force vs. stroke was plotted for each sample across the entire test, including pre-stressing of the sample.

■ Test Results

Results are displayed in the force vs. stroke plots shown in Fig. 3 for Test B1, Fig. 4 for Test B2, and Fig. 5 for Test C. The dip in the force, seen in Fig. 3, is due to stress relaxation of the foam as the crosshead stroke is held for 60 seconds. The horizontal lines seen in Fig. 4, are also due to stress relaxation in the foam. For the latter test, the crosshead continues to compress the sample to maintain force, which increases the total stroke.

The pre-stress force vs. stroke is also shown on the plot. The IFD values, IRGL values and the 50% compression values are shown in Table 2. The ratio of the IFD values also allows for the calculation of the support factor of the foam. This value was calculated to be 2.03, which is in the middle of standard support factor values for polyurethane foam.

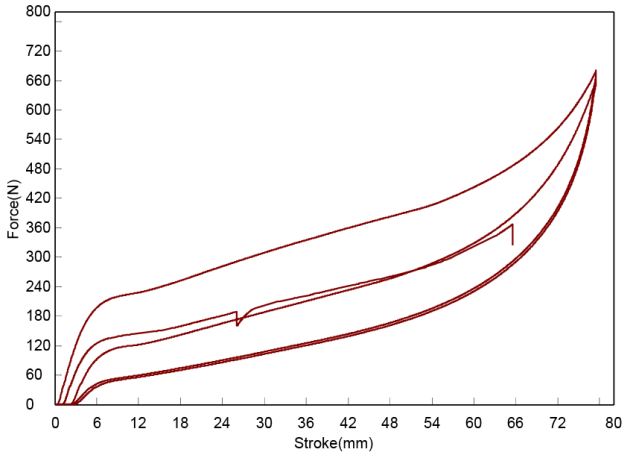

Figure 3: Force vs. stroke plots for Test B1

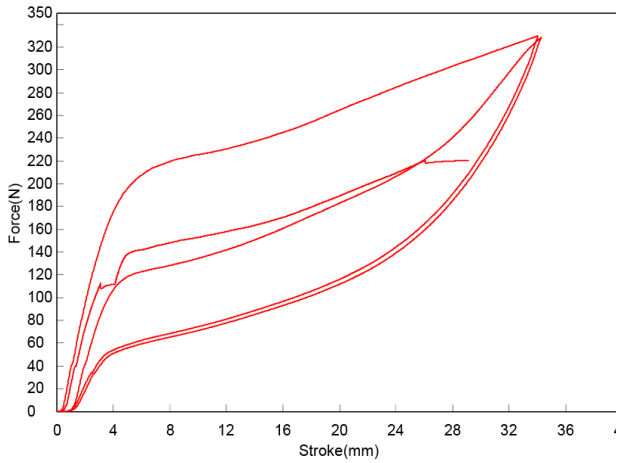

Figure 4: Force vs. stroke plots for Test B2

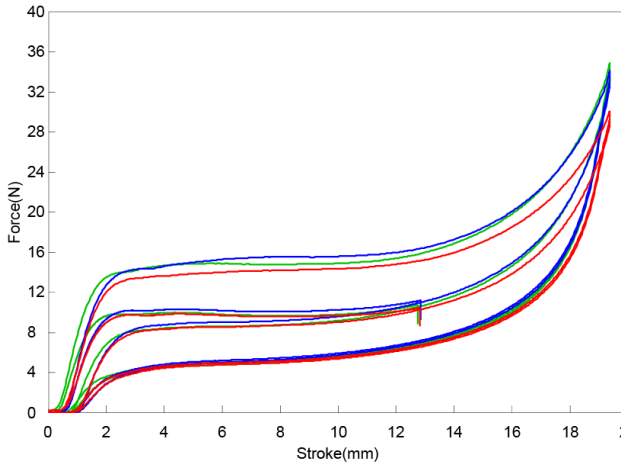

Figure 5: Force vs. stroke plots for Test C

Table 2: IFD values, IRGL values and the 50% compression values

	25% deflection (N)	65% deflection (N)
Test B1 – IFD	156.652	317.683

	Thickness at 4.5 N (mm)	Thickness at 110 N (mm)	Thickness at 220 N (mm)
Test B2 – IRGL	99.3308	95.9026	70.8351

	Thickness after contact (mm)	Stress at 50% deflection (kPa)
Test C	24.4944 ± 0.1334	3.5780 ± 0.1268

■ Summary

The Shimadzu AGS-X was used to perform the compression tests from ASTM D3574 on polyurethane foam rubbers. These methods require a multi-segment test procedure that uses measured data to configure future change points and gives precise control over the frame for a set amount of time. ASTM D3574 specifies various tensile and tear tests, which can also be measured using this test frame with additional fixtures.

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