Application News

No. i272

Precision Universal Testing Machine

Creep Test of Rubber Materials (JIS K 6273, ISO 2285)

Rubber is an extremely familiar material that has characteristic mechanical properties such as elasticity and stretchability and is widely used in a variety of industrial and consumer products, particularly in applications that require vibration-proofing or shock-absorbing functions. Synthetic rubber now accounts for the majority of rubber materials. Because a diverse range of unique synthetic rubber products suited to specific applications have been developed, evaluation of the mechanical properties of these materials is extremely important.

Creep characteristics can be mentioned as one mechanical property that requires evaluation. Creep is a phenomenon in which deformation of a material gradually progresses when a constant load is applied continuously for an extended time, and is a cause of malfunction or failure of industrial products in long-term use in some cases. Thus, in order to estimate the useful life of a rubber material based on the intended application or to select a fit-for-purpose material, an understanding of the creep characteristics of rubber materials is needed in the development design stage.

This article introduces an example of an evaluation of creep characteristics by tensile test of chloroprene rubber, which has excellent weatherability, oil resistance, and heat resistance and is most widely used as a representative synthetic rubber.

This test was conducted referring to JIS K 6273, ISO 2285 (Rubber, vulcanized or thermoplastic – Determination of tension set, elongation and creep) using a Shimadzu Autograph AGX™-V model Precision Universal Testing Machine. This material testing system is also suitable for creep test, as it provides higher test force holding performance than conventional testing machines.

C. Oya

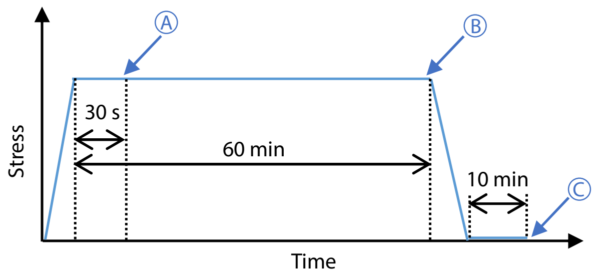
Test of Tension Set at Constant Load (JIS K 6273, ISO 2285)

Table 1 shows the equations for calculation of the test items in JIS K 6273 section 6.5, and Fig. 1 shows the load pattern used in the creep test. In this test, the gauge lengths at points Ⓐ to Ⓒ in Fig. 1 were measured, and elongation at constant load, creep, and tension set at constant load were calculated.

Table 1 Equations for Test Items in JIS K 6273 Section 6.5

	Equations for calculation
Elongation at constant load E_2 (%)	$E_2 = (L_3 - L_0) / L_0 \times 100$
Creep E_3 (%)	$E_3 = (L_4 - L_3) / (L_3 - L_0) \times 100$
Tensile set at constant load E_4 (%)	$E_4 = (L_5 - L_0) / L_0 \times 100$

(Notes)
L_0 (mm) : Gauge length before test
L_3 (mm) : Gauge length at elapsed time of 30 s (point Ⓐ) from start of loading
L_4 (mm) : Gauge length at elapsed time of 60 min (point Ⓑ) from start of loading
L_5 (mm) : Gauge length at 10 min (point Ⓒ) after specimen is removed from test device following measurement of length L_4 and is then allowed to contract



Ⓐ: Point at elapsed time of 30 s from start of loading
Ⓑ: Point at elapsed time of 60 min from start of loading
Ⓒ: Point at 10 min after specimen is removed from test device

Fig. 1 Loading Pattern of Test

Specimen

Table 2 shows the specimen material information, Fig. 2 shows the specimen geometry, and Fig. 3 shows the condition of the test. The specimen geometry conforms to standard.

Table 2 Specimen Material Information

Material	Chloroprene rubber
Specimen dimensions	Thickness 2.0 mm, width 4 mm, parallel length 100 mm

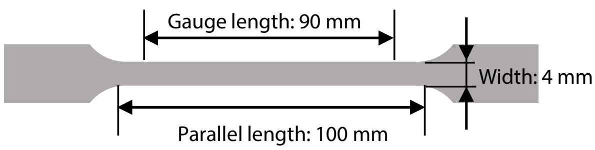


Fig. 2 Geometry of Specimen

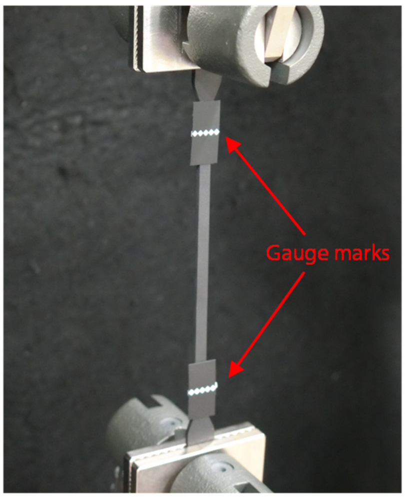


Fig. 3 Condition of Test

Test Conditions and Instrument

This test was conducted with the test loading pattern shown in Fig. 1 using the control software TRAPEZIUMX-V under the test conditions in Table 3. Fig. 4 and Table 4 show the operation screen (controlled test) of TRAPEZIUMX-V and an explanation of the screen areas. In the controlled test software, the test conditions are divided into areas and the content of the test can be set freely.

Table 3 Test Conditions

Instrument	Shimadzu Autograph AGX-10 kNV Precision Universal Testing Machine
Load cell	1 kN
Jig	Pneumatic flat grip + Single-side file teeth grip faces
Displacement gauge	Noncontact digital video extensometer
Software	TRAPEZIUMX-V Control

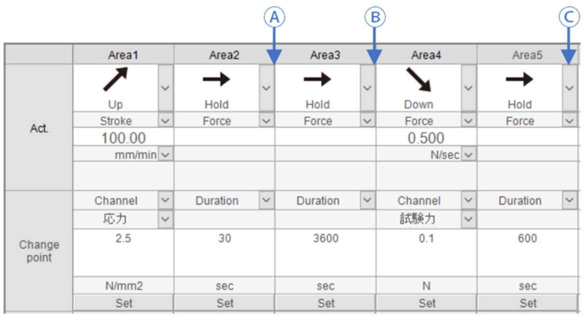


Fig. 4 Operation Screen of TRAPEZIUMX-V (Controlled Test)

(Notes) In this figure, Ⓐ, Ⓑ, and Ⓒ correspond to the loading pattern of the test. Because L5 is set automatically, in this test the gauge length was calculated at an elapsed time of 10 min after the test force reached 0.1 N, without removing the specimen.

Table 4 Explanation of Areas of TRAPEZIUMX-V Operation Screen

Area 1	Load to 2.5 N/mm² at 100 mm/min.
Area 2	Acquire displacement (L_3) after holding test force for 30 s.
Area 3	Acquire displacement (L_4) after holding test force for 3,600 s.
Area 4	Unload to test force of 0.1 N at 0.500 N/s.
Area 5	Acquire displacement (L_5) after holding test force for 600 s.

Results

Table 5 shows the test results, and Fig. 5 and Fig. 6 show the stress-displacement curve and the stress-time curve, respectively. Fig. 5 indicates that the creep phenomenon is occurring, as deformation progresses while the test force is being held. Fig. 6 shows that the transition from stroke control to test force holding (from Area 1 to Area 2) was executed smoothly, and stress holding amply satisfies the allowable value of ±0.1 Mpa given in the standard.

Table 5 Test Results

L_0	(mm)	90.2
L_3	(mm)	190.5
L_4	(mm)	199.7
L_5	(mm)	93.3
Elongation at constant load E_2	(%)	111.1
Creep E_3	(%)	9.3
Tension set at constant load E_4	(%)	3.4

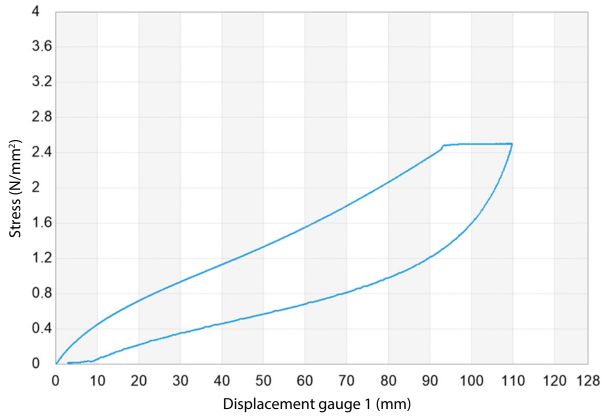


Fig. 5 Stress-Displacement Curve

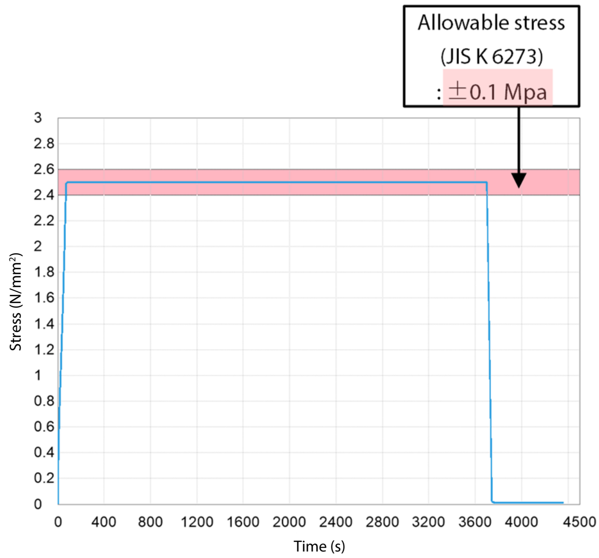


Fig. 6 Stress-Time Curve

Conclusion

In creep tests of soft rubber materials, a large drop in the test force is seen at the start of test force holding with conventional test devices because the material deforms easily. The Shimadzu Autograph AGX-V Precision Universal Testing Machine used in this experiment provides improved test force holding performance, making it possible to conduct creep tests of rubber materials as specified in standards. In addition to simple tensile tests and compression tests, it is also possible to conduct tests with complex loading patterns if a control program is installed with Shimadzu TRAPEZIUMX-V. The Shimadzu Autograph AGX-V Precision Universal Testing Machine is suitable for determining the creep characteristics of rubber materials as provided in the standard JIS K 6273, ISO 2285.

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