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Application News

Precision Universal Testing Machine AGS™-V

Temperature Dependence of Puncture Strength of Separators

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User Benefits

- Strength can be measured under actual temperature environments by using a thermostatic chamber.
- A simple fixing method with nuts is used, so it is easy to install and remove the sample from the jig.
- When the AGS-V is used, strength tests can be conveniently performed with excellent precision.

■ Introduction

Lithium-ion batteries are used in a wide variety of fields in modern society, such as mobile phones, notebook computers, and electric vehicles, and the high energy density and long life of this important technology support our lifestyles. One of the most important issues in developing this technology is ensuring the safety of lithium-ion batteries. In particular, the separator within the battery prevents short circuits by physically separating the cathode and the anode, so it plays an important role in maintaining the normal operation of the battery.

If the separator is damaged, the cathode and the anode can come into direct contact, causing a short circuit. Short circuits cause rapid heating within batteries, which can lead to fires and explosions. Since separator damage can be caused by various external factors, such as dendrites (dendritic crystals), mechanical impacts, and overloads, evaluating these factors is key to improving safety. Puncture testing, which is widely used to evaluate the strength of separators, quantitatively measures durability and strength properties by applying a load to a separator at a constant speed and measuring the occurrence of puncture failure.

This article introduces an example of performing puncture tests on the separator of a lithium-ion battery while varying the environmental temperature.

■ Equipment Configuration

The equipment configuration is shown in Table 1. The test was performed using the AGS-V precision universal testing machine and a boil-in-bag piercing test jig. This jig is simply fixed using nuts, so it is easy to install and remove the samples. The tests were performed in a chamber using a cage-type jig. When tests are performed in a thermostatic chamber, the jig is connected via a long rod, so there is a possibility of buckling due to the compressive load. The cage-type jig is a jig for performing compression tests in which load is applied when it is actuated in the tensile direction (Fig. 1). Compression tests are performed by moving the blue part upward, with the green part fixed. Therefore, the tests can be performed without buckling occurring due to the load.

The test conditions are shown in Table 2. Tests were performed on 3 types of separators made by different manufacturers under 3 temperature conditions. By applying a 0.1 N preload and adjusting the stroke origin position, the tests could be performed with good reproducibility. Fig. 2 shows the AGS-V precision universal testing machine with the TCE-N300A and the test jig mounted.

Table 1 Equipment Configuration

Testing Machine:	AGS-V
Load Cell Capacity:	500 N
Test Jigs:	Boil-in-bag piercing test jig and cage-type jig
Thermostatic Chamber:	TCE-N300A compact type thermostatic chamber
Software:	TRAPEZIUM™ X-V (single)

Table 2 Test Conditions

Test Speed:	50 mm/min
Preload:	0.1 N
Specimen:	Separator (three types: Company A, Company B, Company C)
Environmental Temperature:	Room temperature, 60 °C, 90 °C
No. of Test Repetitions:	3

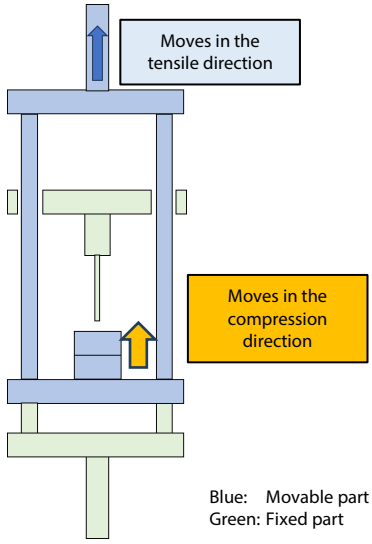

Fig. 1 Principles of the Operation of the Cage-Type Jig

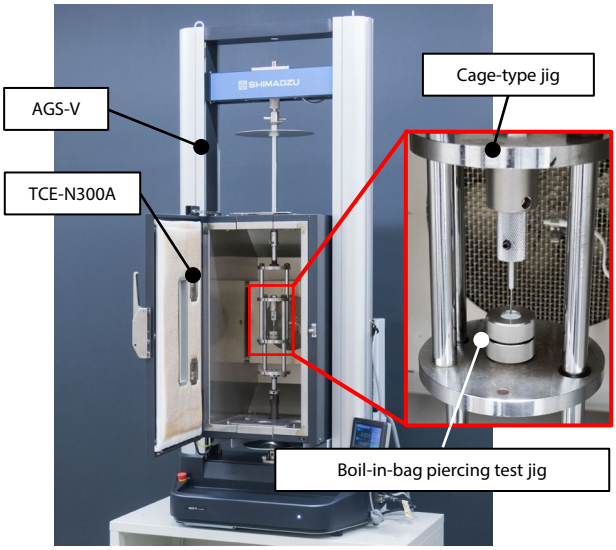

Fig. 2 AGS™-V and TCE-N300A

■ Test Results

Examples of the puncture test results are shown in Fig. 3. The horizontal axis indicates stroke; the vertical axis indicates test force; the solid line curves (red) are for room temperature; the dotted line curves (blue) are for 60 °C; and the dash-dotted line curves (green) are for 90 °C. A summary of the test results is shown in Fig. 3. The strength of the separators of all of the manufacturers was reduced at higher temperatures. Table 4 shows the calculated strength values at each temperature, with the strength at room temperature taken to be 100 %. The strength for all manufacturers decreased by about 50 % at 90 °C, but Company A's product showed little decrease in strength at 60 °C.

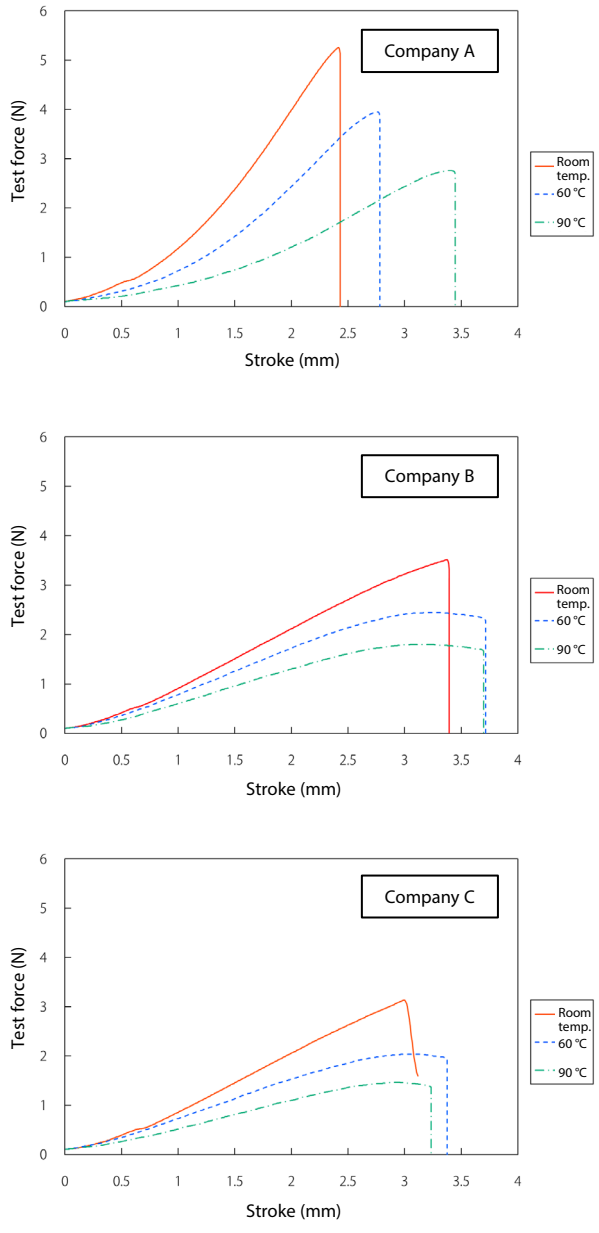

Fig. 3 Examples of the Puncture Test Results
(From the top, the curves are for Company A, Company B, and Company C)

Table 3 Summary of Strength (Mean Values, n = 3)

Environmental temperature	Company A	Company B	Company C
Room temperature	5.29 N	3.47 N	2.88 N
60 °C	3.95 N	2.40 N	2.00 N
90 °C	2.78 N	1.81 N	1.47 N

Table 4 Strength when Room Temperature is Taken to be 100 %
(Mean Values, n = 3)

Environmental temperature	Company A	Company B	Company C
Room temperature	100 %	100 %	100 %
60 °C	74.7 %	69.2 %	69.4 %
90 °C	52.6 %	52.2 %	51.0 %

■ Conclusion

Puncture tests were performed on separators at various environmental temperatures in a thermostatic chamber. A simple fixing method was adopted for the boil-in-bag piercing test jig using nuts, so it was easy to install and remove the samples from the jig.

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