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Application News

Temperature Dependence Evaluation of Tensile Shear Strength of Adhesive

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User Benefits

- Tensile shear bond strength measurement of adhesives conforming to JIS K 6850, JIS K 6831, and ISO 4587 is possible.
- Tensile shear bond strength in a temperature environment from -40 °C to 250 °C can be measured using the thermostatic chamber introduced in this article.
- The AGX-V2 enables detailed measurement of rapid and minute changes in brittle fracture in thermal environments with sampling rates of up to 10 kHz.

■ Introduction

Adhesives have been used for various purposes since ancient times for connecting objects. In recent years, the demand for adhesives in the automotive industry has increased. Until now, automotive parts have been made of metal materials, and welding and bolting have been the main methods of joining. However, with the increase in the number of automotive parts made of lightweight materials such as reinforced resin as alternatives to metal, the use of adhesives suitable for joining different materials has increased. Furthermore, the bonding of components using adhesives is expected to offer advantages not found with conventional welding or bolted connections, such as improved stress distribution and rigidity of the bonded part as a result of surface bonding, and a shortened polishing process of the bonded surface.

Adhesives for automotive applications are required to have high cold resistance in the low-temperature environment of extremely cold regions, high heat resistance in the high-temperature environment of desert areas, as well as high heat resistance in the high-temperature environment around engine rooms and brakes. Therefore, it is necessary to select an adhesive suitable for the operating environment. The effect of temperature changes on the tensile lap-shear adhesive strength was measured using a precision universal testing machine and a thermostatic chamber in the test.

■ Test Sample

Four types of ThreeBond (TB) adhesives were used in this test. Fig. 1 shows the shape of the test specimens, Table 1 shows the test specimen information, and Table 2 shows the curing conditions for each adhesive. SUS304 was used as the adherend, and spacers were used for the grips to ensure that the load was applied correctly to the adhesive bonding surface. In addition, since TB1160 is a moisture-curing type which cures by reacting with ambient moisture, the thickness of the adhesive layer was set to 1 mm.

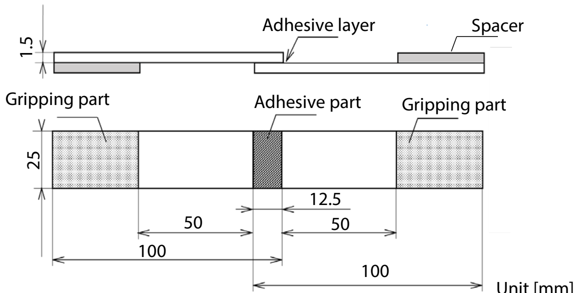

Fig. 1 Test Specimen

Table 1 Specimen Information

Adhesive Type:	TB1160 (One-component, room-temperature-curing non-silicone sealant) TB2049/2149 (Two-component, room-temperature-curing epoxy resin) TB2237J (One-component, heat-curing epoxy resin) TB3953 (Two-component, room-temperature-curing elastic adhesive)
Adherend:	SUS304
Adhesion Area:	25 × 12.5 mm
Specimen Size:	W25 × t3 × L187.5 mm (TB1160 only t4 mm)

Table 2 Curing Conditions

TB 1160:	(23 °C, 50 %RH) × 168 h
TB 2049/2149:	25 °C × 24 h
TB 2237J:	120 °C × 60 min
TB 3953:	(23 °C, 50 %RH) × 168 h

■ Instruments and Test Conditions

Tensile lap-shear tests were carried out using an AGX-V2 precision universal testing machine and a thermostatic chamber TCR1WF. Fig. 2 shows the test setup, and Table 3 shows the equipment configuration. The test conditions are shown in Table 4. In this test, a total of eight temperature conditions were set from -25 °C to 150 °C. The test specimens were placed in the chamber at the set ambient temperature for a sufficient period of time, then attached to the jig and tested after confirming that the temperature had stabilized.

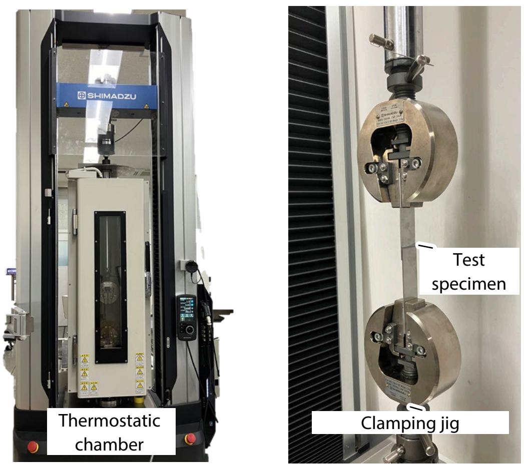

Fig. 2 View of the Test

Table 3 Instrument Configuration

Testing Machine:	AGX-10kNV2D
Load Cell Capacity:	10kN
Jig:	10kN Manual Type Non-Shift Wedge Type Grips
Thermostatic Chamber:	Refrigerator thermostatic chamber, water-cooled type TCR1WF (Temperature range -40 °C to 250 °C)
Software:	TRAPEZIUM™X-V

Table 4 Test Conditions

Test Speed:	1.2 mm/min
Set Atmosphere Temperatures:	-25 °C, 0 °C, 25 °C, 50 °C, 75 °C, 100 °C, 125 °C, 150 °C (Total eight conditions)
Distance between Grips:	112.5 mm
Number of Tests:	N = 3 (at each set atmosphere temperature)

■ Testing Results

Fig. 3 shows the test lap-shear strength-stroke diagrams for each adhesive under the temperature conditions of -25 °C, 25 °C, 75 °C, and 125 °C as examples of the test results. Fig. 4 shows the relationship between tensile lap-shear strength and temperature. It can be seen that the strength of TB1160 decreases significantly at 0 °C and then gradually decreases (Fig. 3, Fig. 4). TB2049/2149 had the highest strength at room temperature, and the strength decreased below room temperature. This is considered to be due to the increase in the rate of fracture (interfacial fracture) at the bonding interface between the adhesive and the adherend as the temperature decreases to 0 °C and -25 °C. In the case of interfacial fracture, the variation in adhesive strength increases, and it is not an appropriate fracture state. On the other hand, cohesive failure within the adhesive is determined by the physical properties of the adhesive, resulting in small variations in adhesive strength and an ideal fracture state.

If the fracture state is interfacial fracture, the rate of cohesive fracture can potentially be increased by applying surface treatment to the adherend and strengthening the adhesive bonding at the interface. Additionally, there was a significant decrease in strength at 50 °C. TB2237J has high adhesive strength even at high temperatures compared with the other three types of adhesives, and the strength gradually decreases as the temperature increases. The adhesive strength of TB3953 significantly decreased up to 25 °C but was then maintained from 25 °C to 75 °C, decreased again from 75 °C to 125 °C, and remained constant after 125 °C. Adhesives tend to lose strength significantly above the glass transition temperature (Tg), and this is probably because TB3953 has two glass transition temperatures as it is a two-component mixture of epoxy resin and modified silicone. This test enabled measurement of the differences in the temperature characteristics of each adhesive.

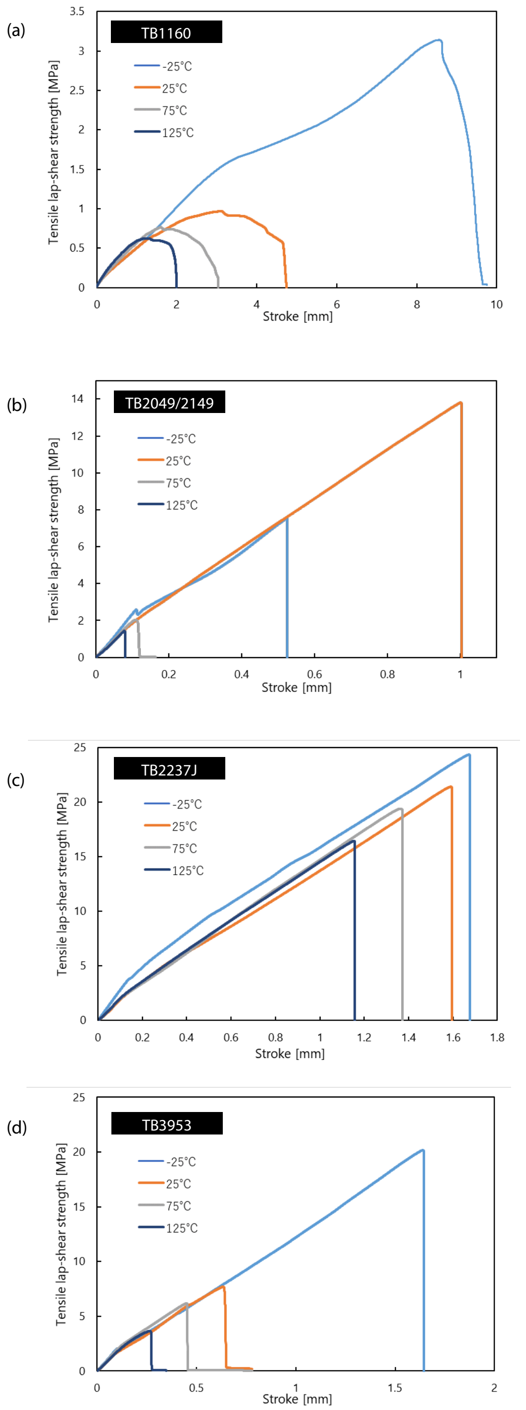

Fig. 3 Tensile Lap-Shear Strength-Stroke Diagram
(a) TB1160, (b) TB2049/2149, (c) TB2237J, (d) TB3953

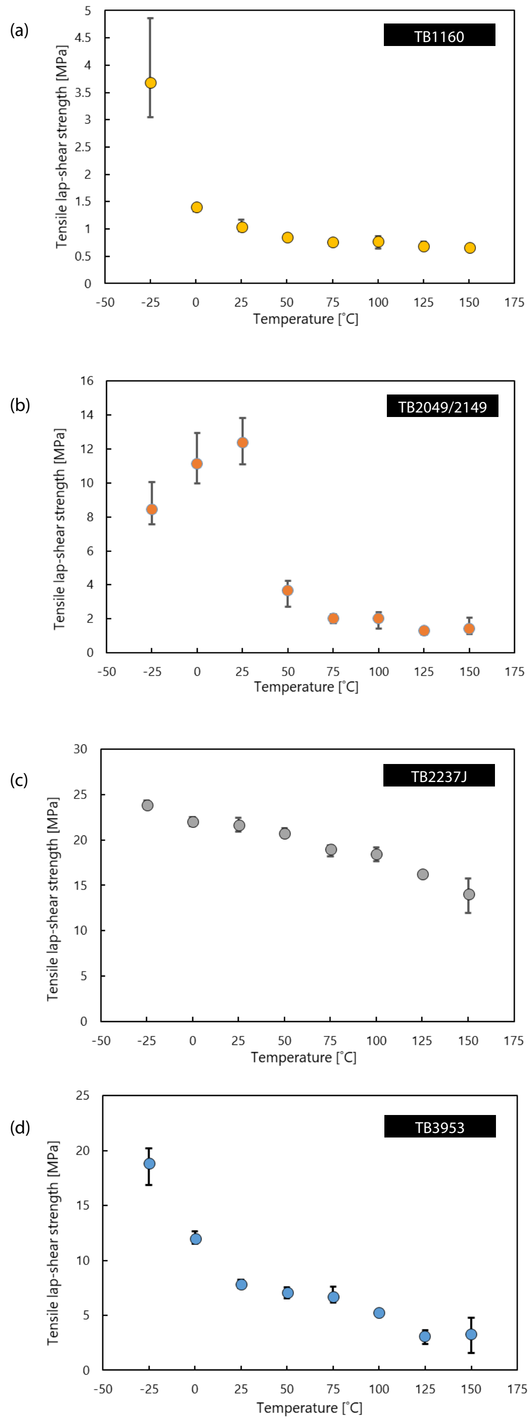

Fig. 4 Tensile Lap-Shear Strength-Temperature Diagram
(a) TB1160, (b) TB2049/2149, (c) TB2237J, (d) TB3953

Fig. 5 Fracture State of TB2049/2149 at -25 °C, 0 °C and 25 °C

■ Conclusion

In these tests, the temperature characteristics of tensile lap-shear strength were evaluated for four types of adhesives. The adhesive strength of TB1160 decreased significantly at 0 °C. TB2049/2149 showed a decrease in adhesive strength due to interfacial fracture at low temperatures. TB2237J maintained high adhesive strength even at high temperatures. TB3953 is a two-component resin mixture of epoxy resin and modified silicone, and the adhesive strength gradually decreased with an in. By using this equipment configuration, it is possible to conduct tensile shear tests in accordance with JIS K 6850, JIS K 6831, and ISO 4587 and evaluate the temperature dependence of adhesive tensile shear bond strength.

Acknowledgment

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<Related Applications>

1. Test Speed Dependence Evaluation of Shear Strength of Adhesive and Fracture Observation, Application News No. 01-00743-EN
2. Shear Fatigue Testing of Adhesives, Application News No. 01-00790-EN

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