ThreeBond
TECHNICAL NEWS

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Two-Part Acrylic Elastic Epoxy that Cures at Room Temperature

Introduction

SGAs (second generation acrylic adhesives) are two-part mixture acrylic adhesives that are generally considered to cure quickly at room temperature for excellent productivity. They can also increase work efficiency and save energy by eliminating the need for UV irradiation chambers, hot air drying ovens and other curing equipment.

In this document, we will introduce a two-part mixture acrylic adhesive that boasts improved durability and elasticity even after quickly curing at room temperature.

Hereafter, ThreeBond is abbreviated as TB.

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1. Background

1-1 Environmental Concerns

In recent years, manufacturing industries such as automotive, electrical and electronic manufacturers have been required to put measures in place to prevent global warming during production processes. Manufacturing technologies are being developed intensively to promote resource and energy conservation in the ever-expanding effort to develop products that protect the global environment. In the automotive industry, development continues on hybrid (HV/PHV), electric (EV/FCV) and other environmentally friendly vehicles in an effort to reduce carbon dioxide emissions and convert to petroleum substitutes. When these vehicles were first introduced on the market, they had the image of being higher priced than conventional vehicles, but thanks to initiatives lowering automotive manufacturer price, the Ministry of Economy in Japan, Trade and Industry's introduction of a subsidy system to further demand and other national policies, the market share of environmentally conscious vehicles continues to expand. In response to this growing demand, automotive manufacturers must improve both vehicle productivity and performance. Further resources and energy conservation efforts, such as eliminating heat generation, are underway within production processes in consideration of environmental efforts.

To meet these market demands, ThreeBond has launched a two-part acrylic elastic adhesive capable of curing at room temperature. Mixing the main agent with a curing agent allows it to cure quickly at room temperature without additional curing equipment.

1-2 Properties Required of Adhesives

Various adhesives and sealants are used for a wide range of applications in automotive and parts manufacturing, from areas around glass, headlights and inside seats to drive parts and cooling units in engines and transmission. In particular materials and parts connected to internal combustion in engines and transmission must be able to withstand heat of 150°C. To handle this, one-part silicone sealant that is moisture curable is widely used as an adhesive sealant for these parts.

In addition to withstanding 150°C temperatures, silicone sealants maintain a rubbery elasticity over a wide range of temperatures, making them excellent for following vibrations, resisting impact and mitigating stress created by automobiles while driving. But while these performance characteristics are excellent, curing speed is an issue. Curing one-part silicone sealant in moisture requires an environment of 23°C and a RH of 50% over several days to completely cure, which is not good for productivity. Because of this, two-part mixture adhesives that can be cured at room temperature for practical strength in a short amount of time have been drawing attention in the production lines of electronic components and other places where high productivity is required.

1-3 Sealant Adhesive Curing Methods

Sealant adhesive is divided into moisture, heat, UV and anaerobic curing as well as two-part mixture curing types. There are plusses and minuses to each curing method, so the appropriate adhesive and sealant are chosen as required by the application (Table 1).

In UV and heat curing adhesives, curing is performed by applying the required energy to start the reaction. This elimination of restrictions on working time due to pot life in combination with excellent curing shortens overall process time. However, expensive curing equipment is required, making initial investment costs high, and a lot of energy is consumed during curing. In large parts such as those for automobiles, public works and construction, moisture-curing sealant adhesives are widely used because they can be cured at room temperature, thus eliminating the need for curing equipment. However, curing is more time-consuming and is affected by changes in the usage environment, such as temperature and humidity. Caution must be exercised during use, because curing speed is faster in environments with lower temperature and humidity (Fig. 1).

Table 1 Merits by Curing Methods

Type	Moisture-curing	Thermosetting	UV curing	Moisture-curing	Two-part mixture
Curing speed	×	△	◎	△	○
Line equipment cost reduction	○ - △	×	×	◎	◎
Energy efficiency	○ - △	×	×	◎	◎
Adherend usability	○	×	×	×	◎
Curing inhibitor	○	×	○ - △	○ - △	○ - △
Impact of use conditions	×	○	○	△	○
Large surface adhesion	×	○	○ - △	○	◎

◎: Excellent ○: Good △: Possible ×: Inadequate

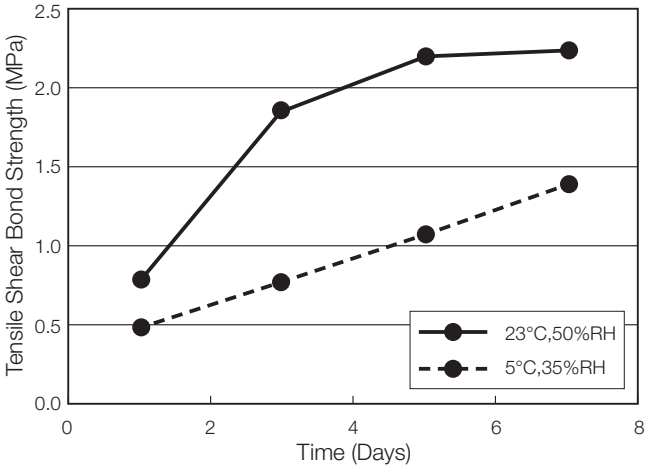


Fig. 1 Adhesive Development in Moisture-Curing Sealant by Environment

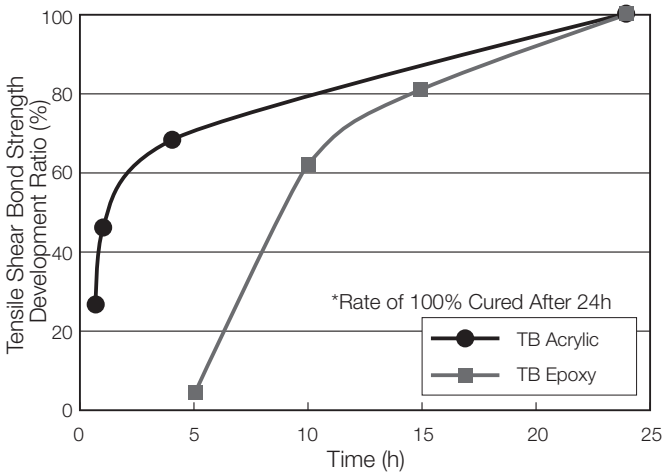


Fig. 2 Two-Part Mixture Epoxy and Acrylic Resin Curing Speeds

Therefore, if faster curing is required without the use of curing equipment, two-part mixture adhesives are used.

In two-part mixture adhesives, the curing reaction begins when the main agent and the curing agent are mixed in the prescribed ratio. The basic categories of base resin are epoxy, silicone and acrylic, with each demonstrating specific attributes and physical properties (Table 2). They are selected as needed for the application (such as structural adhesive or elastic sealant), but acrylic resin demonstrates the fastest curing speeds (Fig. 2).

Table 2 Two-Part Mixture Base Resin Properties

Base	Acrylic		Epoxy	Silicone
	TB3955	Conventional Product		
Curing speed	○	○	○	△
Adhesive strength	○	◎	◎	△
Flexibility	◎	△	×	◎
Heat resistance	○	△	○	◎
Humidity resistance	○	△	○	○
Chemical resistance	○	△	○	○

2. Acrylic Adhesive Development

As shown in Fig. 3-a, acrylic adhesive is a generic name for adhesives having a (meth)acrylic acid chemical structure, or a monomer or polymer of a derivative acetate thereof that cures through radical polymerization (Fig. 3-b). Through a combination of monomers and polymers, a variety of cured physical properties can be achieved.

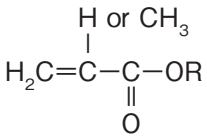


Fig. 3-a Acrylic Structural Formula

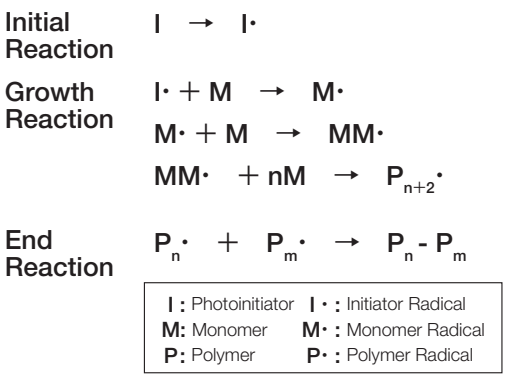


Fig. 3-b Radical Polymerization Reaction Mechanism

Acrylic adhesives are divided by reaction type. First-generation acrylic adhesives (FGA)*1 are composed of acrylic monomer, a catalyst and elastomer, but no chemical reaction occurs between monomer and elastomer during curing. Even though the composition is almost identical, adhesive where there is a chemical reaction between monomer and polymer is called a second-generation acrylic adhesive (SGA)*2. These demonstrate superior performance in various aspects, such as adhesive strength and durability. Acrylic adhesives where polymerization is initiated by exposure to UV, electromagnetic waves or electron beams (Fig. 3-b) are classified as third generation, and these are a part of our ThreeBond 3000 product lineup. Other acrylic adhesives include anaerobic and instant types and these are available in the ThreeBond 1300 and 1700/7700 series, respectively.

3. Acrylic Elastic Adhesives

Until now, a wide variety of acrylic adhesive products have been developed to meet a wide range of applications. These products are now widely used, and demand continues to grow. However, they could not be used in automobile internal combustion and other environments requiring resistance to high heat and flexibility.

This led ThreeBond to work towards the development of an acrylic elastic adhesive that can withstand temperatures of at least 120°C. These products feature acrylic rubber polymer as their base component. They boast high resistance to both heat and oil, while also featuring a low glass transition temperature and a silicone-like rubber elasticity that is maintained in a wide temperature range. Until now, we have offered UV, heat and moisture curing resins expressly for electrical parts in the transport market where high resistance to heat and oil is required.

Now, we are pleased to introduce ThreeBond 3955 (hereafter abbreviated to TB3955), our two-part mixture adhesive that cures at room temperature (Table 2, 4).

TB3955 Features

- **Quickly cures at room temperature.**
- **Glass transition temperature below zero degree that maintains rubber flexibility in a wide range of temperatures.**
- **Withstands high temperature (150°C) and high temperature and humidity (85°C, 85% RH) environments.**

4. Applications

Here are some of the applications for our two-part acrylic elastic epoxy that cures at room temperature.

4-1 Bonding Dissimilar Materials

Advances in automotive part material development are an important part of the technological innovation that has made performance improvements a reality. By adopting materials optimized for the performance of these parts and then incorporating them into product design, performance continues to improve along with reductions in size and weight. Adhesives that bond materials of different properties are required to accompany these developments. Especially in materials with different coefficients of linear expansion, expansion and contraction ratios differ in the material itself depending on temperature changes in the usage environment. This means that there is greater distortion acting on the adhesive used to fix these materials, which results in peeling and cracking. This issue occurs under changes from the curing temperature and under severe conditions and occurs repeatedly particularly during the heat cycle. In these cases, we need adhesives with the ability to bond with these materials and the flexibility to adapt to their expansion.

Motor magnet affixing is one example of this kind of bonding of dissimilar materials. Most of the synchronous motors used in HV (PHV), EV and other environmentally friendly

Table 3 Acrylic Elastic Adhesive Product Lineup

Curing Method			Moisture-curing	Thermosetting	UV curing	Remarks
*Curing Conditions			(23°C, 55% RH) × 7 days	150°C, 90min	45kJ/m^2	
Product name			TB1158	TB1156B	TB3013Q	
Features	Unit	Testing Method	Measured Value			
Hardness	—	3TS-2B00-004	A20	A6	A32	Durometer A
Elongation rate	%	3TS-4190-001	300	275	195	—
Tensile strength	MPa	3TS-4190-001	1.8	1.2	2.7	—
Tensile shear bond strength	MPa	3TS-4100-013*, 023**	1.8 (Al/Al)**	1.5 (Al/Al)**	4.1 (Fe/glass)*	—
Glass transition temperature	°C	3TS-4730-001	-40.0	-40.5	-31.0	DMA method 1Hz, E" peak

*1 First generation acrylic adhesive
*2 Second generation acrylic adhesive

automobiles are PM[*3] motors, which use permanent magnets in the rotor. Among permanent magnets, neodymium magnets produce the largest amount of energy and are highly magnetic, making their adoption ideal for high capacity, low size motors. In addition to use in electric and hybrid automobiles, PM motors are also the main electric motor used for EPS[*4] and other systems that use small motors. An epoxy, anaerobic and two-part (acrylic) adhesive that cures at room temperature are used to affix the permanent magnet to the stator. In high torque-generating medium and large electric motors that produce high temperatures, a one-part thermosetting epoxy adhesive with a high glass transition temperature and high heat resistance is used. The issue with this is that when temperature changes, such as in the post-curing cooling process or in the heat cycle, resin contraction and the difference in the coefficient of linear expansion between the stator and the permanent magnet cause the peeling as well as cracking in the magnet. Additionally, quick room temperature curing is also required to improve productivity by reducing heat curing equipment and processes to better handle mass production of small motors.

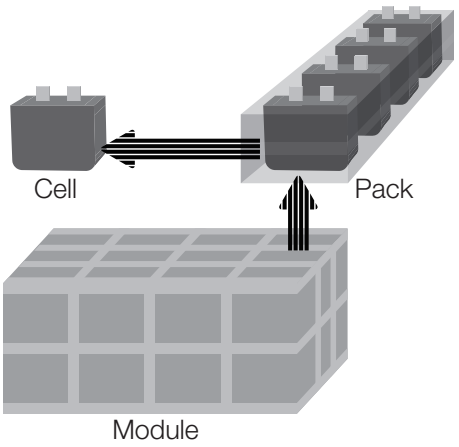
TB3955 has a low glass transition temperature and is highly flexible after curing, making it excellent for application in areas with large amounts of expansion and contraction where stress mitigation is required. It is also ideal for affixing motor magnets because it cures quickly at room temperature, eliminating the need for curing equipment to improve productivity.

4-2 Surface Bonding

Two-part mixture adhesives are effective for bonding large areas. Generally, when UV or heat cannot be applied to an adherent, adhesives that cure at room temperature are used. However, because moisture-curing types require contact with air, completely curing large adherents all the way to the center becomes problematic, which negatively impacts both reliability and productivity. Therefore, two- part mixture adhesives that uniformly bond large surfaces and cure quickly are used.

Looking at parts for electric vehicles, the battery, which requires laminated cells, is one such example of this kind of application. There are two main types of battery cell shape, round and long, which are developed by various manufacturers. When installing either shape of cell into an automobile, several cells are formed into a pack then assembled as a module (Fig. 4).

Fig. 4 Battery



Adhesive is used between the cells to affix them to each other for laminating and packing. Though thermosetting adhesives are effective for bonding large areas, they cannot be used in this particular application because heat cannot be applied to the cells. For this reason, two-part mixture adhesive that cures at room temperature is used to bond cell surfaces. This adhesive must also have the flexibility to adapt to vibrations incurred after installation, making two-part mixture acrylic elastic adhesive the ideal material for bonding the various parts used in battery assembly.

4-3 Potting

Elastic adhesives are used in potting to affix and protect parts in electronic assemblies. The rubbery elasticity of the potted adhesive protects assembly parts and absorbs impacts to the assembly in which they are installed to reduce the risk of detachment which can lead to product failure. For many of these applications, one and two-part moisture-curable silicon and modified silicone elastic adhesive cut with low-molecular siloxane are used. These adhesives maintain an excellent rubbery elasticity when hardened and can be cured at room temperature so that boards need not be inserted into curing ovens after assembly. However, as mentioned previously, even two-part mixture silicone and modified silicone resins take considerable time to fully cure, so this time must be further reduced. Productivity is improved in this regard by using a two-part mixture acrylic resin, which can be cured at room temperature more quickly. Potting agents must also be moisture resistant to better protect electrical and electronic parts, so TB3955 is the optimal adhesive for affixing and protecting assembly parts as it is moisture resistant and maintains flexibility when cured (Fig. 7).

[*3] Permanent magnet
[*4] Electronic power steering

5. Material Properties

Here are some of the properties of TB3955, our two-part acrylic elastic epoxy that cures at room temperature.

5-1 Curing Efficiency

Previous two-part room-temperature curing adhesives had excellent reaction speed, but this was also problematic because it meant a short pot life that reduced working time. Therefore, we optimized pot life for TB3955 in consideration of workability and productivity (Fig. 5). However, we also ensured that once the curing reaction starts, it accelerates rapidly to quickly reach practical strength. When cured at a 25°C room temperature, the adhesive has a pot life of around five minutes, then develops to a strength of 2 MPa or more in 60 minutes and is almost completely cured after 12 hours (Fig. 6).

5-2 Curing Efficiency

Once cured, TB3955 has a low glass transition temperature for a rubbery elasticity that allows it to be used in a wide range of temperatures (Fig. 4).

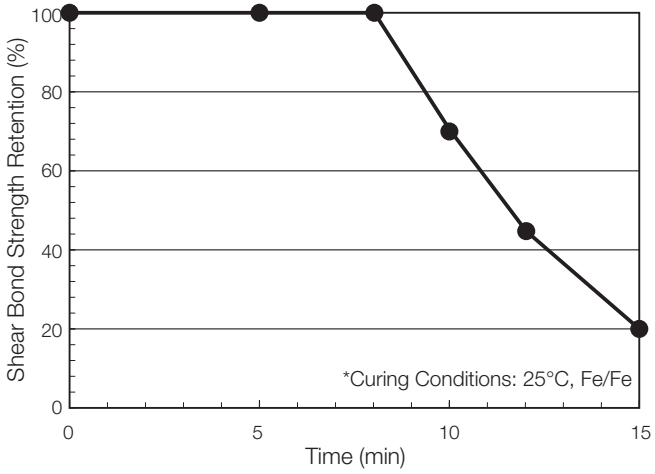
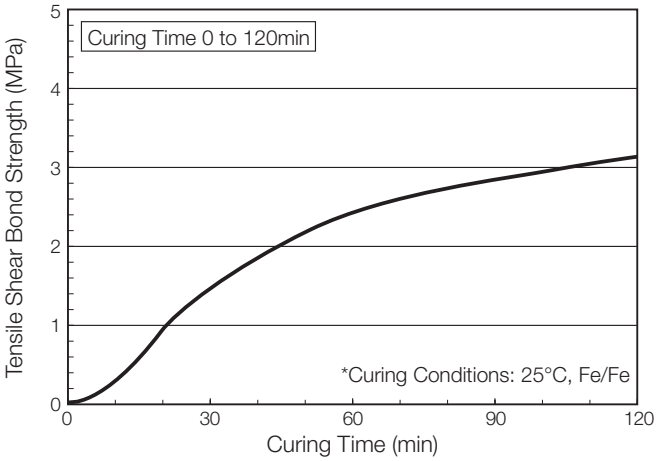


Fig. 5 TB3955 Adhesion Pot Life



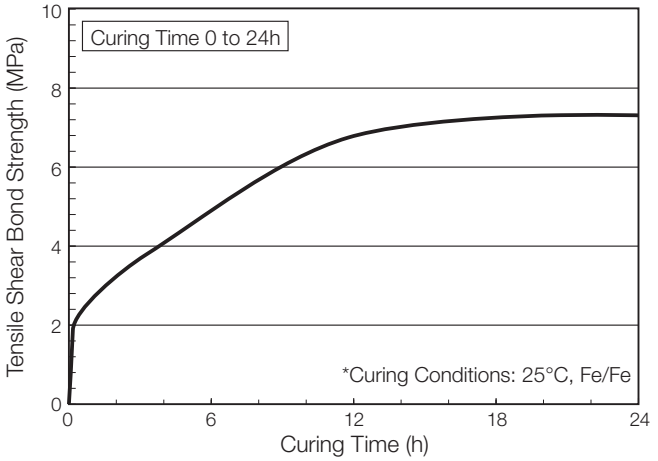


Fig. 6 TB3955 Adhesive Development

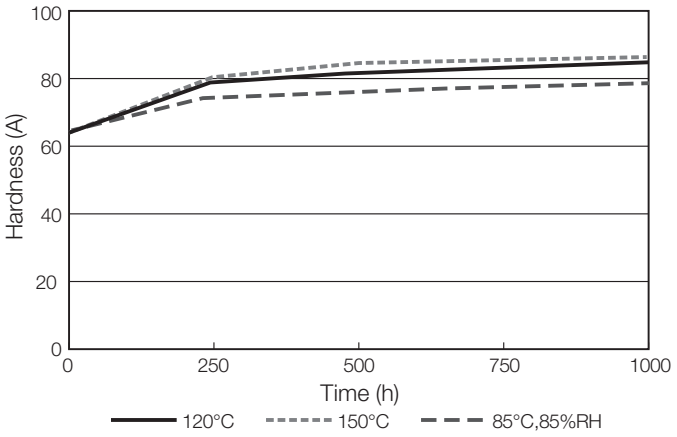
Furthermore, it does not weaken and maintains performance even in high temperature environments of 150°C and high humidity and temperature environments of 85°C and 85% RH (Fig. 7).

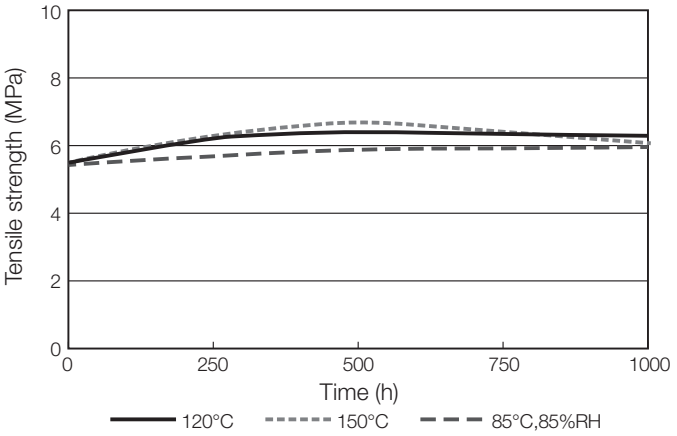
Table 4 TB3955 Cured Characteristics

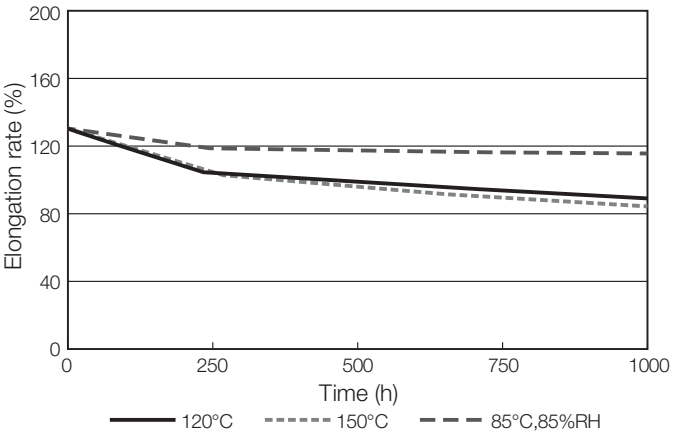
Features		Unit	Measured Value	Testing Method	Remark(s)
Hardness		—	A65	3TS-2B00-004	Durometer A
Elongation rate		%	130	3TS-4190-001	No. 3 dumbbell
Tensile strength		MPa	5.2	3TS-4190-001	No. 3 dumbbell
Tensile shear bond strength		MPa	6.6	3TS-4100-013	Fe / Fe (SPCC,SD)
			6.2		SUS/ SUS (SUS-304)
Rate of contraction when curing		%	0.9	3TS-Z365-001	φ20
Glass transition temperature		°C	-45	3TS-4730-001	DMA method 1Hz, E" peak
Coefficient of linear expansion	α_1	ppm/°C	66.0	3TS-4740-001	–100 to –70°C
	α_2		221.5		0 to 50°C

Curing conditions: 25°C×24h

5-3 How to Use







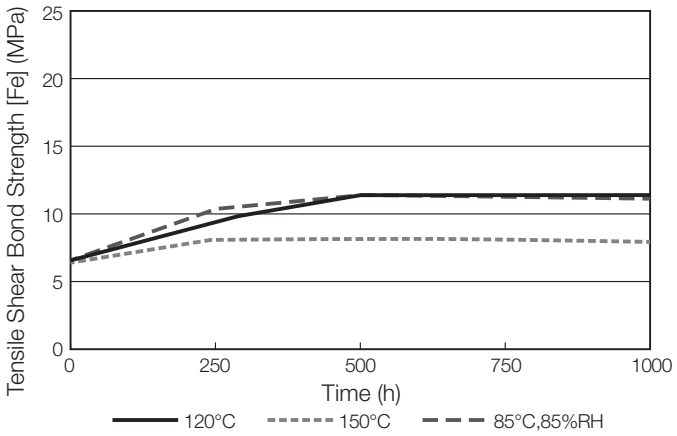


Fig. 7 TB3955 Durability

In TB3955, the curing reaction begins when the main agent and the curing agent are mixed in a 1:1 ratio. This product was commercially released in twin cartridges so that it can be mixed in a static mixer then applied directly to the adherent (Fig. 8). Workability is excellent because the required amount can be mixed in the appropriate ratio without weighing.

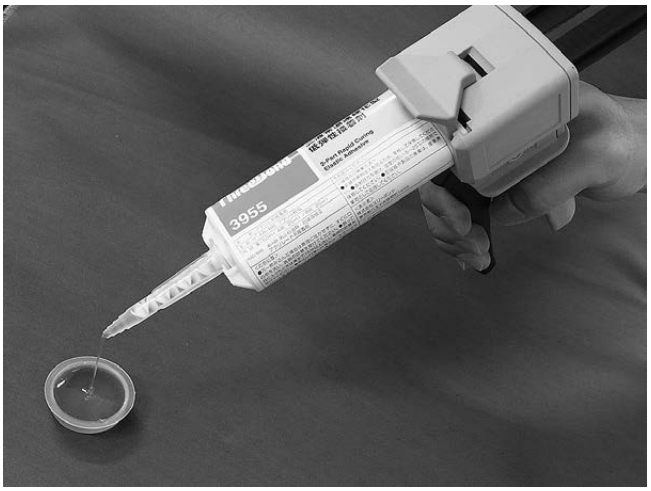


Fig. 8 TB3955 Specifications

Closing

TB3995, our new two-part acrylic elastic adhesive which cures at room temperature, boasts durability, flexibility and curing speeds unprecedented in previous two-part mixture adhesives. It is perfect for a wide range of fields and application development, from transportation to electronics and even public works material markets.

At ThreeBond, we are constantly striving to further our technological development in order to create products that meet an ever-widening range of customer needs.

<References>

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