ThreeBond
TECHNICAL NEWS

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Developing the Oily Surface and Magnesium Alloy Adhering FIPG

Introduction

Thanks to their flexibility when cured and excellent heat and chemical resistance, Silicone FIPG (Formed In Place Gasket) s are used for a variety of sealing and adhesion applications such as in automotive engine Areas. ThreeBond has developed products that have been specifically tailored to meet our customers high requirements.

Recent years have seen manufacturers overhauling the manufacturing process, replacing iron, aluminum, etc., with lighter materials in order to reduce labor production costs and organic solvent use while reducing vehicle fuel consumption. While investigations into reduction of degreasing processes for cases and oil pans are a part of this overhaul, oil inevitably sticks to adherends for these parts, necessitating FIPG that bonds with oily surfaces. Additionally, the magnesium alloys and engineered plastics being considered for weight reduction are difficult to bond to, so increasing the adhesive strength of FIPG is a major concern.

Here, we will introduce two of the latest in FIPG technology, our oily surface and lightweight materials (magnesium alloy) adhering FIPG.

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1. Background

1-1 Automotive Industry Efforts

Recent years have seen the automotive industry and others progress towards environmentally conscious manufacturing through reductions in CO_2 emissions, pollutants and vehicle fuel consumption.

In order to both reduce emissions and use renewable petroleum substitutes, hybrid (HV/PHV), clean diesel, electric (EV), fuel cell (FCV) and other eco-friendly vehicles have been released one after another, and their market share continues to grow. Particularly for increased fuel-efficiency, competition among manufacturers continues to steepen, with continued improvements from a variety of angles, such as increasing motor/battery performance, optimizing transmission and control systems and introducing high mileage oil and low resistance tires.

1-2 Developing Lightweight Materials

Weight reductions directly linked to fuel economy have also continued, with parts being reduced both in size and complexity as the weight of the materials used to make them is reduced. Currently, aluminum (aluminum die casting) and iron (cation electrodeposition coated plate) are the two materials most widely used in areas such as automobile engine blocks, cases and oil pans (Fig. 1). As an alternative lightweight material, magnesium (Mg) alloy and nylon-based engineered plastics have gained traction, with various tests underway geared towards their practical use.

1-3 Manufacturing Plant Efforts

Environmental efforts pursued in completed vehicles (products) have also taken hold in manufacturer production lines, with a growing focus on improved productivity coupled with reductions in CO_2 emissions, organic solvents and other pollutants leading to an overhaul of manufacturing processes (labor production cost reduction and simplification). Degreasing processes used for the engine cases and oil pans are one target of these efforts, as organic solvents are used.

1-4 Oil and Dirt on Adherends

Engine blocks and similar parts are usually produced by molding and cutting iron or aluminum die cast. In these cases, cutting oil is used as a process coolant, where a certain, a certain amount of which remains on the flange even after cleaning.

Additionally, various industrial equipment in operation within an engine manufacturing plant scatter lubricant oil, creating a mist (small particles of oil in the air) that attaches to adherends to cause oil leaks or deterioration to adhesive strength and movement followability.

Applications: Adhesive sealant for oil pans, chain cases, etc.

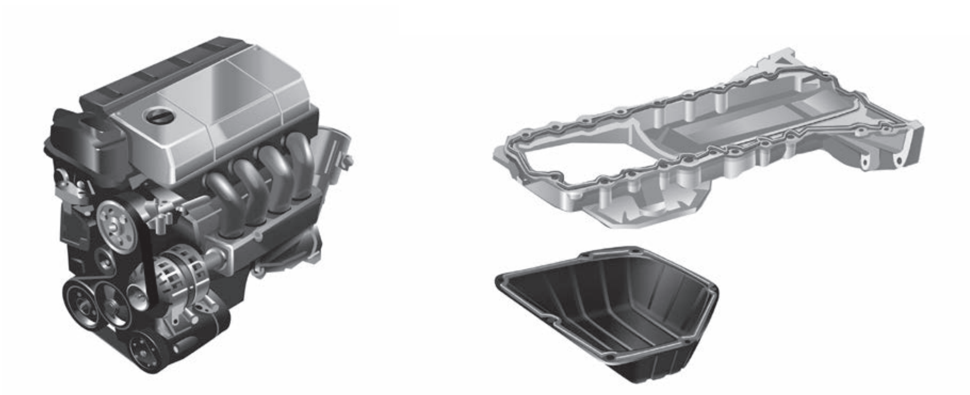


Fig. 1 Parts Where FIPG are Used

2. FIPG

2-1 What are FIPG?

Liquid gaskets (FIPG: Formed-in-Place Gasket) are used in the process Currently RTV silicone is the most widely used material for FIPG.

*RTV: <u>R</u>oom <u>T</u>emperature <u>V</u>ulcanizing

2-2 FIPG Seal Theory

While solid gaskets maintain a seal through repulsive force, FIPG seal oily mediums mainly through bonding, adhesion, viscoelasticity and cohesive force. These characteristics must be excellent in order to seal sufficiently. fully seal (Fig. 2-1, 2-2).

Solid Gaskets

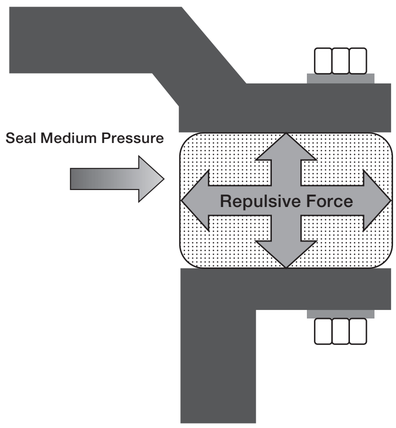


Fig. 2-1 Solid Gasket Seal Theory

Liquid Gaskets

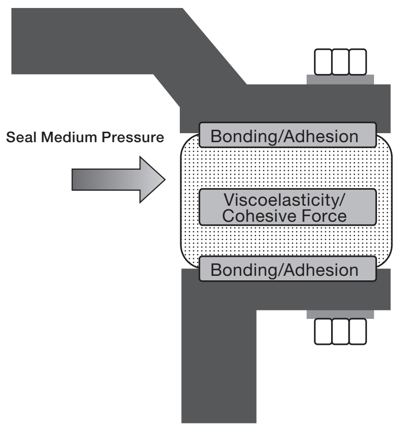


Fig. 2-2 Liquid Gasket Seal Theory

2-3 Types of Leaks

The three main types of leaks are permeation (inner layer) leakage, where the inside of the gasket is penetrated by the medium, burst leakage, where the gasket itself breaks, and junction leakage, where leakage occurs at the interface of the gasket and the flange (Fig. 3).

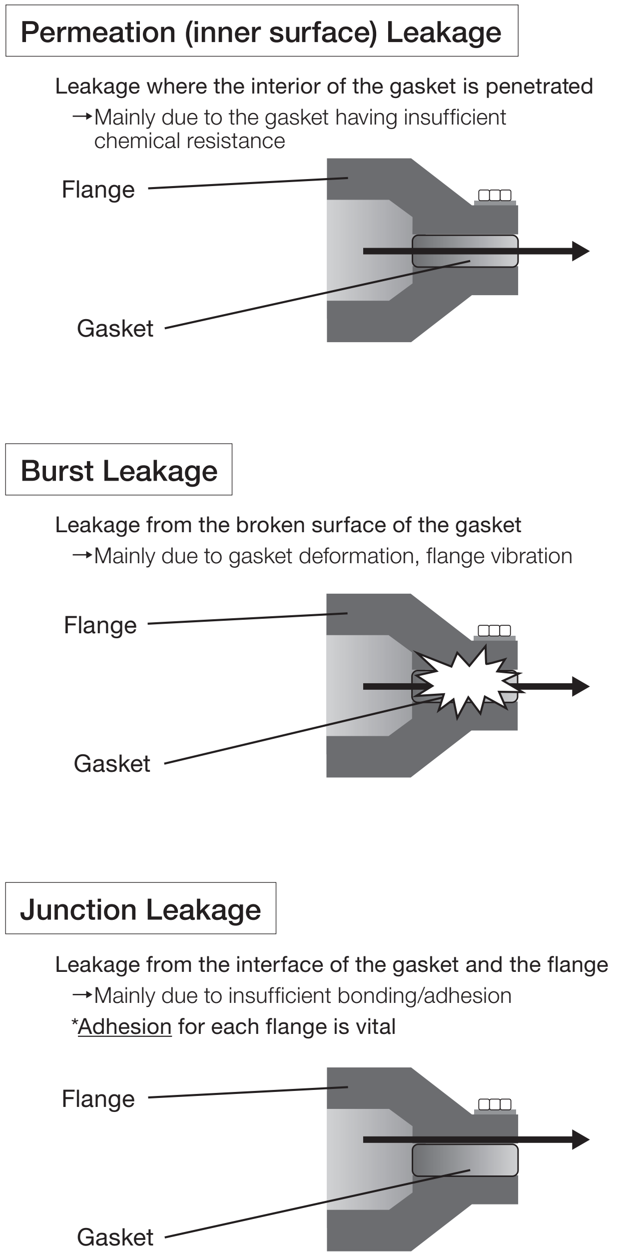


Fig. 3 Types of Leaks

There are various causes of leakage, FIPG are important because of their durability for the sealed medium, ability to follow flange vibrations and opening displacement and their ability to adhere to the flange.

3. Required Characteristics

3-1 Adhesion to Oily or Dirty Parts

Currently, degreasing processes are used to remove oil attached to adherends, but as these processes are reduced due to environmental concerns, this oil and dirt remains on those surfaces.

Oil or dirt on an adherend greatly reduces adhesive strength, which may then lead to market defects, and it is the improvement of adhesion in this kind of well-known situation for which FIPG are most needed.

3-2 Adhesion to Various Parts

While magnesium alloy, nylon and similar light-weight materials contribute to vehicle weight reduction, they are also more difficult to bond to than aluminum, iron, etc. This is why conventional FIPG, which do not bond well, must be improved and modified for use with these light-weight materials (see Fig. 4 for criteria used to determine adhesiveness).

3-3 Durability versus Oil

Silicone FIPGs are used to seal engine and transmission oils, so it is important that strength and elasticity do not suffer in high temperatures (120°C or more), while also ensuring effective adhesion (bonding) to the parts so they can be properly used as a sealant.

3-4 High Elongation

FIPGs are mainly used in vehicle parts (such as engines or transmissions) that vibrate or are subjected to impact, so the ability to follow vibrations and displacement in openings in those parts is required in addition to good adhesion. Oil leaks occur due to FIPG fractures when displacement followability is insufficient even if adhesion is sufficient.

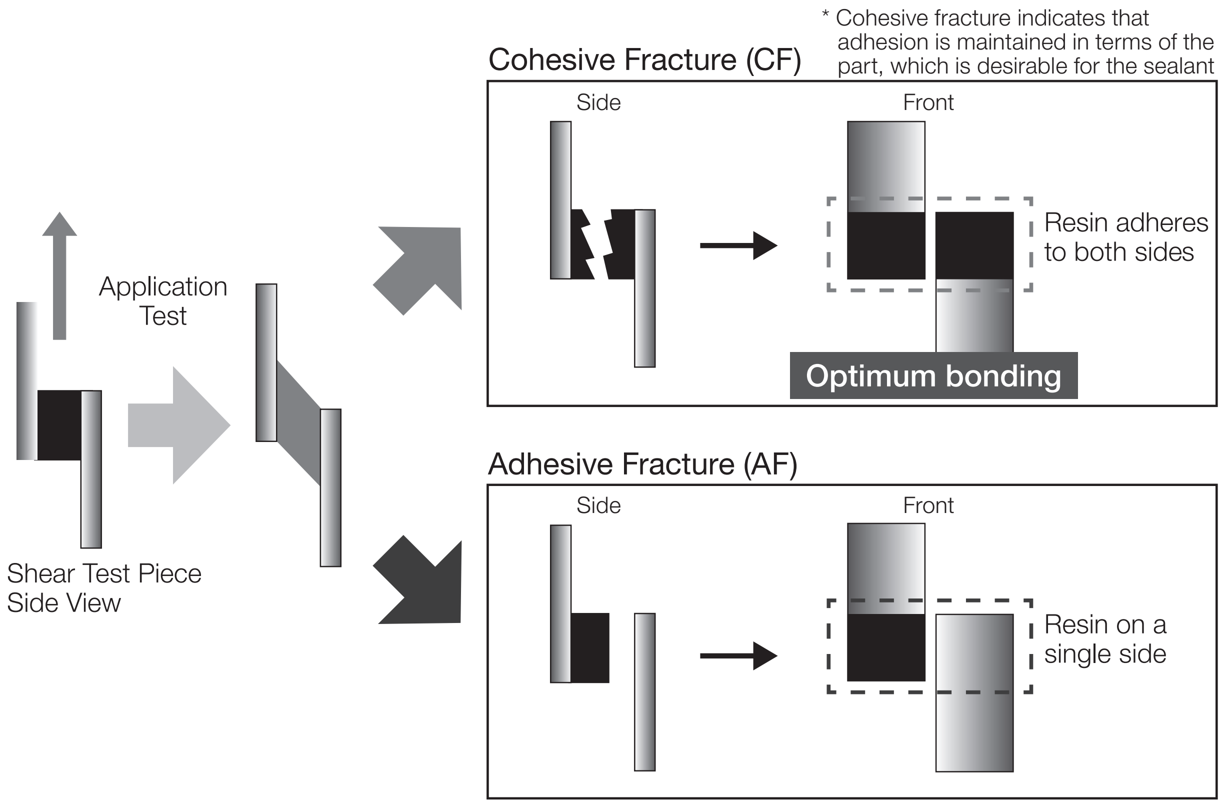


Fig. 4 Cohesive and Adhesive Fractures

4. Product Lineup

Here, we explore the features and properties of ThreeBond 1217M and ThreeBond 1217N (hereafter abbreviated to TB1217M and TB1217N, respectively), which overcome the issues presented above (Table 1, 2).

4-1 TB1217M: Oily Surface Adhesion and FIPG Performance

TB1217M demonstrates excellent adhesion to oily surfaces. Additionally, it boasts displacement followability, curability and other characteristics such as chemical resistance equal to that of conventional products. These traits make it excellent for sealing and adhesion applications where conventional FIPG products do not produce sufficient adhesion to oily and dirty surfaces which are the result in changes to degreasing and cleaning processes.

* Effectiveness varies depending on oil type. Effectiveness for the oil type, concentration and other factors must be checked before use after degreasing.

4-2 TB1217N: Magnesium Alloy Adhesive FIPG

TB1217N demonstrates excellent adhesion to magnesium alloys. Additionally, it boasts displacement followability, curability and other characteristics such as chemical resistance equal to that of conventional products. These traits make it excellent for sealing and adhesion of lightweight materials (magnesium alloys) compared to conventional FIPG.

* Adhesive performance varies depending on the type of magnesium alloy, so confirming with the material to be used is required.

Table 1 Properties

Property	Unit	Conventional Product	TB1217M	TB1217N	Testing Method	Remarks
Curing Method		Oxime type	Oxime type	Oxime type	—	
Appearance		Gray	Black	Gray	3TS-2100-002	
Viscosity	Pa·s	300	280	280	3TS-2F30-001	SOD
Specific gravity		1.37	1.37	1.45	3TS-2500-002	
Tack free time	min	5	7	6	3TS-3130-003	
Thick film curing performance	mm/day	2.4	2.2	2.9	3TS-3160-005	

* Test environment: 23°C, 50% RH

Table 2 Cured Material Characteristics

Cured Material Characteristics	Unit	Conventional Product	TB1217M	TB1217N	Testing Method	Remarks
Hardness	—	A60	A45	A35	3TS-2B00-004	
Elongation Rate	%	430	500	440	3TS-4190-005	
Tensile Strength	MPa	2.6	2.5	3.1	3TS-4190-005	
Shear Bond Strength	MPa	2.1	1.6	2.7	3TS-4100-023	Al/Al

* Curing conditions: 23°C, 50% RH×168h
* Al: Aluminum

5. ThreeBond 1217M Evaluations

5-1 Oily Surface Adhesion

To check adhesion to oily or otherwise dirty parts, engine oil was diluted to a specific concentration using a solvent, applied to an aluminum plate which was used as the test piece, then the shear bond strength was checked (Fig. 5).

■ Conventional FIPG

Shear bond strength, shear elongation (variation) and the cohesive fracture ratio all began to drop from an oily surface concentration of around 1%, becoming almost entirely adhesive fractures (AF) at around 5% (Fig. 6-1, 6-2).

■ TB1217M

Adhesive performance was maintained, with no reduction in shear bond strength, shear elongation or the cohesive fracture ratio until reaching an oily surface concentration of around 7% (Fig. 7-1, 7-2).

The below study results indicate that TB1217M demonstrates better adhesive performance on oily surfaces than conventional FIPG products.

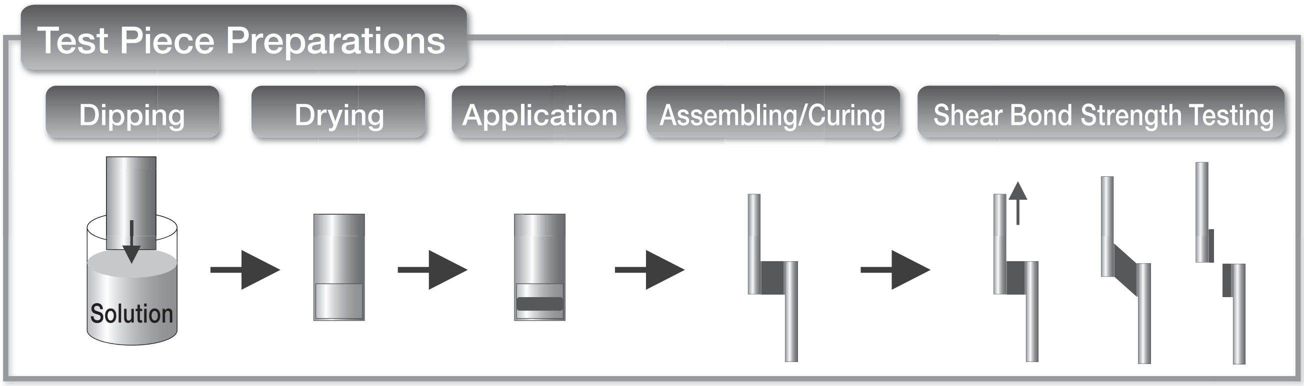


Fig. 5 Test Piece Preparation

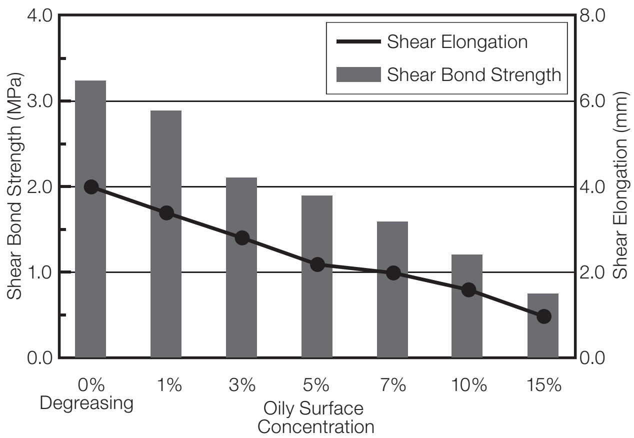


Fig. 6-1 Conventional FIPG Oily Surface Adhesion Test Results

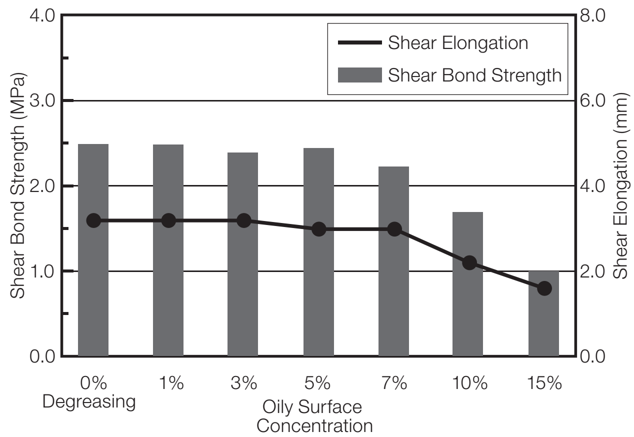


Fig. 7-1 TB1217M Oily Surface Adhesion Test Results

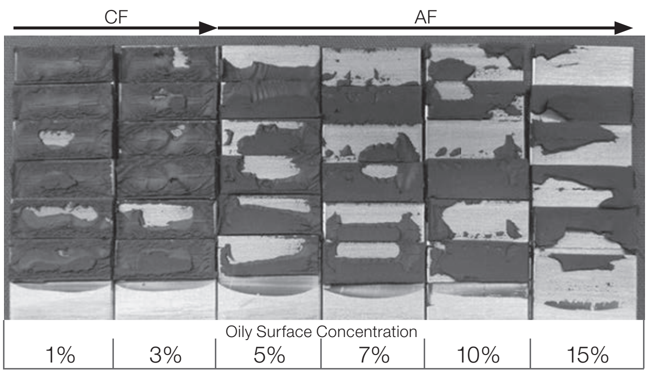


Fig. 6-2 Fractured Conventional FIPG Test Specimen Cross-Section

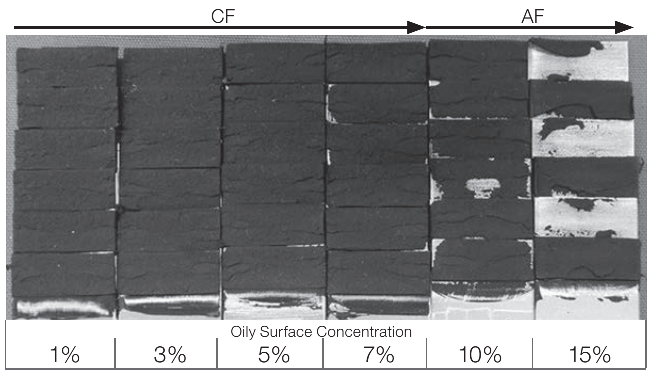
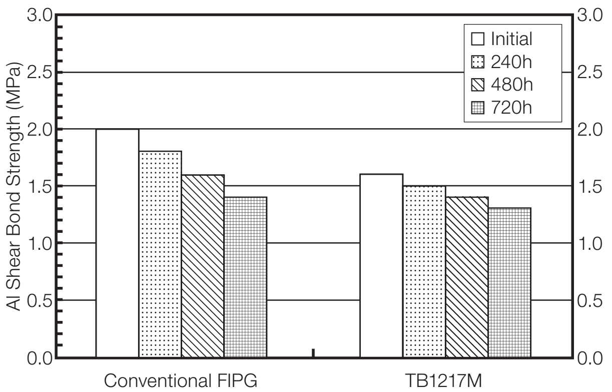


Fig. 7-2 Fractured TB1217M Test Specimen Cross-Section

5-2 Long-Term Durability

The test specimen was cured at standard conditions (23°C, 50% RH×168h), immersed in 150°C engine oil, then checked for changes in physical properties.

TB1217M maintained more stable characteristics than conventional FIPG after immersion in 150°C engine oil for up to 720 h (Fig. 8).



*Al: Aluminum

Fig. 8 TB1217M Long-Term Durability Oil Test Results (Aluminum/Aluminum)

6. ThreeBond 1217N Evaluations

6-1 Magnesium Alloy Adhesion

The shear bond strength was checked using magnesium alloy (AZ-91D) as the test specimen.

■ Conventional FIPG

The poor adhesion to magnesium alloy indicates low shear bond strength, causing an adhesive failure (AF) on the adherend.

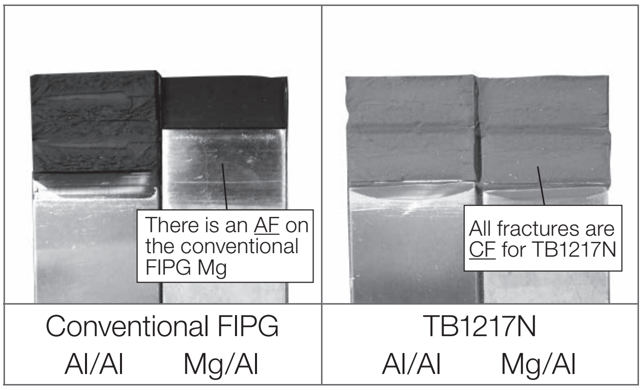
■ TB1217N

Excellent shear bond strength to magnesium alloy that is equivalent to that to the aluminum (Table 3, Fig. 9).

Table 3 Magnesium Alloy Adhesion

Features		Unit	Conventional FIPG	TB1217N
Mg/Al	Shear Bond Strength	MPa	0.2	2.6
	Cohesive Fracture Ratio	%	0	100
Al/Al	Shear Bond Strength	MPa	2.0	2.7
	Cohesive Fracture Ratio	%	100	100

*Testing method: 3TS-4100-023
*Mg: Magnesium, Al: Aluminum
*Curing conditions: 23°C, 50% RH×168h

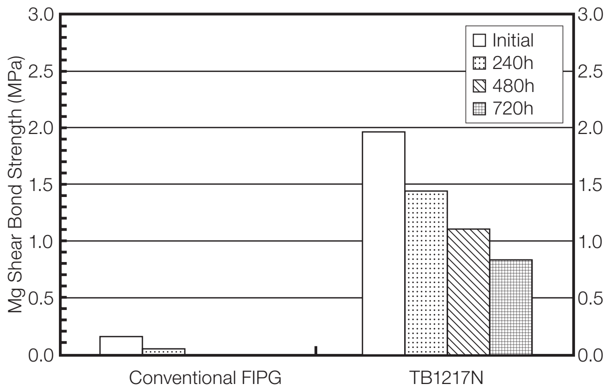


*Mg: Magnesium, Al: Aluminum

Fig. 9 Shear Bond Strength Fracture

6-2 Long-Term Durability

TB1217N maintained better characteristics than conventional FIPG in the same test conditions as in 5-2. Additionally, TB1217N maintains excellent adhesion to magnesium alloy, which is difficult to bond with (Fig. 10).



*Mg: Magnesium

Fig. 10 TB1217N Long-Term Durability Oil Test Results (Magnesium/Aluminum)

As described above, TB1217M and TB1217N demonstrate oily surface adhesion and adhesion to magnesium alloy, respectively, while both have similar properties, characteristics and durability as conventional FIPG.

Closing

The oily surface adhering TB1217M and magnesium adhering TB1217N FIPG introduced here are both products that aid in resource and environmental conservation while reducing processes required and helping to make vehicles lightweight. 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.

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