ThreeBond TECHNICAL NEWS

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Ultra-Soft UV-Cured Formed-in-Place Gaskets

Introduction

ThreeBond is a company founded on a mission of preventing leaks that occur in the manufacturing industry, and we hold the distinction of releasing Japan's very first liquid gasket.

Currently, liquid gaskets have been widely adopted for the FIPG (formed-in-place gaskets) used with the automatic coating equipment employed in automobile, electronics, infrastructure and a wide range of other industries and fields.

Within sealing, there are also UV-CIPG (UV-cured-in-place gaskets) introduced in ThreeBond Technical News No. 72, which are assembled then sealed after coating and UV curing. Restrictions in UV-CIPG materials led to risks such as dimensional tolerance-induced seal failure and issues where compression could not be achieved for low-rigidity components.

Here, we will introduce ThreeBond 3166, an ultra-soft UV-cured formed-in-place gasket with reduced dimensional tolerance risk thanks to being made softer, more durable and more chemically resistant than former ThreeBond products for a wider compression ratio.

Hereafter, ThreeBond is abbreviated as TB.

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1. What is a Gasket?

According to JIS (Japanese industrial standard), gasket is defined as "an object used to prevent joint leakage through insertion in joints of pipes and equipment and tightened by a bolt or some other method" as show in Figure 1.

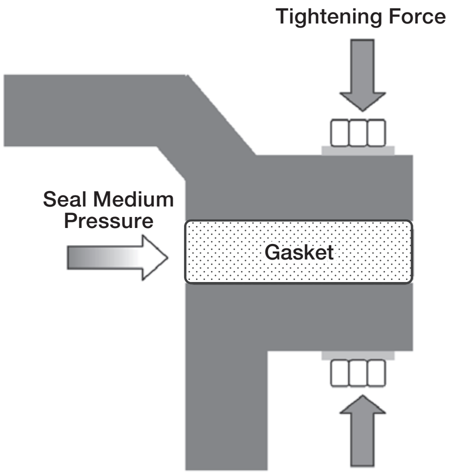


Fig. 1 Basic Gasket Seal Structure

Gaskets are used in automobile engines, electronic parts and a wide range of markets to seal everything from lubricants and hydraulic fluid to water and dust. Gaskets are classified by their properties into solid and liquid types.

Previously, solid gaskets had been widely used to seal flange surfaces, but liquid gaskets (FIPG) replaced these solid gaskets thanks to being easy to use. However, the problem with the moisture-cured FIPG materials that are generally used is that it takes considerable time to fully cure these. To take this in account, a UV-CIPG was designed where the liquid gasket can be applied to the flange surface in a way that enables it to be sealed in a short amount of time when cured with UV.

2. Gasket Type Comparison

Table 1 shows a comparison of each gasket types.

UV-CIPG are assembled after a liquid sealant is applied to the flange surface then UV-cured (Fig. 2).

Table 1 Gasket Type Comparison

		Liquid Gaskets			Solid Gaskets
		Ultra-Soft UV-CIPG	UV-CIPG	FIPG	
Forming Method		UV curing	UV curing	Moisture curing	Molded
Seal		Single-side compression + adhesion	Single-side compression	adhesion	Double-side compression
Speed	Curing speed	○	○	×	—
Line Construction	Automation	○	○	○	△
	Storage Management	○	○	○	×
Freedom of Design	Shape Change	○	○	○	×
	Removability	○	○	×	○
	Dimensional Control	○	×	○	×

○: Excellent △: Okay ×: Poor —: Not applicable

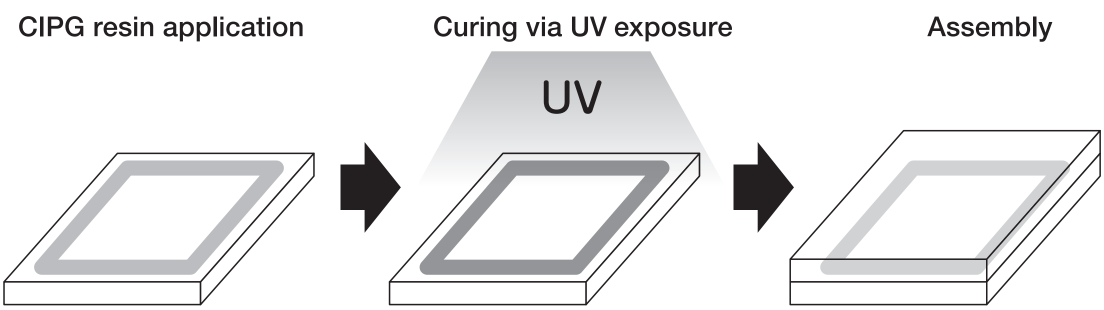


Fig. 2 UV-CIPG Formation

With moisture-cured silicone FIPG, a liquid sealant is applied to the flange surface then assembled with the workpiece while uncured. To cure sealant takes time after assembling.

Solid gaskets are formed as required by the workpiece in advance.

Although every method has advantages and disadvantages, UV-CIPG demonstrate considerable merit over other gaskets as follows.

1. Cured, formed and assembled in a short amount of time for fast-acting seal performance.
2. Automation possible.
3. Removal possible.

On the other hand, there are limits to the compression ratio which means precise dimensional control of components is required.

3. Circumstances Leading to Ultra-Soft UV-CIPG Development

For conventional TB UV-CIPG materials, the proper compression range was calculated from the view of the compression ratio versus both pressure resistance and compressive set, leading to a narrow range of 20 to 40% for the initial bead height. Because of this, a large dimensional difference in components and bead shape where the compression ratio deviated from the determined range, could lead to a high risk of sealing failure.

Additionally, recent years have seen a greater number of low-rigidity workpieces used in the interest of component weight reduction, so in conventional CIPG materials with a high modulus of elasticity there was also the issue that e compression deformed the workpiece, making it impossible to obtain the determined surface pressure, which in turn further increased the risk of sealing failure.

To improve these issues, a more flexible UV-CIPG material was required, which led to the launch of TB3166.

4. Recommended Flange Shape

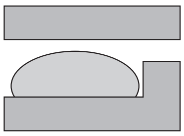
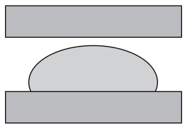
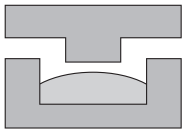
UV-CIPG demonstrates different sealing performance and durability depending on flange shape, so flange design was required to fit the application.

Table 2 shows the suitability of UV-CIPG versus different flange shapes.

A single-wall flange is recommended for use with UV-CIPG.

In this formation, the wall comes in contact with the flange mating surface to enable a stable compression ratio. It also fills the role of protecting the CIPG beads from water, oil and dust. TB3166 is softer than conventional TB products, which means it enables greater dimensional and compression width control which expands the types of flange shapes that can be developed.

Table 2 UV-CIPG Compatibility vs Flange Shape

Flange	Shape	 Single-wall		 Flat		 Raised	
	Machinability	△		○		△	
	Coatability	○		○		△	
UV-CIPG Traits		TB3166	Conventional TB Product	TB3166	Conventional TB Product	TB3166	Conventional TB Product
Bead Dimensional Control		◎	○	◎	○	○	△
Compression Control Width		◎	○	○	△	◎	○
Pressure Resistance		○	◎	△	○	○	◎
Durability		◎	◎	◎	○	◎	○

◎: Outstanding ○: Excellent △: Somewhat poor

5. TB3166

5-1 Characteristics

TB3166 is a silicone-base non-solvent UV curing resin with characteristics as follows.

1. Cures quickly with UV light.
2. Very soft when cured.
3. Can be assembled assembled on workpieces with lower surface pressure and rigidity than conventional CIPG materials.
4. Usable with a wide range of compression ratios.
5. Demonstrates resistance to heat and cold that is particular to silicone.
6. Excellent chemical resistance.

5-2 Characteristics

Table 3 shows TB3166 uncured material properties.

You can see if TB3166 has been applied thanks to its blue color. Once it is cured, this blue color fades to a pale yellow.

5-3 Measurements

Table 4 shows TB3166 cured material properties.

TB3166 is softer with a lower storage elastic modulus than conventional TB products. It also boasts a very low curing contraction rate, so its dimensions are influenced very little when it is cured with UV light.

5-4 Compression Ratio and Surface Pressure

Figure 3 shows a comparison between a conventional TB product and TB3166 for measured surface pressure per compression ratio.

Table 3 TB3166 Characteristics

Features	Unit	Measured Value	Testing Method	Remark(s)
Appearance	—	Blue	3TS-2100-020	—
Viscosity	Pa·s	330	3TS-2F00-007	25°C Shear Velocity: 2.0 (2^{-1})
Structural Viscosity Rate	—	3.7	3TS-2F10-007	25°C Shear Velocity: 1.0 (s^{-1})/5.0 (s^{-1})
Specific gravity	—	1.01	3TS-2500-002	25°C

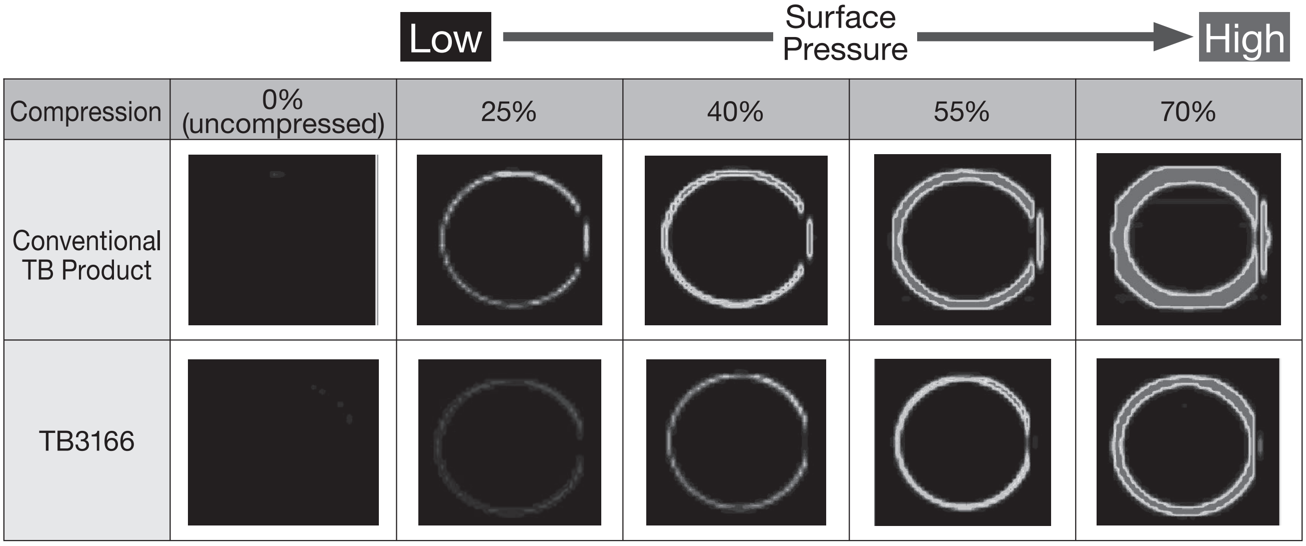
Table 4 TB3166 vs Conventional TB Product Cured Characteristics

Features	Unit	TB3166	Conventional TB Product	Testing Method	Remark(s)
Hardness	—	E15	E55(A27)	3TS-2B00-010	—
Tensile Strength	MPa	0.8	1.8	3TS-4190-001	No. 3 dumbbell
Elongation Rate	%	500	180	3TS-4190-001	No. 3 dumbbell
Thick film curing performance	mm	6.0	3.6	3TS-3160-001	—
Curing Contraction Rate	%	0.7	3.1	3TS-2600-001	ø32, 1.5g
Storage modulus (E')	Pa	5.6×10^5	2.1×10^6	3TS-4730-001	25°C
Elastic modulus (E")	°C	-52	-47		1 Hz, peak value
Loss tangent (tanδ)	°C	-40	-29		1 Hz, peak value
Compressive Set (CS) 120°C×72h	%	34	5.4	Bead height: 1.5mm Measurement equipment by Mitaka Kohki Non-contact 3-dimentional measurement equipment	20% contraction
		54	Bead separation		50% contraction
		60	Bead separation		80% contraction
Sufficient detachment strength 120°C×250h	MPa	0.16	—	*	PBT/aluminum 50% contraction

Curing conditions: Estimated light approx. 45kJ/m^2

*Testing Method:

1. Apply on 10×25×1.0 (thickness) mm surface area of PBT (Duranex 2002) then cure in UV.
2. Cover cross-wise with aluminum, insert the spacer to achieve a set thickness then leave for a set amount of time using a compression jig.
3. Once cooled to room temperature, conduct a 50mm/min. tensile (peeling) test and record the maximum intensity.



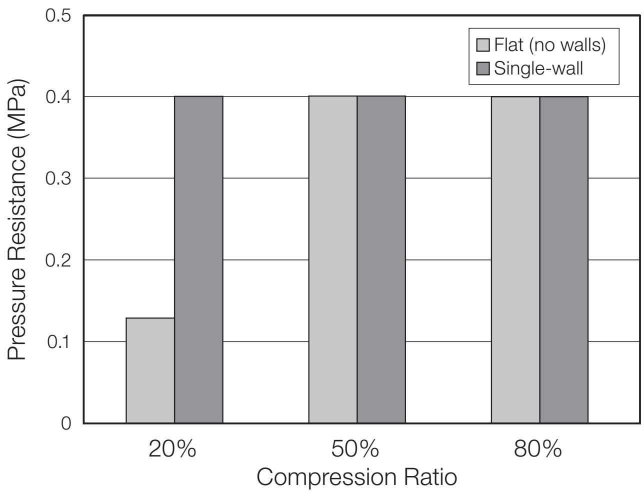
[Test conditions]
Bead height: 1.5mm; Surface pressure measurement device: NITTA Corporation I-SCAN;
Curing conditions: Estimated light approx. 45kJ/m^2

Fig. 3 Compression Ratio vs Surface Pressure

In conventional TB products, surface pressure increases at a compression ratio of 55% or more, but TB3166 maintains a ratio, even at 70%, and achieves compression on workpieces with very low rigidity.

5-5 Compression Ratio and Pressure Resistance

Figure 4 shows pressure compression ratio and pressure resistance vs flange shape.



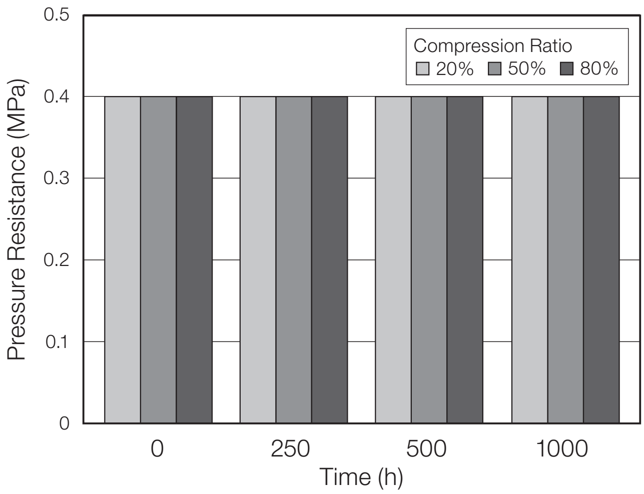
[Test conditions]
Bead height: 1.5mm
Flange shape: Flat, single-wall
Curing conditions: Estimated light approx. 45kJ/m^2
Pressure application: Air
Pressurizing conditions: Raised at 0.01MPa/15sec.
*Maximum pressure 0.4MPa

Fig. 4 Flange Shape vs Compression Ratio and Corresponding Pressure Resistance

The results indicate a change in pressure resistance depending on the presence or lack of a wall. In single-wall flanges, the wall suppresses pressurized sealant movement to improve sealability, even at a 20% compression ratio.

5-6 Pressure Resistance Post-Durability Test

Figure 5 shows pressure resistance after placement in a 120°C environment for a set period of time.



[Test conditions]
Bead height: 1.5mm
Flange shape: Single-wall
Curing conditions: Estimated light approx. 45kJ/m^2
Pressure application: Air
Pressurizing conditions: Raised at 0.01MPa/15sec.
*Maximum pressure 0.4MPa

Fig. 5 Compression Ratio and Pressure Resistance after Enduring 120°C

These measurements confirmed that TB3166 can seal 0.4 MPa pressure with 20 to 80% compression ratio after 120°C for 1000h.

These results indicate a usability of TB3166 in a wide range of compression ratios with excellent durability.

5-7 Post-Durability Test Rubber Characteristics

Figures 6, 7 and 8 indicate rubber characteristics after exposure to various conditions.

Although rubber characteristics tend to be a bit lower at 120°C, a sufficient level was maintained in all conditions.

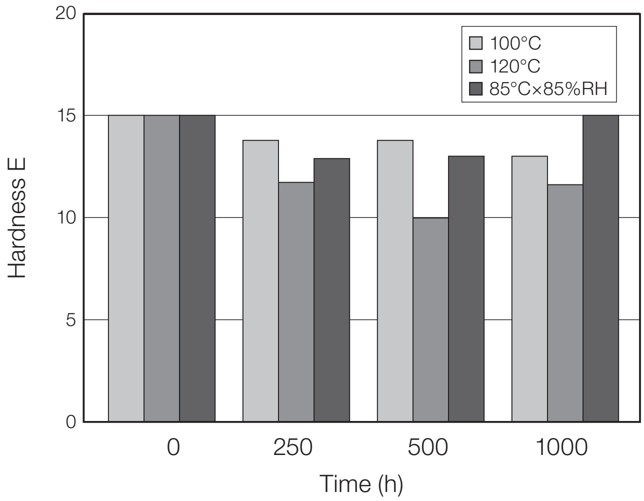


Fig. 6 Post-Durability Test Hardness

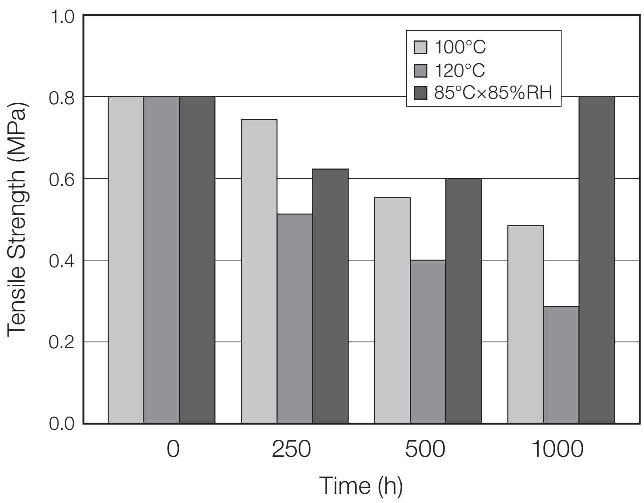
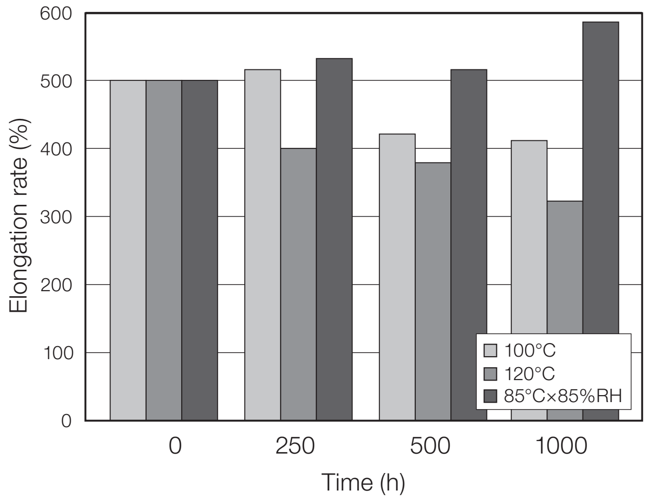


Fig. 7 Post Chemical Resistance Test Tensile Strength



[Test conditions]
Cured item: No. 3 dumbbell, 2mm thick
Curing conditions: Estimated light approx. 45kJ/m^2
Tension rate: 500mm/min

Fig. 8 Post-Durability Test Elongation Rate

5-8 Chemical Resistance

Figures 9 and 10 show rubber characteristics after immersion in different chemicals.

No deterioration was seen after immersion in various chemicals assumed for use within the transport market, indicated high chemical resistance. Conventional TB acrylic UV-CIPG contains ester in the molecular framework which tends to have low resistance to water-based chemicals (brake fluid, antifreeze). TB3166, however, does not contain ester in its molecular framework, so it demonstrates sufficient durability to water-based chemicals.

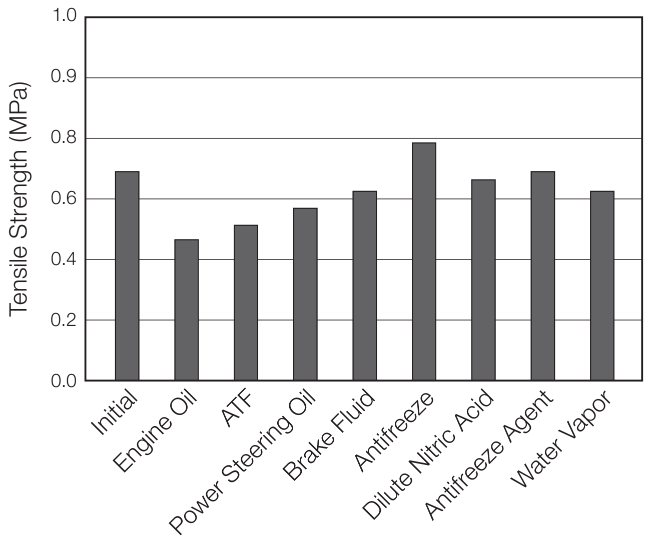
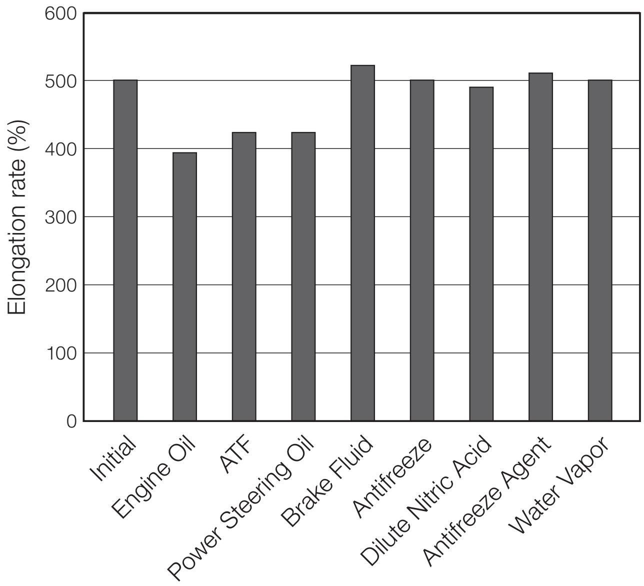


Fig. 9 Tensile Strength after Chemical Resistance Testing



[Test conditions]
Cured item: No. 3 dumbbell, 2mm thick
Curing conditions: Estimated light approx. 45kJ/m^2
Tension rate: 500mm/min
[Immersion conditions]
120°C×72hrs (Room temperature for dilute sulfuric acid only)
Chemicals: Engine oil, ATF, power steering oil, brake fluid, antifreeze (50wt%), dilute sulfuric acid (40wt%), antifreeze agent (50wt%), water vapor (120°C, 100% saturated, 2 pressure environments)

Fig. 10 Post-Chemical Resistance Test Elongation Rate

6. Applications Examples

Thanks to excellent durability and chemical resistance as mentioned above, it is usable as a water and dust-proof electrical part sealant in automobiles (Fig. 11).

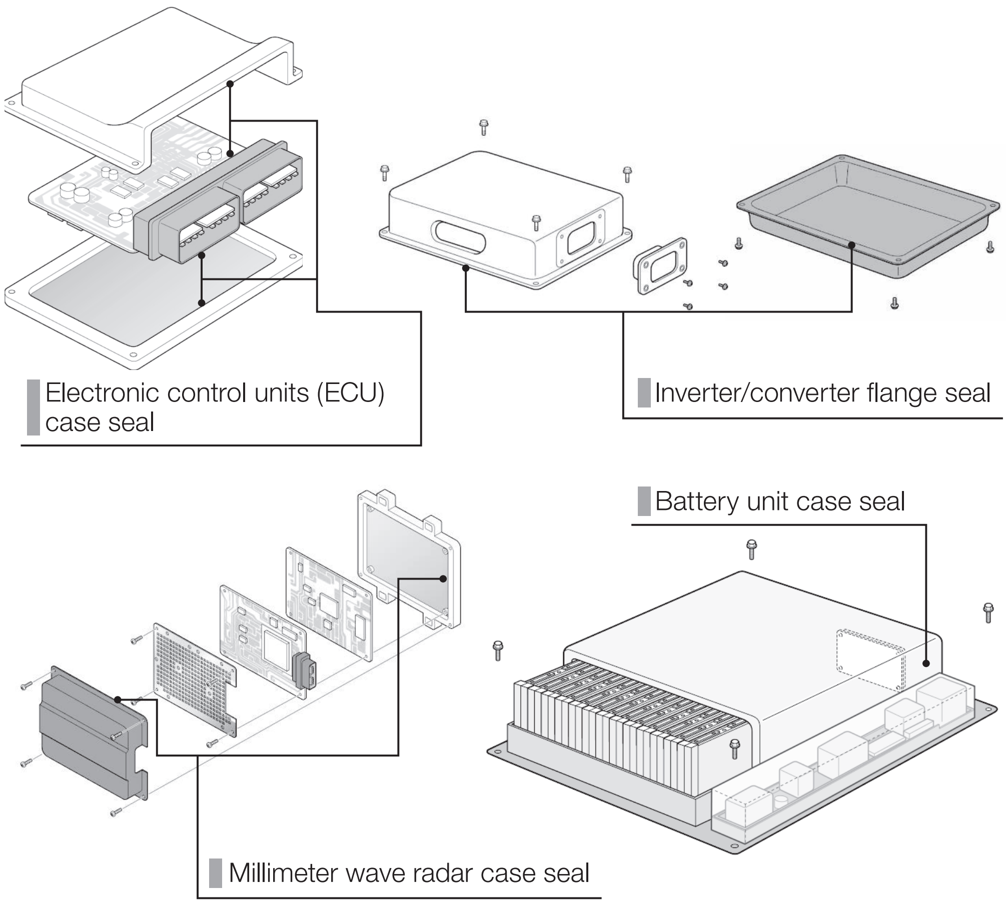


Fig. 11 TB3166 Applications

Closing

Here, we introduced an even softer material than conventional UV-CIPG to mitigate case dimension control width two times issue not good in these products. TB3166 demonstrates excellent durability and chemical resistance which will lead to future development for application in a wide range of markets.

We at ThreeBond will continue to focus our efforts on product and technology development in line with market trends in order to ensure the contribution our products make to the industry.

<References>

1) JIS B 0116

2) JIS K 6262 (ISO 815-1, ISO 815-2)

3) ThreeBond Technical News No. 72, 2009, ThreeBond

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