

# ThreeBond TECHNICAL NEWS

ThreeBond Technical News  
Published on January 1, 2009

72

## UV-Cured-In-Place Gasket

### Introduction

---

ThreeBond, founded with the mission to prevent leakage in industrial operation, has put liquid gaskets first on the Japanese market in 1955.

At present, FIPG (Formed-In-Place Gasket) method has been widely adopted with the use of automatic coating equipment in a wide range of markets of transportation, and electrical and electronic industries.

CIPG (Cured-In-Place Gasket) method, which is also used for liquid gaskets to be assembled and sealed after coating and curing, has both features of solid gaskets and FIPG method.

In this issue, we introduce outline of CIPG method and our products which have been developed for high performance.

### Contents

Introduction .....	1	5 Material Properties .....	4
1 Background .....	2	5-1 Curing Properties .....	4
2 Sealing Mechanism .....	2	5-2 Sealing Properties .....	5
3 Process Comparison between Methods .....	3	5-3 Durability .....	5
4 CIPG Evaluation .....	4	6 Precautions for Flange Design .....	7
4-1 Pressure Resistance .....	4	6-1 Flange Design .....	7
4-2 Compression Set .....	4	6-2 Example of Flange Design .....	7
		7 Applications .....	7
		Conclusion .....	8

## 1 Background

In JIS (Japanese Industrial Standard), a gasket is defined as “any of such objects that is used to prevent leakage from joint parts by inserting it between contact surfaces of pipes or equipment devices or by bolting or bolting or tightening it by other methods”, and it is used as shown in Figure 1.

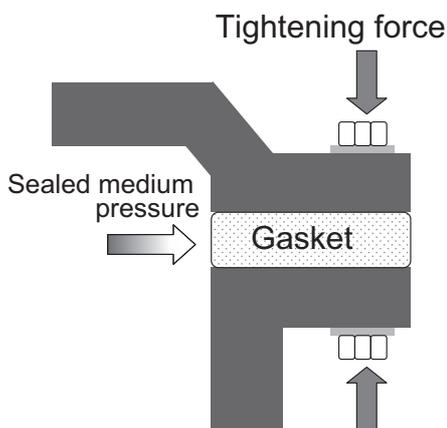


Figure 1. Basic sealing mechanism of gaskets

Gaskets are used in various markets like automobile, electric and electronic components, etc. and mediums to be sealed also vary from lubricant oil, working oil to water, dust, etc. Gaskets are broadly classified into two types by their properties: solid gaskets and liquid gaskets.

Conventionally, solid gaskets have been widely adopted to seal flange surfaces, but recently, liquid gaskets (FIPG method) have come to be used widely as the alternative sealing method to solid gaskets because of its ease of use. However, there remains the problem that it requires a large amount of time for complete curing when general moisture-curing FIPG materials are used.

In order to get stable sealing in a shorter time, CIPG method has been invented which coats liquid gaskets on flange surfaces and assemble it after curing.

Early CIPG materials were heat-curing type and required curing in a heating furnace. That meant a large size workpiece required longer time for curing process and heat resistant material accordingly, which prevented CIPG from practical use.

Then, we focused on UV curing and developed UV-curing CIPG materials (UV-CIPG) which can be cured in short time and don't give negative effect on heat sensitive components.

In this issue, we introduce UV-CIPG sealing method and material properties.

## 2 Sealing Mechanism

Sealing mechanism of gaskets can be broadly classified into compression seal and adhesive seal.

As shown in Figure 2, CIPG and solid gaskets prevent leakage with its own compressed reaction force which is generated by being tightened up.

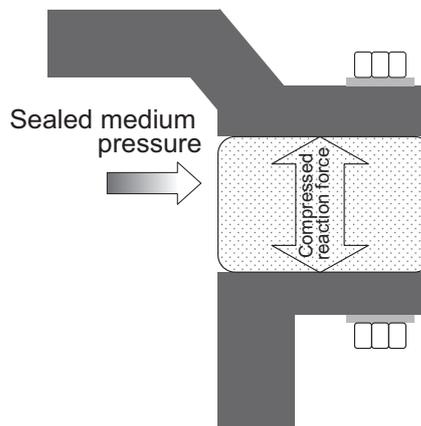


Figure 2. Sealing mechanism of CIPG and solid gaskets

On the other hand, FIPG is effective to fill uneven spots on contact surfaces as it is liquid. Also, as shown in Figure 3, it adheres to contact surfaces and prevents leakage with its own cohesive force which is generated after being cured.

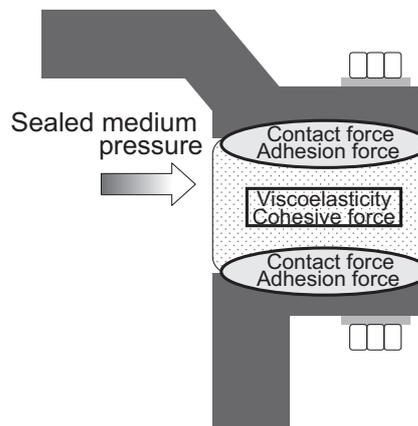


Figure 3. Sealing mechanism of FIPG

### 3 Process Comparison between Methods

Process comparison between methods is shown below.

Each method takes different processes according to its features.

In CIPG, the liquid sealant coated to flange surfaces is generally hardened by heating and assembled. UV-CIPG which we introduce now is UV-curing type and can be hardened by ultraviolet irradiation for several seconds or several tens of seconds. Figure 4 shows processes where UV-curing or heat-curing materials are used.

In FIPG, a workpiece is assembled before the liquid sealant coated to flange surfaces hardens. Curing time is necessary for hardening after assembly.

Solid gasket uses each pre-molded workpiece to insert and assemble.

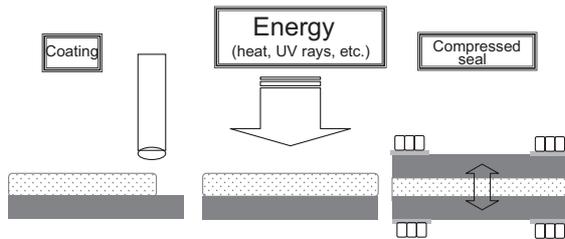


Figure 4. Image of CIPG processes

As described above, each method/process has advantages and disadvantages. Shown in Table 1 is comparison of other methods with UV-CIPG which we introduce this time.

Table 1. Comparison of each gasket method

		Liquid gaskets		Solid gaskets
		CIPG	FIPG	
Method		UV-curing	Moisture-curing	Molding
Sealing		Compressed seal	Both side seal	Compressed seal
Process Speed	Curing speed	○	△	●
Line Configuration	Automation	○	○	△
	Administration	○	○	△
Design Flexibility	Shape change	○	○	△
	Removability	○	△	●

Each item evaluated based on UV-CIPG performance as standard:

●: Excellent ○: Equal △: Fair

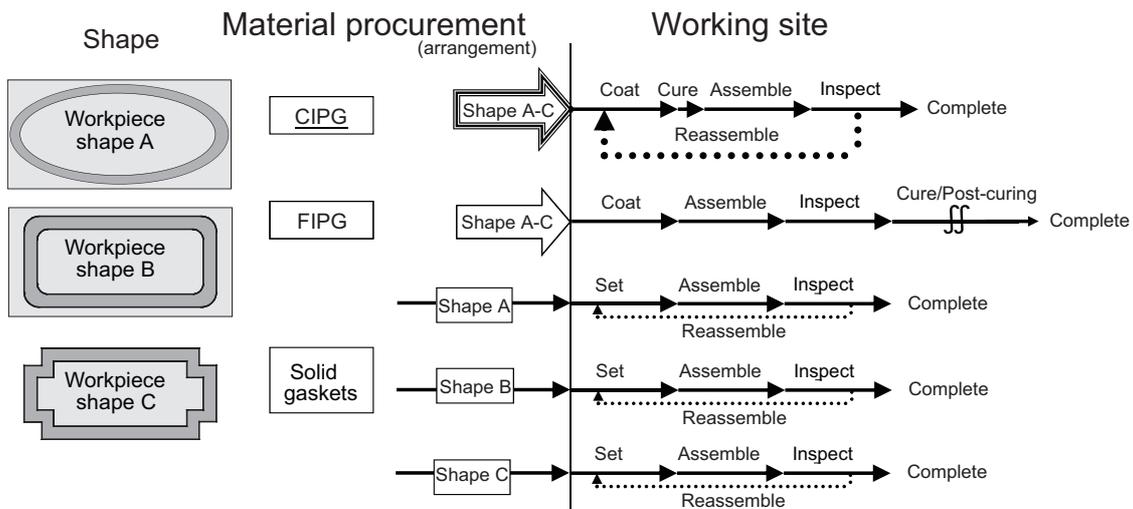
Advantages of UV-CIPG over solid gaskets are:

- Labor cost can be saved by automation
- Flexibly to handle workpiece shape change
- No inventory required for each workpiece

Advantages over FIPG are:

- Shorter curing time by UV
- Easy to remove (workpiece can be reused)

Figure 5 illustrates processes from material procurement to assembly completion of each gasket method. This indicates that UV-CIPG process is the shortest. This results from easy material procurement and short working site processes.



Note: ... indicates that a workpiece can be reassembled when it was rejected by inspection.

Figure 5. Process time for each gasket method

## 4 CIPG Evaluation

How to evaluate CIPG is described below.

### 4-1 Pressure Resistance

Pressure resistance is checked using model flange shown in Figure 6.

Compression rate was controlled by a spacer and maximum pressure was set to 0.4MPa.

Other conditions are as follows.

Model flange:

Flange outside diameter: 70mm

Flange inside diameter: 56mm

Flange width: 7mm

Pressure media: Air

Pressure rising condition: Pressure increased by 0.01MPa/15sec



Figure 6. Flange for pressure resistance test

### 4-2 Compression Set

Compression set is to evaluate distortion of gasket after durability test. The larger the value, the larger the distortion of gasket, and it means keeping sealing performance becomes difficult.

To evaluate, set a test piece in a test jig as shown in Figure 7, and tighten up using a spacer to keep stable compression rate, then perform durability test under a given condition. Compression set is calculated from the thickness of the test piece before and after durability test using following equation.

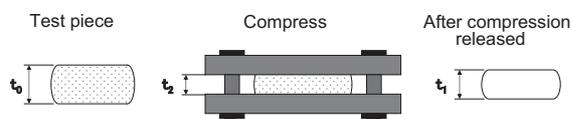


Figure 7. Evaluation method of compression set

$$Cs = (t_0 - t_1) / (t_0 - t_2) \times 100$$

Cs: Compression Set [%],

$t_0$ : Original thickness of test piece [mm]

$t_1$ : Thickness of test piece after compression test [mm]

$t_2$ : Thickness of spacer [mm]  
(JIS K6262 compliant)

## 5 Material Properties

ThreeBond3081J (hereinafter TB3081J) is described below, which was developed for UV-CIPG. Also, characteristics required for UV-CIPG are described.

### 5-1 Curing Properties

Reaction mechanisms for CIPG materials are UV-curing, heat-curing, room temperature-curing, etc., and UV-curing is appropriate for fast-curing.

For complete curing, moisture-curing takes several days, heat-curing takes several tens of minutes, but UV-curing takes only several seconds or several tens of seconds. UV-curing is faster than others.

Reaction mechanism of ultraviolet-curing is shown in Figure 8.

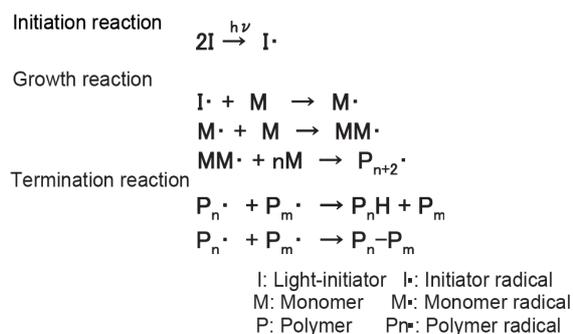


Figure 8. Reaction mechanism of radical polymerization

By irradiating UV, active radical is generated and radical polymerization is initiated.

Figure 9 and 10 show evaluation results regarding requisite energy (integrated light intensity) for curing TB3081J.

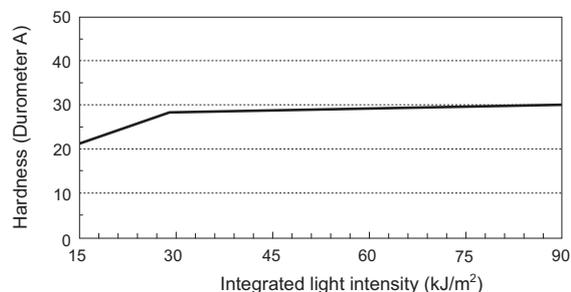


Figure 9. Relationship between integrated light intensity and hardness

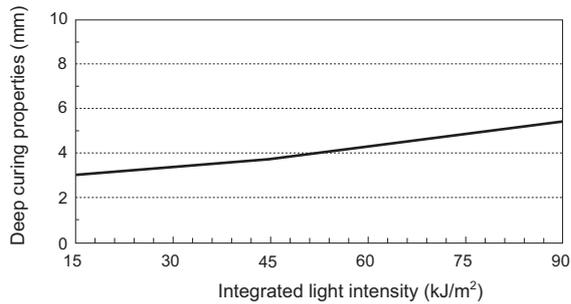


Figure 10. Relationship between integrated light intensity and deep curing properties

As shown in Figure 9 and 10, stable characteristics can be seen when integrated light intensity is approximately 45kJ/m<sup>2</sup> or more, and deep curing properties enough for CIPG usage are retained.

### 5-2 Sealing Properties

TB3081J provides requisite sealing performance with its compressed reaction force generated by tightening.

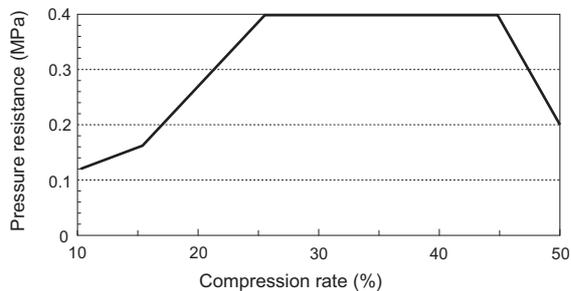


Figure 11. Relationship between compression rate and pressure resistance

Since pressure resistance of TB3081J rises in proportion to compression rate (as shown in Figure 11), compression rate can be set within a range where necessary pressure resistance is obtained for the product.

However, as you can see that pressure resistance declines at 50% compression rate, it is important to use within a range where TB3081J gets no crack nor significant creep.

As shown in Figure 12, compression range of TB3081J can be set by the evaluation of compression set for each compression rate.

Compression set is good when compression rate is within 20 - 40% range, and it is recommended to use TB3081J in this range.

Note: However, appropriate compression range

differs depending on workpiece shapes or other conditions.

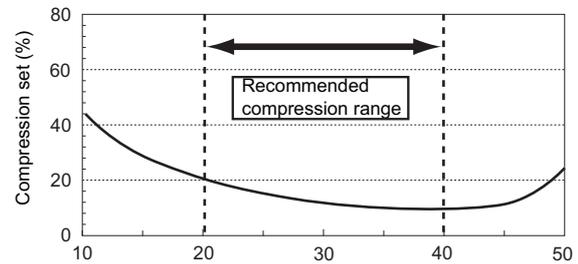


Figure 12. Relationship between compression rate and compression set 120°C × 72h

### 5-3 Durability

It is important that UV-CIPG materials should not show any significant changes (heat resistance, moisture resistance, cold resistance) in the environment used.

Followings are durability evaluation results in assumed usage environment.

[Test contents]

- (1) Compression set (25% compression)
- (2) Rubber properties (hardness, elongation, tensile strength)

[Curing condition]

Integrated light intensity: 45kJ/m<sup>2</sup>

[Durability test condition]

- (1) High temperature (120°C)
- (2) High temperature and humidity (85°C × 85%Rh)
- (3) Heat cycle test (-40°C × 30min      120°C × 30min)

TB3081J has excellent durability in compression set (Figure 13) and rubber properties (Figure 14~16) required for UV-CIPG materials under the test condition of high temperature, high temperature and high humidity, and heat cycle, showing no big changes.

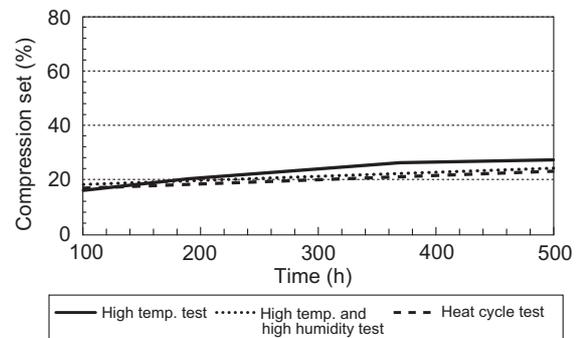


Figure 13. Durability of TB3081J - Compression set      Compression rate: 25%

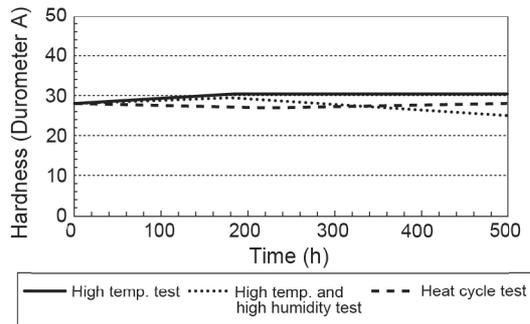


Figure 14. Durability of TB3081J - Hardness

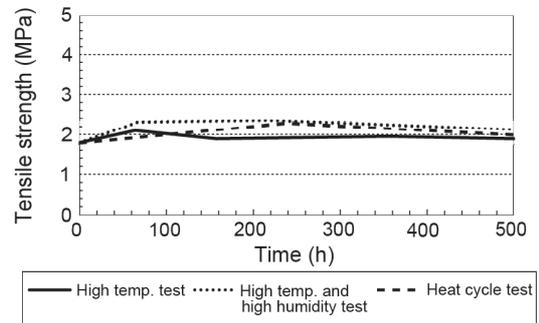


Figure 16. Durability of TB3081J - Tensile strength

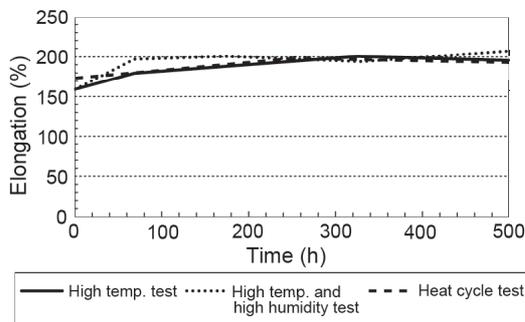


Figure 15. Durability of TB3081J – Elongation

Table 2 shows other characteristic values of TB3081J. Low glass transition point indicates that the product provides flexible rubber elasticity in a wide range of temperature.

These results prove that TB3081J has requisite characteristics as UV-CIPG: curing properties, sealing properties, durability, etc.

Table 2. Other physical properties of TB3081J

Item	Unit	Properties/Characteristics	Test Method	Remarks
Appearance	—	Pale yellow-clear	3TS-201-01	
Specific gravity	—	1.11	3TS-213-02	25°C
Viscosity	Pa · s	95	3TS-210-10	2.0s <sup>-1</sup> at 35°C
Hardness	—	A27	3TS-215-01	Durometer A
Elongation	%	180	3TS-320-01	
Tensile strength	MPa	1.8	3TS-320-01	
Thick film curing properties	mm	3.6	3TS-222-01	
Glass transition point	°C	-55	3TS-501-05	TMA method

Note: Curing condition: Integrated light intensity: 45kJ/m<sup>2</sup>

## 6 Precautions for Flange Design

For optimum usage of UV-CIPG which has characteristics previously described, flange design must be also taken into consideration.

### 6-1 Flange Design

Optimum flange shape for CIPG method is shown in Table 3.

In consideration of sealing properties and durability, one-sided wall shaped flange is recommended.

Table 3. CIPG applicability of flange shape

Flange shape	Name	CIPG durability	Effect on pressure resistance	Coating properties
	One-sided wall shape	◎	◎	◎
	Flat shape	△	○	◎
	Groove shape	×	×	×

◎: Excellent ○: Good △: Applicable ×: Inapplicable  
Note: Assumed that companion flange shape is flat shape

This structure can obtain stable compression rate since it contacts companion flange surface at the wall part, also it functions to protect CIPG bead from water, oil, dust, etc. Groove shape has potential to get CIPG bead cracking as it can't absorb inner stress.

### 6-2 Example of Flange Design

An example of flange design is introduced below describing a model how to set wall height and flange width using Figure 17.

CIPG bead height/width : 2mm/3mm  
Note: Syringe coating (using a nozzle)

As shown below, wall height is designed within a range where good durability and compression set are obtained (in this example, calculated with 30% compression rate).

Wall height  
= Height of 30% compressed CIPG bead height  
= 70% of CIPG bead height is wall height  
∴ =  $2.0 \times 70\% = 1.4\text{mm}$

For designing flange width, it is necessary to set a gap between CIPG bead and wall to prevent CIPG from touching wall when compressed.

Considering expansion of CIPG bead to sideways when compressed 30%, approximately 0.4mm gap for each side (Figure 17) is necessary, resulting as follows.

∴ Flange width =  $3.0 + (0.4 \times 2) = 3.8\text{mm}$  or larger

It is also necessary to consider size tolerance (such as bead/workpiece accuracy) to actually design wall height and flange width.

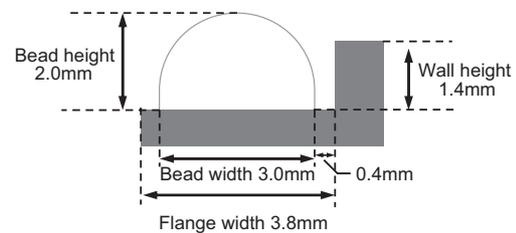


Figure 17. Example of flange dimensions

## 7 Applications

- Case seals of electrical components for vehicles
- Waterproof/dustproof seals for various electric/electronic parts

## Conclusion

CIPG method has both features of solid gaskets and FIPG method. UV-CIPG technology introduced herein has process benefit of fast curing and provides excellent material characteristics in wide temperature range, and it can be applied to various applications.

We expect further CIPG technology innovation by utilizing our sealing/coating expertise which has been accumulated through our long years' experience with FIPG, and we are sure to contribute to the development of industrial world as an attractive "partner" for customers.

## <References>

JIS B 0116

JIS K 6262

JIS K 6824

"ThreeBond Technical News No.42" 1994 ThreeBond

"ThreeBond Technical News No.44" 1995 ThreeBond

"ThreeBond Technical News No.60" 2003 ThreeBond

"ThreeBond Technical News No.69" 2007 ThreeBond

Kuniyuki Watanabe  
Masayuki Tanaka  
Transportation Market Department  
Product Development Division  
R&D Group  
ThreeBond Co., Ltd.

