Instant FIP Gaskets, Just Add Light

By Dr. John Arnold

ltraviolet-curing elastomers have been developed for form-in-place (FIP) gasket applications. A 0.25-inch thick bead completely cures in seconds upon exposure to UV light. Unlike traditional FIP gaskets, the instant cure feature of these gaskets makes them a drop in replacement for preformed gaskets. Simply dispense, UV cure and compress. The UV gasket is immediately

Instant cure eliminates labor costs and plant space devoted to shuffling in-process inventory associated with other FIP technologies. ready for testing or assembly. Total

automation becomes a reality, since the cure rate equals the dispensing rate. One-component chemistry makes automation even easier. Instant cure eliminates labor costs and plant space devoted to shuffling in-process inventory associated with other FIP technologies. Their low compression set and wide range of properties makes these UV-curing gaskets good candidates for many applications.

Comparison of cure times of new UV elastomer and

TABLE 1

other FIP gasket materials

FIP Gasket	Time to Skin Over	Time to Full Cure under ambient conditions
UV Acrylate	Seconds	Seconds
Air-Dry Silicone	Minutes to hours	Hours to days
2-part Urethane	Minutes to hours	Hours to days
UV Silicone	Seconds	Hours to days
Hot Melts	Seconds	Minutes

Introduction

Light-curing adhesives have been used in automotive, appliance, and electronic manufacturing for more than 20 years. Wherever light can reach the resin and the cured resin meets the performance requirements of the application, then the UV "cures in seconds" feature leads to their selection as the assembly or production method of choice. Using light to cure FIP gaskets is the latest utilization of UV productivity.

Cure time for the UV elastomers is shown in comparison to cure times of other form-in-place gaskets (Table 1). As shown in Table 1, UV-acrylate

gaskets are the fastest way to produce

a form-in-place gasket. Due to material cost and performance, traditional silicones and urethanes have been the most commonly used gasketing materials. Unfortunately, urethanes and silicones cure very slowly. No assembly or quality control (QC) testing can be performed until the gasket is fully cured; otherwise, the gasket will remain permanently deformed. Besides their slow cure, silicones can release corrosive byproducts during cure that can affect product durability of electrical circuits. Two-part urethane resins can be difficult to use because they are moisture sensitive, require exacting ratios and air-free mixing. UV silicones cure quickly on the surface (due to their cationic cure), but standard beads are too thick to completely cure with light; so additional heat or moisture cure mechanisms are needed to fully cure the silicone elastomer. Hot

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ing their consideration for small applications and most are not recommended for any thermal applications. **UV FIP Costs** The new UV elastomers are one

melts are very quick, but require a

substantial capital investment eliminat-

component and cure in seconds. The UV elastomers are made from several different acrylated chemistries, including urethanes and rubber elastomers. While slightly higher material cost compared to other liquid gaskets, instant UV elastomers offer dramatic reductions in processing costs. Because the UV FIP gasket process can be completely automated, poten-

tial benefits include: Significant reduction in labor costs. In-line assembly.

- Increased flexibility in both product design (for example, applying the
- gasket to the component side instead of the lid side without facing skyrocketing inventory costs) and process design. FIGURE 1

Elimination of complex and costly packaging designed to protect slower

elastomers that will be realized:

fixtures and jigs.

• Reduction or the elimination of

Additional benefits of the UV FIP

- curing gaskets from being perma-
- nently compressed during shipping. Immediate inspection of gasket compression and placement (and
- removal or process corrections if incorrect.) Reduction of scrap. Reduction of plant space.
- Reduction of inventory. Shortening just-in-time (JIT)
 - manufacturing and shipping cycles. All of these features not only lead to
- smoother and faster manufacturing, but also lead to significant cost

reductions. Figure 1 summarizes the cost benefits of complete UV cure versus other FIP methods. **Material Costs** As shown in Figure 1, while the material costs of UV FIP resins may be

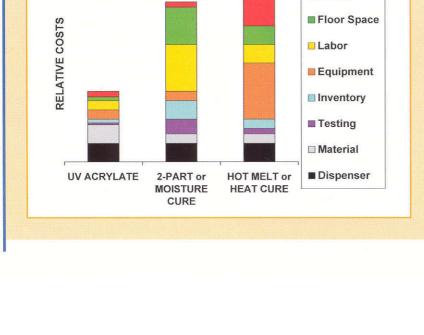
To properly cost a gasket, always first determine the weight or volume of resin that successfully seals the part. When comparing FIP materials, the cost per pound is very misleading. For example, silicone resins have a higher specific gravity than carbon resins, so it always takes more silicone by weight to seal the part. Some resins are so highly filled with inexpensive fillers that their specific gravity may be 2.5 instead of 1-1.1. Specific gravity is not the only material property tied to true resin price. With proper joint design and dispensing, a higher thixotropic (less slumping) resin forms a narrower bead with the same bead height as a lower thixotropic resin—narrower beads use less resin. Similarly, a resin that deflects easier may not need as tall a bead to seal the part. Finally, in cases where the gasket must be resealable, the resin with lower compression set will not require as tall a bead. Thus, the only way to cost a gasket is to first make a successful part and then weigh the gasket.

more than some FIP resins, the overall

costs of a UV process can be low.

Relative costs of UV acrylate FIP gaskets to other FIP gaskets





dispensing. The cost of good fixturing and precision dispensing makes the

FIP gaskets require precision

Dispensing and Equipment Costs

cost of all FIP dispensers nearly equal. Dispensing costs are largely dictated by the part more than the choice of resin. For example, a part requiring 3-axis dispensing versus single-plane dispensing will have the more expensive dispensing-fixturing system. Most dispensing systems have minor premiums for two-part dispensing, moisture sensitivity, and nonreactive material composition.

However, hot melt equipment requires a major premium. UV equipment is rather inexpensive relative to the cost of precision dispensing equipment. The added cost for UV equipment is likely to be less

which become a solid polymer or plastic upon exposure to the UV light. The possibility of instant QC allows manufacturers to avoid costly wastes due to unexpected variations in two-

component mixing or deviations in the

dispensed as 100% reactive resins,

than the cost of unproductive floor

space or the cost of in-process part

racks and certainly a fraction of the

The new FIP UV elastomers are

costs of automated racks.

Testing Costs

deviations in part tolerance. Instant QC means not having to scrap or rework a full day of production or having to retrieve in-process parts that were shipped to your customer and expected to cure in transit. Because no cure occurs before exposure to the light, there is the additional benefit that any mistake in the dispensing process can be detected and corrected by the removal of the uncured resin. Thus, costly and unnecessary scrap can be eliminated. **Inventory Costs**

Assuming no changes in a company's

in-process components. With an instant

cure UV process, only 2-5 parts are excess inventory. With a 1-2 day FIP process, this could mean hundreds to

dispensing system or unexpected

comfort zone with respect to shipping, receiving, and inventory procedures, the excess inventory cost is the cost of

tens of thousand parts in the excess inventory. The cost of that inventory is the sum of the material value of every component in the device, the labor that has been applied to the component, and the energy consumed in manufacturing the assembly to the FIP stage. If you are gasketing small plastic cases, the inventory costs might be small. If you are gasketing durable goods and electronic assemblies, then inventory costs are taking a significant bite out of your profits. FIGURE 3 Flanges Best

less labor than other technologies. UV operations eliminate production steps; for example, the labor associated with

Labor Costs

part shuffling. UV FIP elastomers are easy to automate. UV processes also use a much smaller footprint than other operations. The smaller footprint often allows one person to comfortably load and unload parts while keeping the process running. Floor Space Costs Floor space is costly. Ask anyone who has to build a new site to expand production. UV processes can expand production and fit into spaces that are too small for other FIP processes. Floor space contributes to the real costs of rent and mortgage. Floor space requires maintenance and

cleaning and consumes energy

(heating, cooling and lighting.)

No other FIP process has a smaller

footprint than a UV FIP process. The

UV process with dispensing, curing,

and assembling can be inserted in a

Labor costs are inversely related to

the degree of automation and directly

related to number of parts in process.

Historically, UV applications require

FIGURE 2 O-rings and FIP gaskets work best with different **O-ring or Precut**

Gasket

acrylates allows conveyor speeds of 1-25 ft/min on conveyors fitted with moderate (200 mW/cm²) to high intensity (2,000 mW/cm²) UV lamps. Parts coming off a line at 1-25 ft/min are good assembly rates.

With its small footprint and high

productivity, a UV process can

(which is the same for all FIP resins.)

The cure speed of these new UV

multiply the equation of how many dollars of product can be produced per-square-foot of factory. Flange Designs Suitable for **Using UV FIP Elastomer Gaskets** Figure 2 demonstrates why FIP gaskets should not be dispensed into

walls limit the cross-sectional expansion of a FIP gasket when it is compressed. This is also a wasteful use of resin, since most of the resin is filling the channel instead of sealing the joint.

Deep, narrow grooves have nothing to

do with sealing. Deep, narrow grooves

grooves designed for o-rings. Groove

keep the o-ring from falling out of joint. Don't do this with **FIP Gaskets**

No expansion space.

Expands into open space In time, stressed FIP when compressed gasket will cut & leak

Summary In depth research and marketing trials over several years have resulted Flanges and shallow grooves are recommended in the commercialization of many UV mating part interfaces for FIP applications. FIP elastomer gaskets. Successful applications exist within automotive, electronic and consumer products **Shallow Grooves** markets. UV technology enables manufacturers to replace labor intensive preformed gaskets with fully automated FIP gaskets. UV FIP

Since the FIP gasket adheres to the

Figure 3 demonstrates the proper joint design for form-in-place gaskets. Applying the FIP directly to a flange with no groove provides an excellent

substrate, the gasket does not need a

narrow groove to hold it in place.

seal with minimum resin use for most applications. Adding a shallow groove may improve the seal for applications involving pressure differentials or when sealing chemicals that are known to attack the gasket. Flanges are adequate for most

gaskets. Most gaskets only serve to compensate for deviations in part fit between the box and the lid. Most applications see neither a pressure differential nor an aggressive environment to seal. As with all form-in-place gaskets, UV FIP gaskets are best applied directly on a flange or as a tall thin bead in a shallow, wide channel.

Range of Properties of New UV FIP Products UV FIP elastomers are available in many product profiles. The viscosity of these products can range from thin wicking grades (500 cP) to nonflowing

gels (30,000-150,000 cP at 20 rpm).

Durometer hardness ranges from A10

most o-rings have a hardness of A60. Compression sets are available between 5% and 25%. Compression set is the percent rebound from a 25%

to A60. A10 is for high deflection

applications. A60 is needed for high

temperature sealing, since the gaskets

will soften when heated. For reference,

Rounded edge and

compression less than 25%

deflection after 16 hours at 70°C. Compression set is important for resealable and field serviceable gaskets. Instant UV FIP elastomers will have useful thermal ranges from -65° to 400°F (-55° to 200°C) or -40° to 300°F

 $(-40^{\circ} \text{ to } 150^{\circ}\text{C})$. The thermal range of these products is comparable to traditional urethanes and superior to most hot melts.

The gaskets exhibit good adhesion to a variety of metal and plastic substrates. solvent resistance. UV gaskets are

These gaskets have good moisture and available with different surface properties. They can be smooth for resealable applications or tacky for better sealing. These new gaskets have also worked well in applications requiring sound and vibration dampening. For example, FIP

resins have been used to isolate speaker

cone vibrations from the speaker

cabinet and to quiet machinery.

FIP gaskets.

gaskets offer many savings, process and design advantages over traditional —Dr. John Arnold is a principal investigator with Dymax

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production line in a space as little as 2 x 6 ft². High volume applications may increase the curing distance (from 2-6 feet.) High volume applications may also need room for resin storage