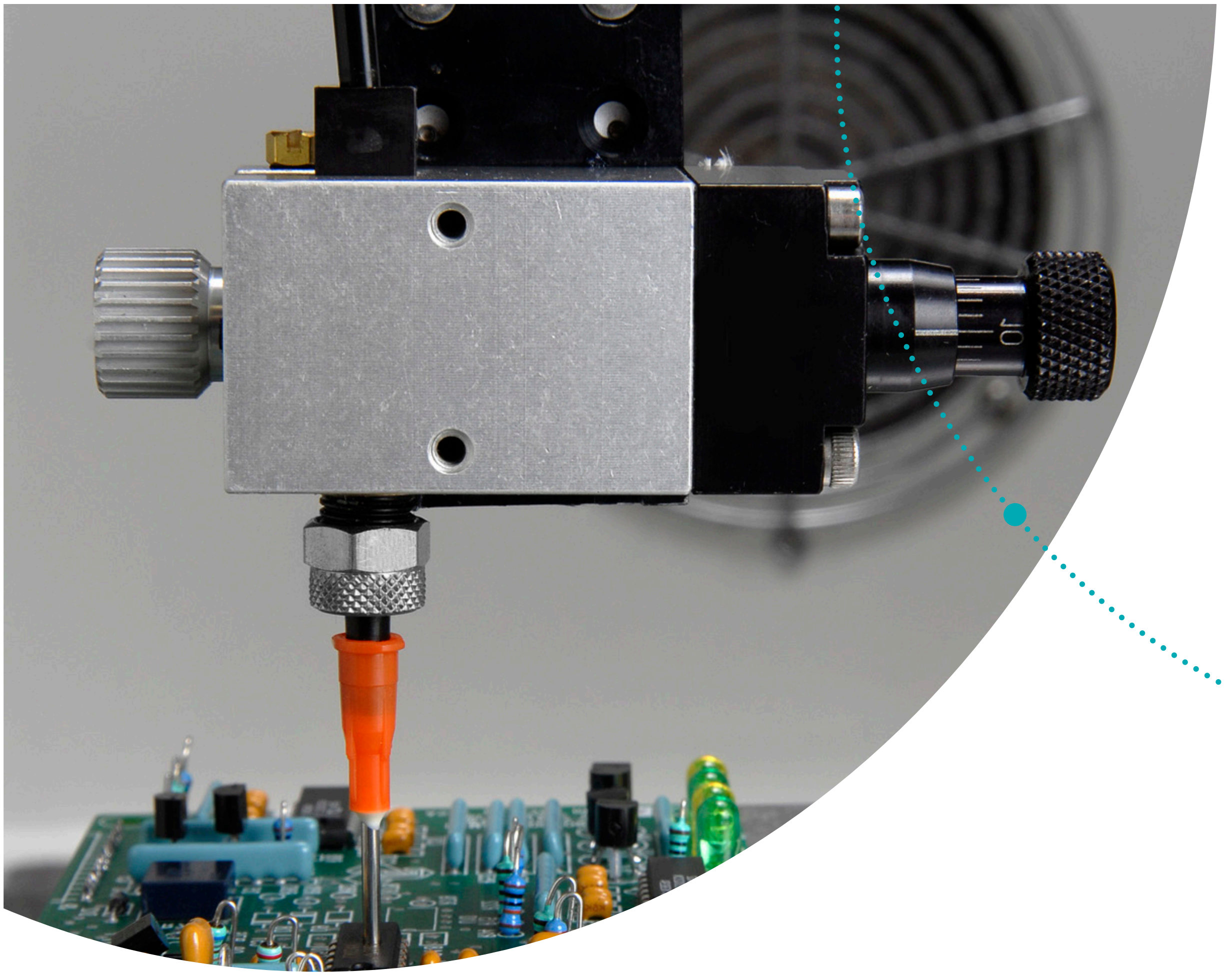

Dispensing Light-Curable Materials: Process Controls & Troubleshooting

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Light-curable adhesives rapidly bond glass, metal, and plastic by curing upon exposure to energy of the proper wavelength. Many factors can affect the controlled dispensing and processing of these materials. This article will discuss the following topics to help troubleshoot dispensing challenges:

- Substrate Compatibility
- Temperature and Viscosity
- Setting Up a Dispense System
- Syringe Dispensing Challenges
- Air Bubbles and Cavitation in Syringes, Cartridges and Pressure Pots
- Preventive Maintenance

Substrate Compatibility

Certain substrates are entirely compatible with light cure adhesives; others are not and can cause problems just by being present in the dispense process. For example, certain metals such as brass, aluminum, and cast iron react with adhesives and make them cure inside the dispensing equipment. Also, certain plastics and rubbers break down over time if used to dispense adhesives, eventually causing rupture of fluid lines.

In a dispense system for light-curable materials, all components must be impenetrable to both UV and visible light, including dispense tips and tubing. Any light that penetrates the dispense line can cause premature curing of the adhesive within the dispense equipment, resulting in blockages and downtime. Table 1 below compares materials that are typically compatible and incompatible with light-curable adhesives.

Table 1. Material Compatibility for Dispensing Light-Curable Materials

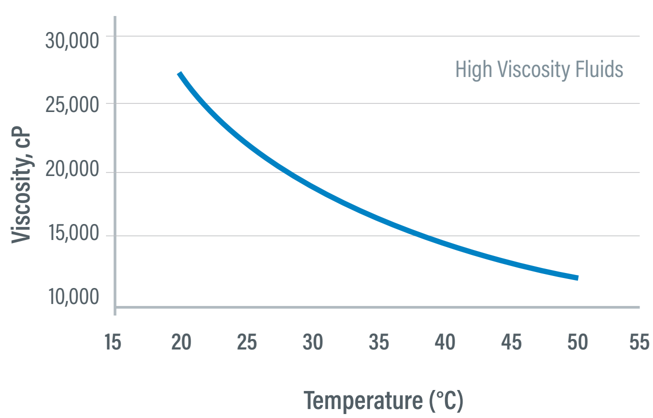
Compatible Materials	Incompatible Materials
Acetyls	Aluminum
Stainless Steel (300 Series)	Brass
Hard Chrome	Bronze
HDPE	Cast Iron
HDPP	Copper
Nylon (Pure)	Magnetic Stainless (400 Series)
Silicone	Steel
Teflon®	N-Butyl
Kalrez	Polyurethane
Aflas	Polycarbonate
Perlast	PVC
	Viton®

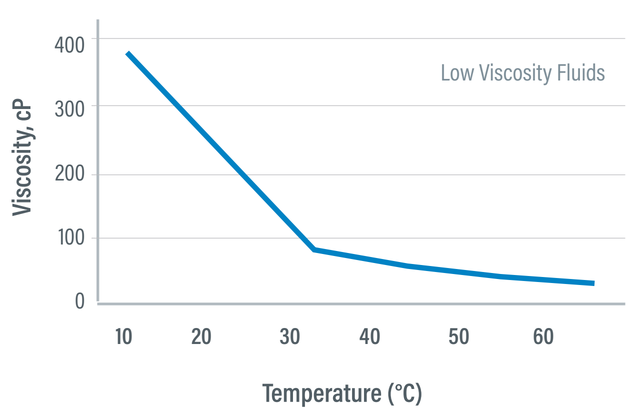
Temperature and Viscosity

For manufacturers with facilities in different countries, regions, and climates, temperature can dramatically affect the viscosity of an adhesive and its dispense requirements. Accepted room temperature can vary by climate zone and region.

Depending on general climate and seasonal differences, manufacturers should adjust their dispense pressure systems to accommodate changes in adhesive viscosity. Viscosity is a measure of a fluid's resistance to flow. As shown in Figure 1, low temperatures increase an adhesive's viscosity and decrease flow, while higher temperatures reduce viscosity and increase flow.

Figure 1. Temperature vs. Viscosity for High & Low Viscosity Materials





Setting Up a Dispense System

A typical adhesive dispense system features a number of components that serve different purposes. The first component is a container that holds the adhesive; this can be a syringe, a cartridge, or a larger reservoir such as a catridge or bottle drop-in reservoir or pressure pot. The container is paired with a controller and regulator that can be adjusted for time, volume, and pressure. An air compressor outfitted with a regulator helps move the adhesive through the system to the dispense tip, which applies the adhesive to the parts to be bonded. Some systems have the ability to provide vacuum, sometimes referred to as "suck-back", to draw fluid back from the tip to help control deposit accuracy and avoid dripping or drooling of material from the tip. The force to create suck-back is created by either an internal venturi vacuum generator or a mechanical displacement force within a valve.

Pressure-time dispensing applies air pressure to a liquid adhesive in a container. The pressure forces material through the system and ultimately to the dispense needle. By varying the duration of time that air pressure is applied, the manufacturer can control the volume dispensed: the longer the time, the greater the volume. Fine adjustments to the controller's time setting will alter deposit size. Input air from the compressor, sometimes called "shop air," needs to be dry and oil free to prevent the risk of adhesive contamination. Moisture (condensation within the compressed air system), oils (blow-by from the compressor), and stray particulate can contaminate the system, potentially causing clogs and/or irregularities or reactions with the adhesive. A filter and dryer are always recommended. High quality precision regulators, used to control fluid pressure, include a filter to eliminate potential contaminants.

Manufacturers can select from a wide variety of dispense tips to find the best tip for their specific application. Tips are typically made of stainless steel or plastic. When dispensing light-curable adhesives, plastic dispense tips must be impervious to all light so that the adhesive will not cure in the dispense equipment and create blockages. In certain cases, dispense tips may also be shielded from light to prevent premature cure.

Figure 2. Taper and Needle Dispensing Tips

The most common dispense tips used with light-curable adhesives are needle and tapered tips. Both are available in various lengths, guages, and shapes. To ensure precise application, the length, shape, and size of the tip will define the shape of the fluid deposit and the dispense performance. Smooth flow tapered tips provide less resistance to flow, shear, and backpressure. These are preferred in most cases. Needle tips allow for access into tight clearances and injection ports; however, they produce more shear force on the adhesive and increase resistance to flow. The backpressure created by this restriction can cause pressure buildup in the reservoir which results in dripping and drooling out of the tip as the pressure continues to escape. Needle tips are typically more compatible with lower viscosity fluids. Using the shortest tips and largest gauges acceptable for the application are recommended in order to reduce unnecessary flow resistance.

Syringe Dispensing Challenges

The quality of syringe components is critical to successful syringe dispensing. Defects in the molded barrels and plungers, or inconsistencies in dimensions or tolerances of components can result in inconsistent dispensing of material. Changes in fluid volume within the syringe barrel can alter deposit size – a factor commonly known as "full-to-empty" syndrome. As the fluid level drops, more pressure is required to push out the same volume of adhesive. With pressure being equal, deposit size will be larger when the syringe is full and smaller as it approaches empty. Smaller diameter syringes reduce the effect of "full-to-empty" syndrome. Syringe size will contribute to accuracy throughout the life of the syringe.

For example, as a 3 ml syringe nears 30% capacity, it will have 2 ml of head space above the piston. As a 30 ml syringe nears 30% capacity it will have gained 20 ml of head space above the piston. In high accuracy applications, this additional volume of air needed to effectively move the piston can cause enough variation that the 30 ml syringe is not suitable with the process; a smaller syringe in needed.

Air Bubble Formation and Cavitation

Air bubbles in the adhesive are often caused when excessive air pressure is applied through the dispense system to the syringe or cartridge. This air backs up past the piston and travels into the adhesive reservoir and causes bubbles. Excessive vacuum that pulls air into the syringe after a bead of adhesive is dispensed can also cause this problem. To prevent bubbles from materializing in syringes, a maximum air pressure of 60 psi should be used. Increasing the tip size and/or shortening the length of the tip can also help.

Ram pump systems can reduce air pressure of high-viscosity adhesives dispensed from cartridges. A ram pump helps move thixotropic materials through the system by using a follower plate to push the material down into the bottom of the pail. This prevents the material from getting stuck on the sides of the pail and a void being created around the opening of the feed tube if the material is too thick to flow and level on its own.

Figure 3. Ram Pump System

If the same type of thixotropic fluid were to be dispensed through a pressure pot, higher pressures would be needed to push the material down. This excess pressure can push air bubbles into the adhesive, or even past the adhesive, which would result in air reaching the valve. It can also cause cavitation, a condition where the adhesive is pushed to the sides of the pressure pot creating a cavity in the center.

It's also good practice to minimize fitting restrictions, such as elbows, along the fluid path from the pressure pot to the valve and to use the lowest air pressure needed to feed the valve sufficiently.

Preventive Maintenance

Manufacturers should regularly conduct the following preventive maintenance procedures on their adhesive dispensing systems:

Dispense Tips

- Replace dispense tips at the beginning of each shift.
- Shield dispense tips from any direct or reflected light.

Dispense Valves

- Rebuild dispense valves once a year or as recommended.
- For diaphragm valves, periodically replace the diaphragm to prevent leakage and control dispense volume.

Air and Fluid Tubing

- Inspect tubing weekly for evidence of fatigue, cuts, or swelling.
- Replace as needed per manufacturer's specifications.

Compressed Air Filters and Dryers

- Inspect weekly.
- Maintain per manufacturers specifications.
- Dirty, wet, or oily compressed air used to pressurize reservoirs will contaminate the adhesive and may cause erratic function or premature failure of dispense valves.

Cleaning Valves and Dispense Systems

- Use IPA to clean uncured material in valves and other wetted components.
- To flush a system, run compressed air through system followed by an IPA flush.
- To thoroughly clean valves, disassemble and clean with IPA.
- Replace fluid lines when changing adhesive formulations.
- Purge a dispense system when changing out syringes or cartridges or any other time that air is introduced or suspected to be in the system.

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