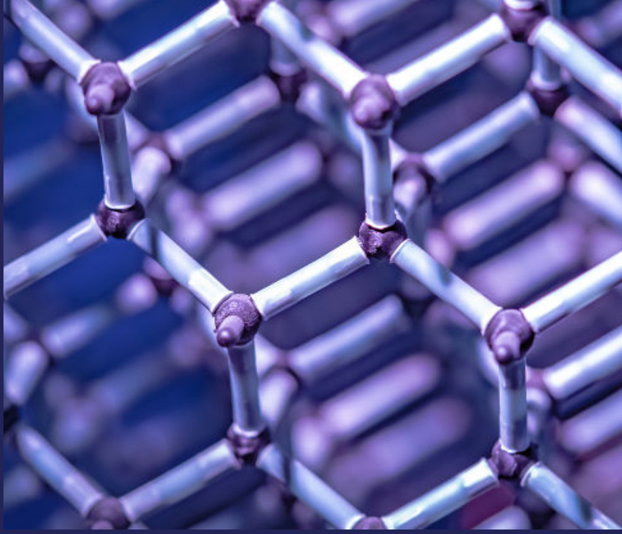
Managing the Effects of Temperature

Prepared by :
St. Clair Systems India, Pvt. Ltd.

Table of Contents

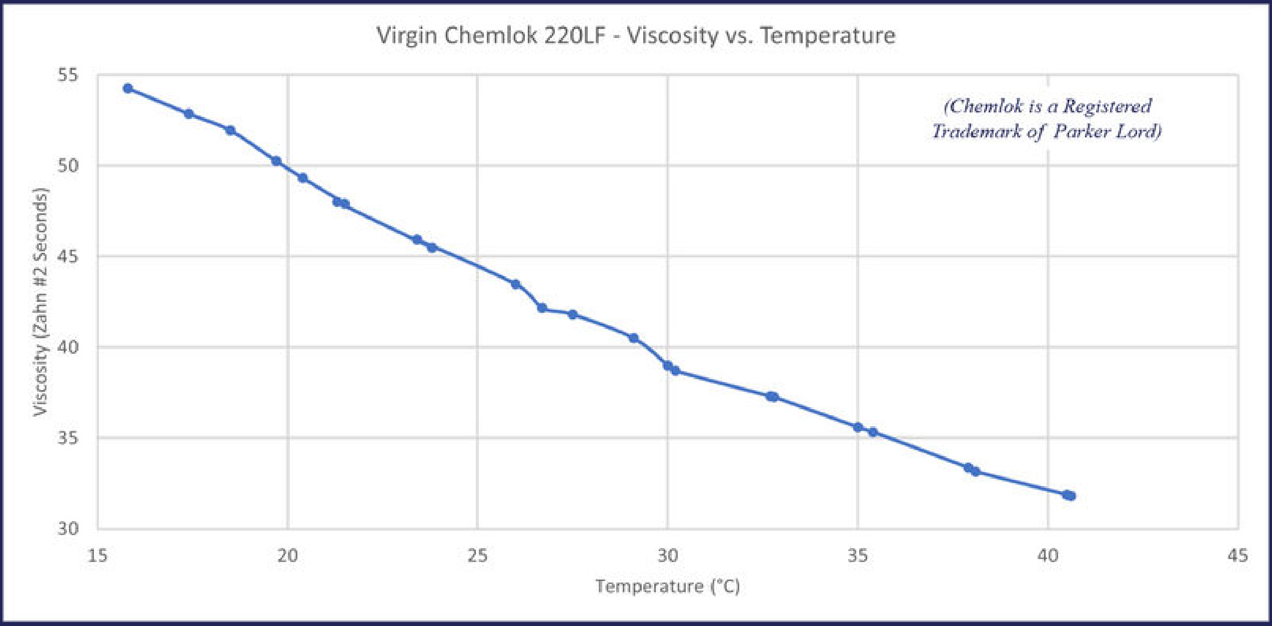


Definitions

Before we get into the details, we have provided a few definitions below:

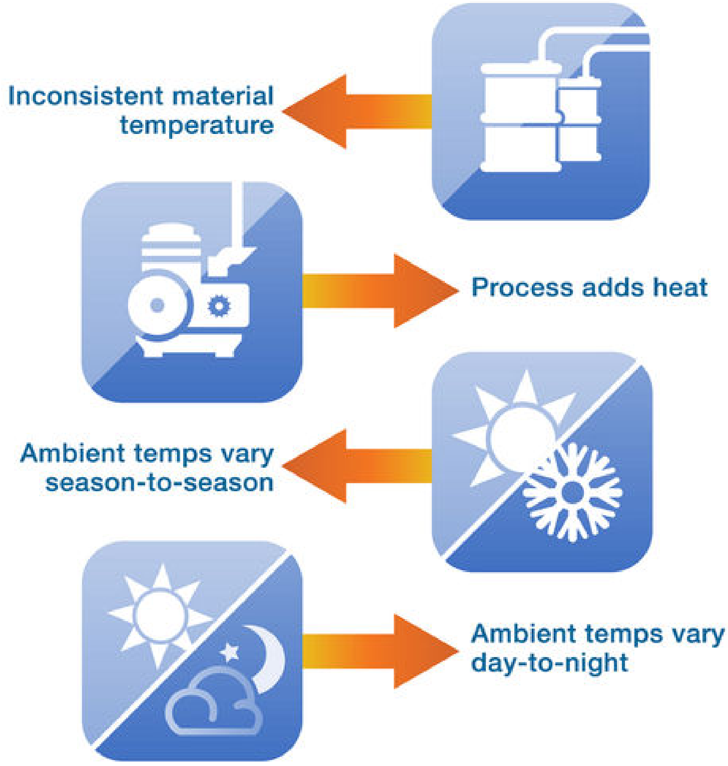
- **Viscosity** - A relatively simple explanation is “the property of resistance to flow in a fluid or semifluid.” Think of Honey in the refrigerator vs. Honey in the sun on a hot day. The change in how it flows represents viscosity change. This applies to virtually all modern industrial coatings.
- **Material Temperature** – For purposes of this document, we are referring to the temperature of the adhesive or bonding agent at the point of dispense. We are only concerned with the material temperature as it is being applied.
- **Ambient Temperature** – We use this term to describe the temperature of the manufacturing environment itself.
- **Flow rate** – This is the rate at which the material flows through the dispense nozzle.
- **Substrate** – The part to which the material is applied.
- **Spray pattern width** – This is the width of the material as it is being applied to the substrate.
- **Coating thickness** – This is the depth of the material, (measured from the substrate to the surface of the material), after the material has been applied.
- **Transfer efficiency** – This is the amount of coating solids that successfully adhere to the substrate divided by the total amount of coating solids that are dispensed during the spraying process.

Temperature vs. Viscosity Relationship



Above we see the viscosity-temperature curve for Parker Lord's Chemlok 220, a common solventborne bonding agent, as measured in St. Clair Systems India's Lab. It is the typical curve we are all familiar with, the **viscosity falling as the temperature increases.**

Temperature Change - Causes

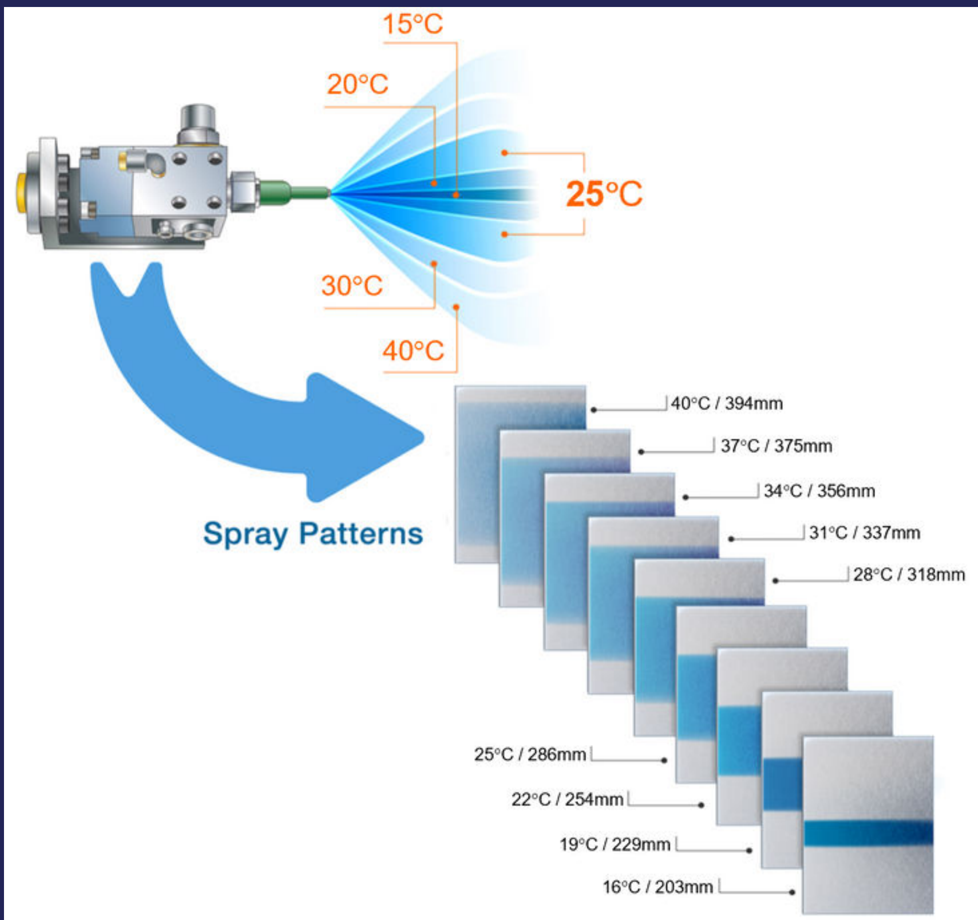


When working with material that has a steep temperature-viscosity curve, such as the Chemlok material shown earlier, material temperature stability is critical. Below is a partial list of the most common causes of temperature variation.

- Ambient Temperature
- Coating Storage Temperature
- Volume of Source Container
- Coating Flow Rate
- Recirculation Rate
- Recirculation Path
- Pressure Settings
- Pump Type / Horsepower
- Shear (Pumps, Agitators, Regulators, Nozzles, Fittings, etc.)

Temperature Change - Impact on Process

We are often asked why we focus on temperature. The answer is that temperature affects viscosity, which in turn affects flow, pressure drop, volume of the dispense, and mix ratio (in the case of 2K materials), but most of all – spray pattern.



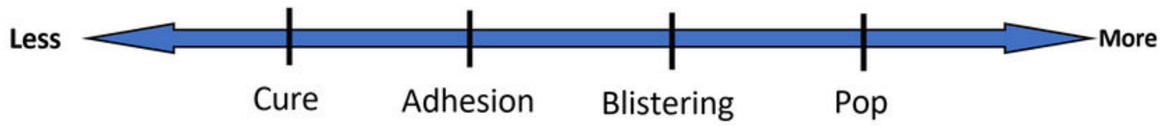
Here we can see how the spray pattern changes, with the width increasing proportional to the temperature. This phenomenon is caused by the change in viscosity. **So, when we talk about temperature, we are talking about viscosity.**

Temperature Change - Impact on Product

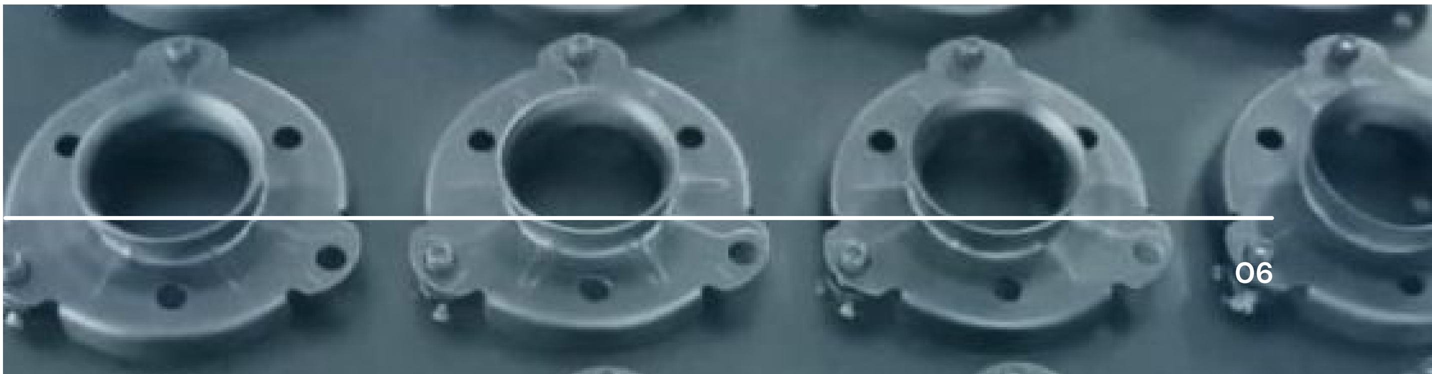
Solvent Issues

Viscosity changes with temperature. Managing viscosity with solvent creates its own set of problems.

Adding solvent alters the carefully developed coating formulation and managing those solvent additions creates many issues that impact the finished product. Add too little and the material does not flow properly affecting the spray pattern. Add too much and you can cause quality defects. We can plot those defects on a continuum as shown below.



Adding too much solvent often presents itself as an issue with curing. Adding more solvent can progress into problems with adhesion, blistering, and ultimately solvent pop. This is one reason that **managing viscosity with temperature is so much more effective than managing viscosity with solvent.**



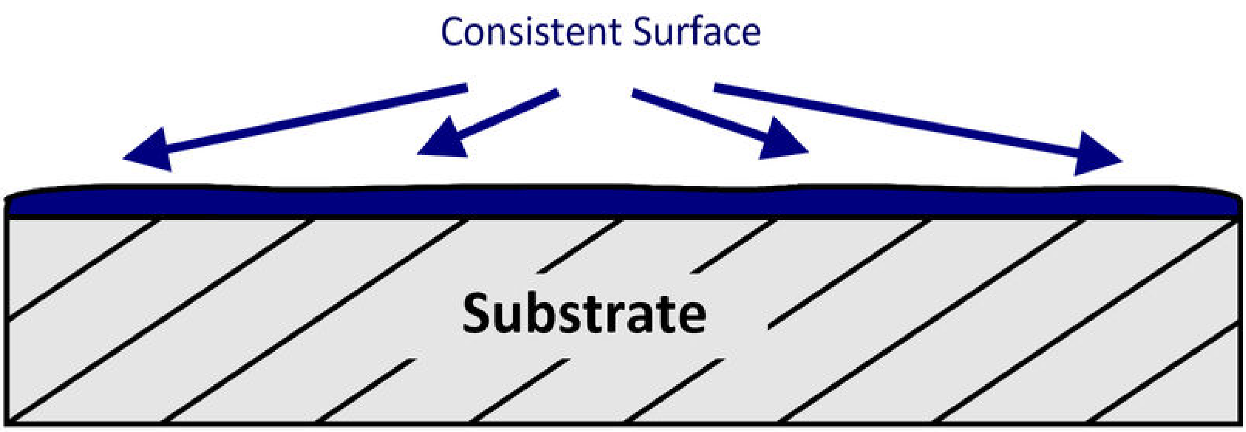
Temperature Change - Impact on Product

Film Formation

Temperature-induced changes in bonding agent and primer viscosity affect the film as it is formed.

To understand the effect of viscosity on film formation, it's important to start with the "Perfect Film".

If the viscosity can be controlled and the system set up such that atomization, deposition, and film build are even across the part, the cure will be even and the result significantly more predictable, as represented below. This more consistent surface will produce a better bond. Not only will the bond be stronger, but the layer will be stronger as well.

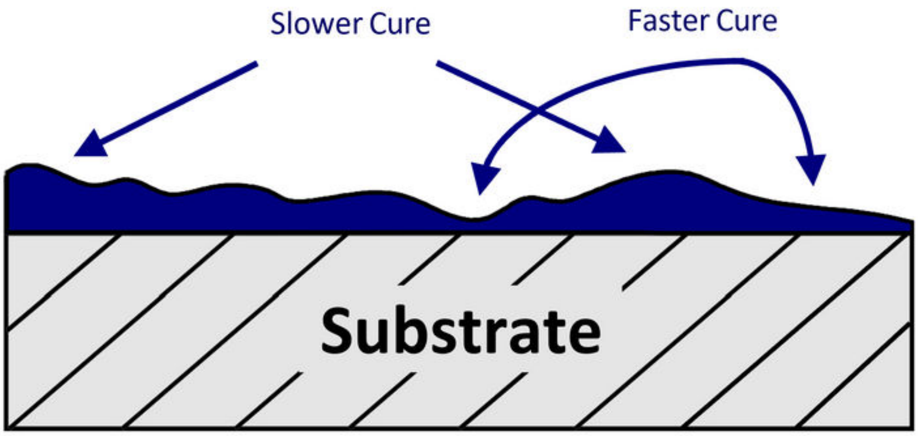


Temperature Change - Impact on Product

Film Formation

Temperature-induced changes in bonding agent and primer viscosity affect the film as it is formed.

The perfect film requires perfect conditions, which are not possible to maintain on a regular basis. If the fluid temperature is wrong, the change in viscosity will affect atomization, spray pattern, flow out, etc. This will result in an imperfect film across the part as shown below, where we can see thinner and thicker areas have formed. This will have a significant impact on film cure. The thinner areas will cure more rapidly than the thicker film areas.



This uneven surface will have a negative impact on bond performance and can also promote the creation of blisters caused by solvent entrapment under the cured surface of the coating. Additionally, if the thinner film areas are at or above the minimum film specification, the thicker film areas represent excess coating applied which increases the coating cost.

Temperature Change - Impact on Product

Failures & Dry Film Thickness Requirements

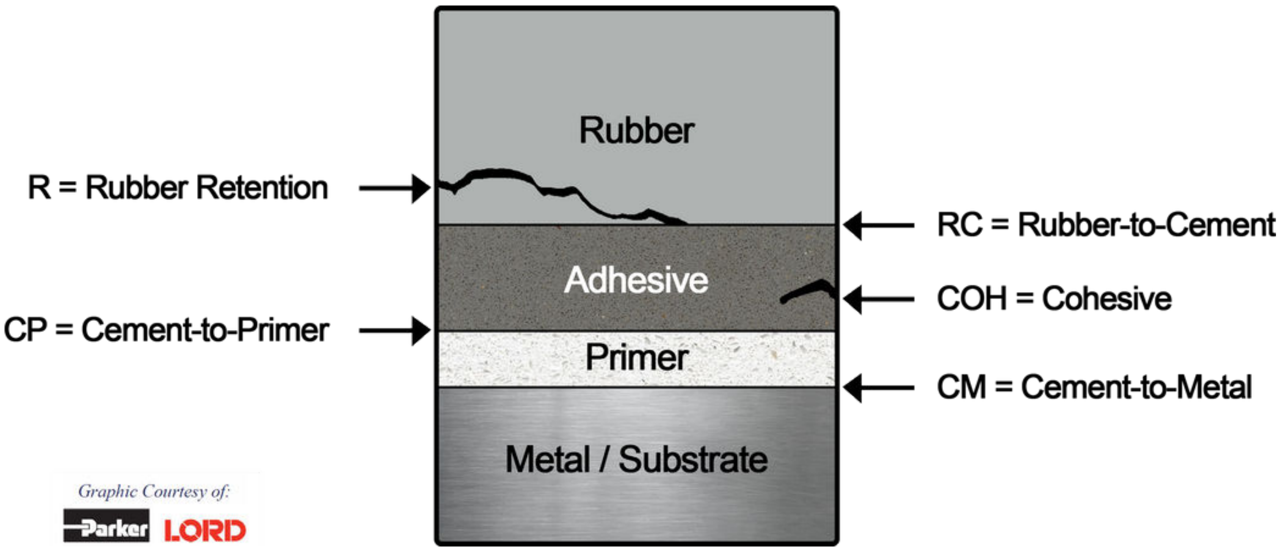
With regard to bonding agents and primers, imperfect film build contributes to common failures.

With regard to bonding agents and primers, imperfect film build contributes to common failures. These are broken into two categories: Interlayer and Intralayer.

Interlayer failures are the result of poor bonding between the substrate and the primer, the primer and the bonding agent, and the bonding agent and the rubber. These are commonly defined as:

CM – Cement to Metal
CP – Cement to Primer
RC – Rubber to Cement

Intralayer failures are usually the result of inadequate layer strength and are commonly referred to as Cohesion (COH) failures. These failures are demonstrated in the figure below, courtesy of Parker Lord.



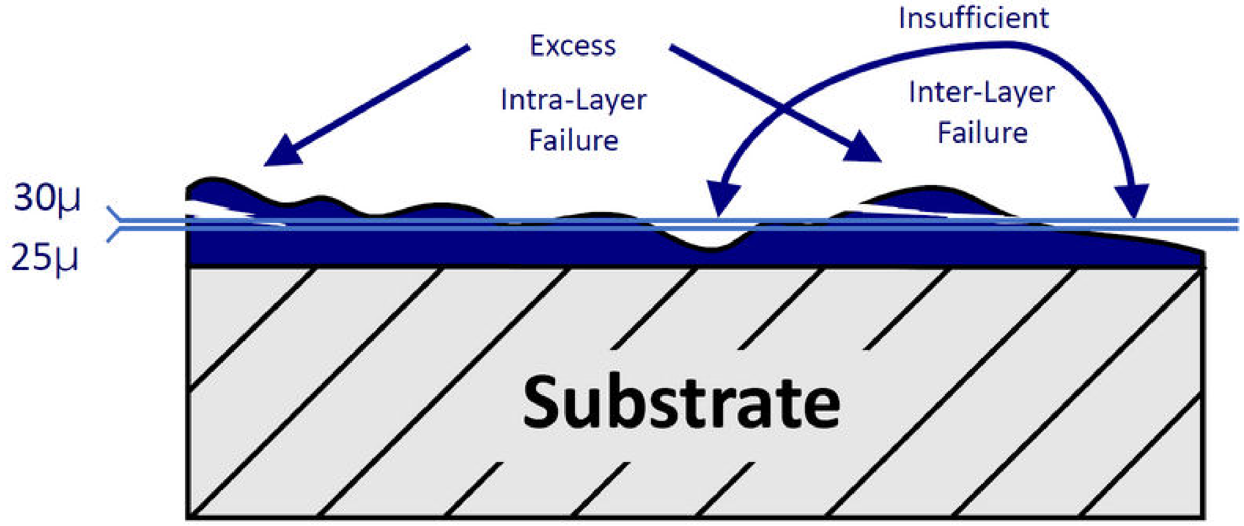
Temperature Change - Impact on Product

Failures & Dry Film Thickness Requirements

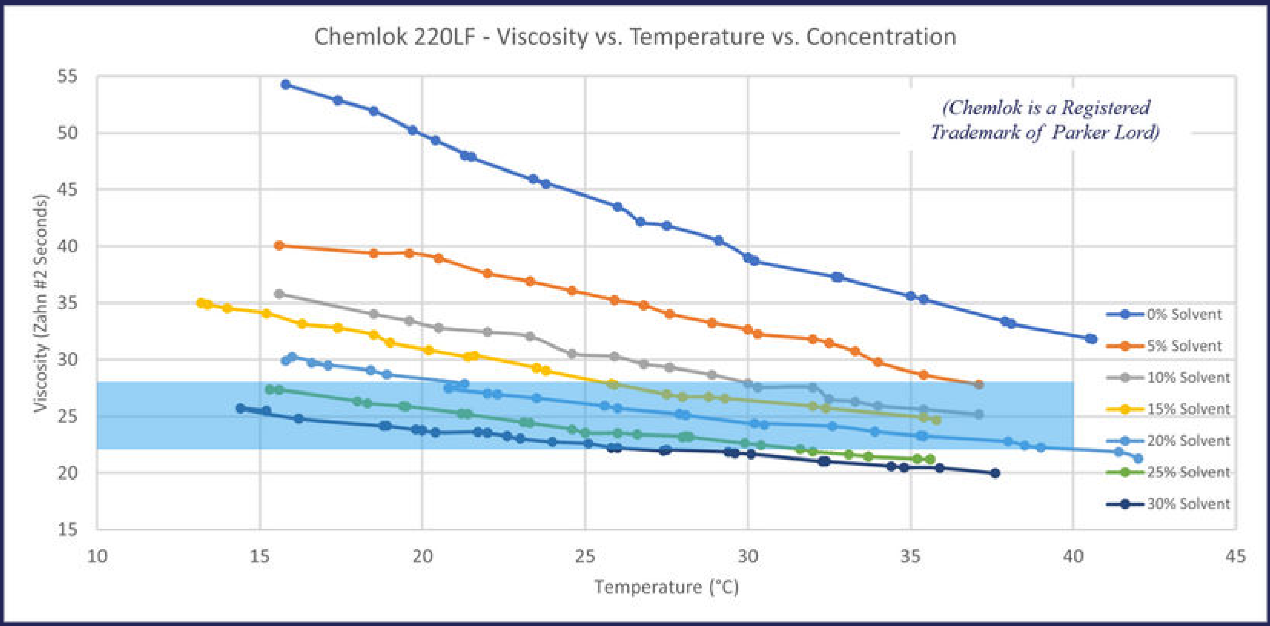
With regard to bonding agents and primers, imperfect film build contributes to common failures.

In general, these failure modes are related to the dry film thickness of the coating layer. Data provided by Parker Lord suggests that primer should be applied at a 5 – 10 micron DFT, whereas the topcoat or adhesive should be then applied at an 18 – 25 micron DFT, for a total dry film of 25 – 30 microns. For single coat applications, the dry film range should be 25 – 30 microns.

When the film build is uneven, it is common to have film thicknesses both above and below the recommended 25 – 30 microns range as demonstrated in the figure below. The areas with insufficient film will be more difficult to bond to and will be prone to interlayer failures. Conversely, the areas with excess film will be subject to intralayer (COH) failures because the excess thickness compromises the strength of the layer.



Temperature Variation and Solvent Usage

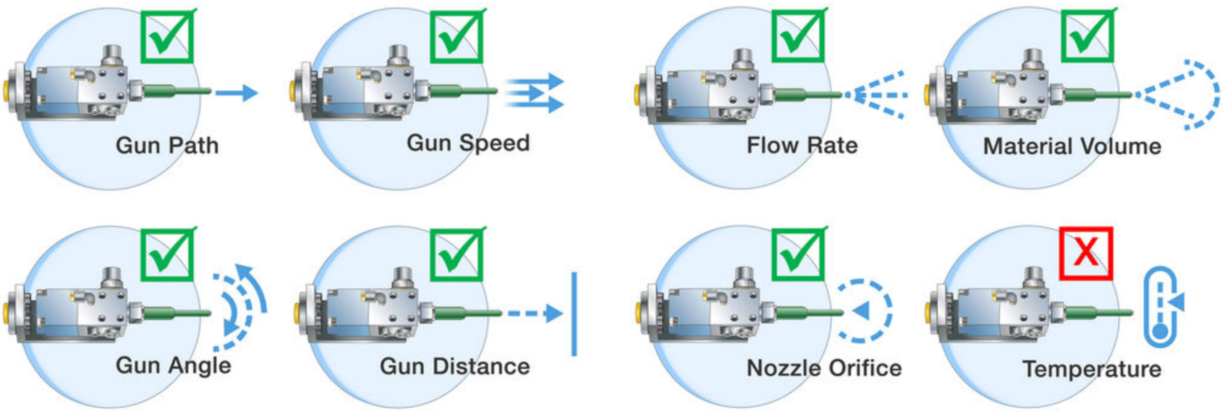


In the chart above, we see the viscosity-temperature curves for various dilutions of Parker Lord's Chemlok 220. Parker Lord's DS3105 data sheet recommends applying this coating at a viscosity of 22-28 seconds which indicates that you must dilute the material before spraying, (shaded in blue on the chart).

That same data sheet recommends diluting this coating with 25% - 50% xylene. If we project the recommended spray viscosity range of 22-28 seconds across these curves, we can see the importance of the interaction between dilution and temperature in the actual viscosity of the fluid. It is apparent that, depending on the temperature, **you can use dilutions as low as 5%, whereas dilutions of 25% - 30% (on the low end of the recommended range) can produce viscosities outside of the recommended range.** It also seems clear that dilutions greater than 30% will produce viscosities below the recommended range for spraying across nearly all temperature conditions.

Temperature Variation and Material Usage

Constants in a Typical Dispensing Process



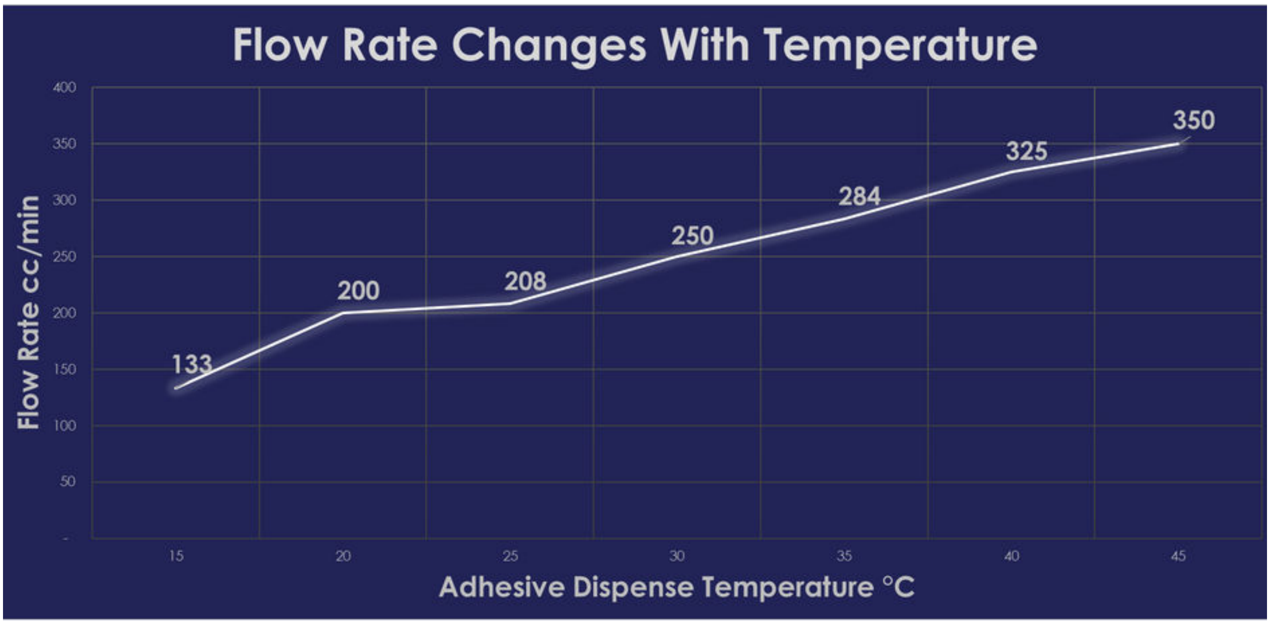
When preparing our process, we work very hard to make sure everything is set up for an ideal dispense. As the graphic above indicates, we make sure that we have controlled our flow rate, material volume, nozzle orifice, and everything associated with our dispense gun. When everything is ready, we start production.

But what about material temperature? More specifically, what about material temperature at the point of dispense?

As we have seen throughout this document, changes in material temperature can adversely affect your process and more importantly, your finished product. The next page highlights another hidden cost of varying temperatures: **Excess Material Usage**.

Temperature Variation and Material Usage

In our lab at St. Clair Systems India, we performed and recorded the results of several tests on the Chemlok 205 and 220 products. The experiment included holding stable the primary variables in dispensing, (i.e., everything on the previous page). **By changing only the material dispense temperature, we witnessed significant changes in the material flow rate.**



In the chart above, we see the flow rate-temperature curve for a 10% diluted Parker Lord's Chemlok 220. **Without constantly monitoring flow rate shifts, this process will see changes in spray pattern, coating thickness, and overall material consumption.** While this chart represents only 10% dilution, we saw the same relationship across a variety of dilutions from 0% to 50%.

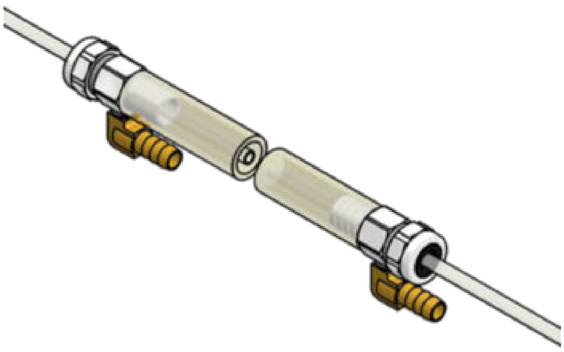
For a complete summary of all testing results and conclusions, please contact us using the contact information at the end of this document.

The Solution

Managing temperature variations and recovering the costs associated with them is easy. Below is a brief description of how we do it.

The foundation of the system is the Temperature Control Unit. Using Peltier technology, the unit senses material temperature and either adds or removes heat to ensure consistent material temperature. The unit is very small and can mount directly on the machine, or sit on a tabletop if necessary.

The system uses our patented coaxial hose to add to and remove heat from the material. Your material hose is surrounded by a second hose. That second hose recirculates fluid that is heated or cooled depending on feedback from the Temperature Control Unit.



The Temperature Control Panel can often be integrated with your existing controls. If separate controls are required, we use a simple control panel with an uncomplicated and intuitive Graphical User Interface. Startup is fast and easy.

Frequently Asked Questions

Below are answers to questions that we hear most often:

I use solvent to control viscosity. How can temperature control help me?

Because temperature impacts viscosity it is easy to show that properly applied temperature control can stabilize coating material viscosity and reduce the amount of solvent used. In addition, solvent-related curing defects such as poor adhesion, solvent pop, and blisters are all significantly reduced. There can also be significant reductions in energy usage and environmental impact when less solvent needs to be removed during the curing process.

How much volume does temperature control add to a system?

A properly designed and implemented temperature-control system will add very little volume, (often just milliliters), to the fluid delivery system.

Why does temperature affect my process?

All liquids change viscosity as a function of temperature. As the temperature of a liquid increases, the viscosity decreases. Likewise, as the temperature of a liquid decreases, the viscosity increases. Bonding materials are no exception. As a bonding material changes viscosity, its behavior in a dispensing system will change. This is generally compensated for by adding solvent to the material, (to reduce viscosity), or by changing system pressures.

I control the ambient temperature of my dispensing environment. Why do I need temperature control?

Though ambient temperature has a significant impact on material temperature, other factors internal to the application system such as pump pressure, friction, shear, etc., often combine to add more energy to the material being dispensed than does ambient. Furthermore, the effect of ambient is determined by multiple factors including (but certainly not limited to) the surface area exposed to ambient and whether or not those surfaces are insulated. All of our studies have shown that ambient-temperature control alone will not control material temperature at the point-of-dispense within an acceptable range.

Summary & Next Steps

1 The Hidden Costs of Temperature Variation

You are likely living with additional costs that you had not yet considered. As conditions change, your process changes. Those changes can create quality defects, cause you to waste material, and require you to use more solvent than necessary.

These excess costs are created by normal variations in your manufacturing process and typical changes in ambient temperature conditions. These variations are easy to control, and the excess production costs are simple to eliminate.

2 Simple Solutions Sourced in India

Saint Clair Systems, Inc., based in the United States, has installed more than 4,000 Process Temperature Control Solutions since 1990.

Summit Engineers and Consultants Pvt. Ltd., based in India, has manufactured and delivered more than 1,500 coating machines since 2005.

In 2021, the management teams from both companies joined to form St. Clair Systems, India Pvt. Ltd. This team is dedicated to providing western technology at Indian prices.

Our team is prepared to help determine whether our solutions are right for your process.

3 What You Can Do

If you would like to learn more on your own, you can visit us at www.stclairsystems.in or visit our parent website at www.viscosity.com.

Additionally, you can contact our Indian team directly. Contact information is available on the last page of this document.

Our team in India can discuss a variety of opportunities for you to evaluate our solutions.

Whether it is a phone consultation, a plant visit, or access to our demonstration units, you have several risk-free ways to help you decide.

Contact Us

D-18 MIDC Shiroli
Kolhapur – 416122
India

+91-7770003944

www.stclairsystems.in
indiasales@stclairsystems.in

St. Clair Systems India Pvt. Ltd.
Temperature & Viscosity Control