



PSTC[®]

PRESSURE SENSITIVE TAPE COUNCIL

A bond you can trust.

RELEASE LINERS: THE MOST IMPORTANT TRASH YOU'LL EVER BUY

Charles Sheeran
Technical Director
MPI Release
Winchester, MA



Charles “Chip” Sheeran is the Technical Director for MPI Release. He is responsible for MPI’s new product development for the release market, among other business areas. His experience also includes process engineering, quality control, and continuous product/process improvement. In addition, during his 20 years in the release liner industry he has been part in several technological and manufacturing expansions at MPI Release. A chemical engineer, he studied at University of Massachusetts at Lowell.

Release Liners: The Most Important Trash You'll Ever Buy

Charles G. Sheeran III, Technical Director, MPI Release

Abstract

If you've been in the pressure sensitive manufacturing business for even the shortest length of time, you have probably had this question asked of you in one form or another: "What do you make?"

This likely leads to a conversation on the details of what you make and how you make it, including some of the subtleties of what makes your product different.

In short, our products can be distilled down to one word...tape. But I think there is a better word for what we as an industry produce:

Performance.

We make and sell performance.

A lot of work is put in to finding the right adhesive and substrate for a given application. Release liners are often the last part of the total product design, a necessary evil required to ensure the adhesive is delivered to the end user. And unless it is a self-wound tape, the release liner usually finds its way to one final destination: the dumpster.

It may seem that thinking of our product as "trash" is downplaying the importance of release liners. But it is really quite the opposite. Sometimes a good product is at its best when the customer doesn't even notice it, and selection of the right release liner definitely falls under this category.

Like tape products, the release liner is a performance product, nuanced in its design. While there are many variables that can impact the performance of a release chemistry, this paper will focus on my list of the "Top Five" variables that can impact how your tape removes from the release liner:

1. Cure Type
2. Additives and Cross-linkers
3. Peel Speed
4. Aging Time
5. Aging Temperature

I will explore these variables using components that are typical in the tape industry to demonstrate how changes in the Top Five will impact the performance in a real world tape application.

In doing this I hope that you, the tape designer, come away with greater knowledge as to how release chemistries may interact with the adhesives you are working with, and how designing tests that accurately mimic your customer's process or end use conditions is critical to the long term success of your product...and your company.

A PRIMER ON SILICONE RELEASE

To better appreciate and digest all the implications of our Top Five, it is important to first have a working knowledge of the available options with silicone release liners on the market today.

Table 1 – Different Methods of Silicone Release Manufacture

Energy Cure				Thermal Cure					
Electron Beam (EB)		Ultraviolet (UV)		Solventless		Solvent		Emulsion	
Cationic	Free Radical	Cationic	Free Radical	Platinum Catalyst	Rhodium Catalyst	Platinum Catalyst	Tin Catalyst	Platinum Catalyst	Tin Catalyst

This is a broad set of variables to consider in selection of release chemistry, even before starting to consider the further subsets within the different categories listed: the individual components.

Table 2 – Components in Silicone Release Coatings

Component	Function
Base Polymer	Primary release component
CRA+ Polymer	Additive to increase release value
Cross-linker	Links polymer chains ¹
Catalyst	Initiates cross-linking reaction
Additives	Provide other characteristics

As one considers different cure methods, different catalyst types, and different components it becomes evident there are a lot of tools available with which to customize a product blend and subsequent performance.

SAMPLE PREPARATION

In order to generate data of value to a discussion of the Top Five, I started by establishing a uniform method of sample generation, outlined below.

1. Wet apply adhesive directly to release liner at a thickness to generate 2-mils dry adhesive
2. Air dry adhesive at room temperature for 10 minutes
3. Oven dry adhesive for 5 minutes at 200°F
4. Allow sample to cool on bench for 5 minutes
5. Apply face stock of 142g PET
6. Cut adhesive coated lamination into 1” strips for aging and testing
7. All peel tests were done at a peel angle of 180° peeling the face stock from the liner

I then set aside sets of samples were then set aside to age under different storage conditions and peeled them at various peel speeds.

¹ Thermal systems only. Also, this is the first (and possibly last) legitimate footnote.

Data reported in this paper represents an average of multiple test strips pulled for each test condition. All data is reported in grams per inch (g/inch).

For this paper, I selected two different solvent acrylic adhesives from two different manufacturers in the industry. They are both standard adhesives on the market for tape applications, and will be identified as TA-1 and TA-2 for the purposes of this paper.

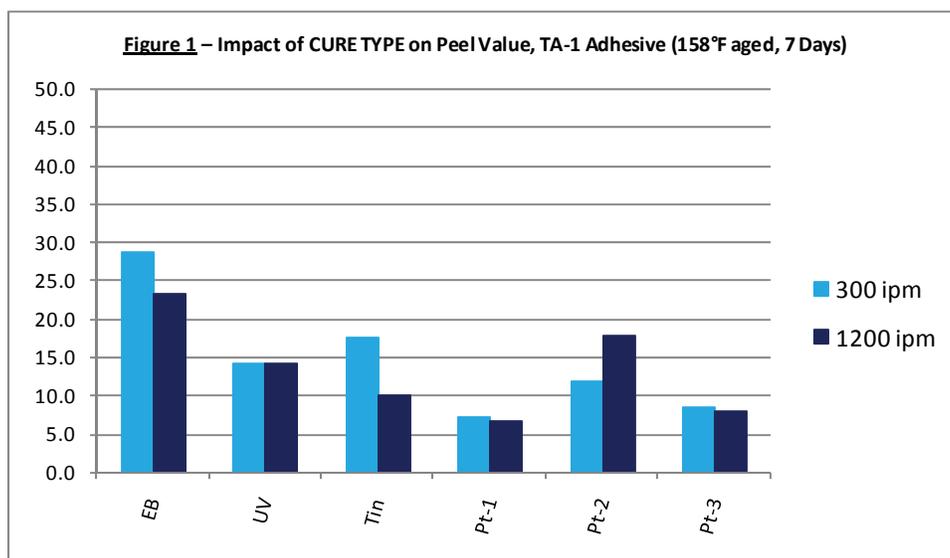
There were a lot of options to consider when selecting blends to compare. In order to keep the data pool from expanding too much, I limited the release blends to evaluate: EB Free Radical (EB), UV Free Radical (UV), Solvent Tin (Tin), and Solventless Platinum (Pt).

Now let's look at the TOP FIVE VARIABLES:

1. CURE TYPE

For the first comparison I looked at cure type and how that may impact release. As “easy” or “premium” release is a common request in the tape industry, the first analysis will focus on a comparison of a number of easy release blends I tested with both adhesives.

For this I opted to look at product aged at an elevated temperature for 7 days.²

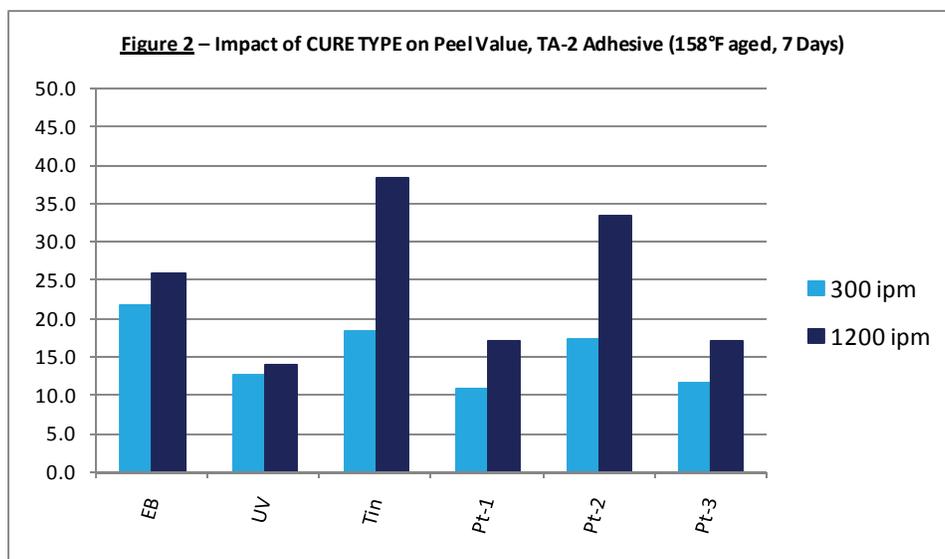


This graph suggests the following:

- EB is the tightest release cure type, which is consistent with generally accepted theory
- Platinum solventless blends have the lowest release, although the blend Pt-2 stands out as an anomaly compared to the other two Pt coatings

Next I'll look at the other adhesive to see if the behavior remained the same.

² It is commonly felt in the release industry that 7 days of heat aging at 158°F simulates between 6 to 12 months aging at room temperature (70°F), depending on the nature of the adhesive.



The behavior of adhesive TA-2 differs in two key ways from TA-1: The release of the Tin system jumps substantially with peel speed, as does the release on blend Pt-2. There is also a rise in the EB Release with peels speed with TA-2, where it drops with TA-1

I will explore the impact of peel speed on release value later in the paper, and will be revisiting this particular example.

It should be noted that with the two adhesives selected for this evaluation, the EB and UV free radical chemistries demonstrated good performance. However it should be stressed that free radical chemistries can tend to increase in release value as it ages.

KEY OBSERVATIONS

- When looking for a premium release product, use of EB and Tin are likely not the best candidates.
- Not all Platinum solventless blends behave the same, making it critical to understand how it works with your adhesive.
- Not all Premium release chemistries are built the same and can vary greatly by cure type and by peel speed.

How a premium release blend functions with your tape adhesive also becomes very important when developing differential tapes. This is another subject I will cover later in this paper.

2. ADDITIVES AND CROSSLINKERS

While understanding how cure type may impact performance is important, it can't be overlooked that the chemical nature of energy curable chemistries is different from thermal cured systems. So in a way, when selecting cure type, one is also selecting a certain set of components that will make up the blend.

CROSS-LINKERS

That said, I have observed that even though there are three different Pt solventless blends, they behave differently. In order to understand what is driving this, one must consider what components were used to make them.

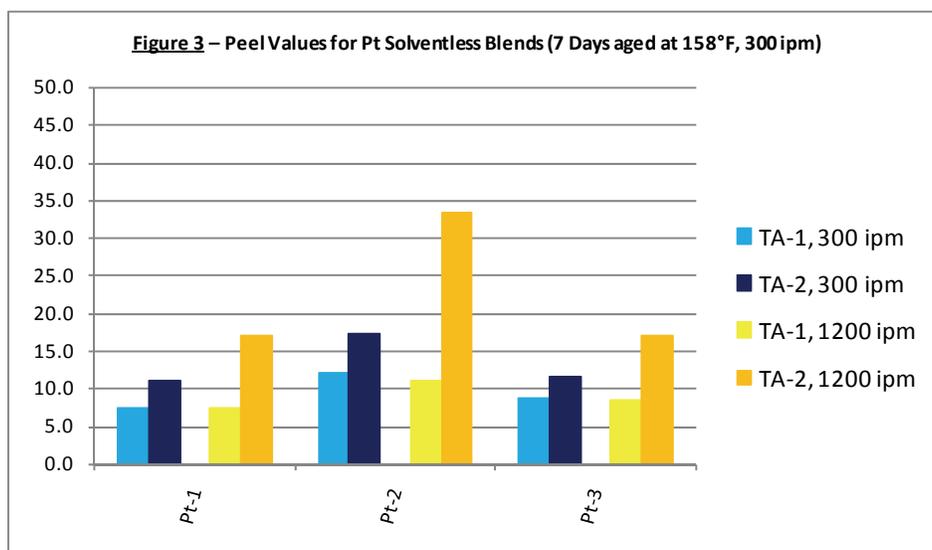
Table 3 – General Construction of Platinum Catalyzed Blends

Blend	Polymer	Cross Linker	Pt Loading	SiH:Vinyl Ratio
Pt-1	Polymer 1	Cross Linker 1	140 ppm	1.8
Pt-2	Polymer 1	Cross Linker 2	140 ppm	1.8
Pt-3	Polymer 2	Cross Linker 3	140 ppm	1.8

For these blend I set the Pt loading and SiH:Vinyl ratio as constants. The logic behind this was:

- A level of 140 ppm Pt would assure proper cure while minimizing any excess platinum that may cause further interaction with the adhesive
- An SiH:Vinyl ratio of 1.8 was selected to assure good cure and limit chemical interaction between the release chemistry and acrylic adhesives.

The graph below focuses in on some of the data gathered for the Pt solventless blends.



Without knowing what the blends are composed of, two statements can be made:

- Blends Pt-1 and Pt-3 are similar in performance
- Blend Pt-2 is noticeably tighter with both adhesive systems
- The data highlights the very different performance characteristics of the two adhesives

Referencing Table 3 the polymer system, platinum load, and SiH:Vinyl ratio for Pt-1 and Pt-2 are identical, while the cross-linker is varied between the two blends. This clearly suggests that the cross-linker is the driving factor for the tighter release demonstrated.

That said looking at this data one can see that despite greatly varied compositions, the peel values for Pt-1 and Pt-3 are very similar, suggesting that there are multiple paths to get to identical release values.

KEY OBSERVATIONS

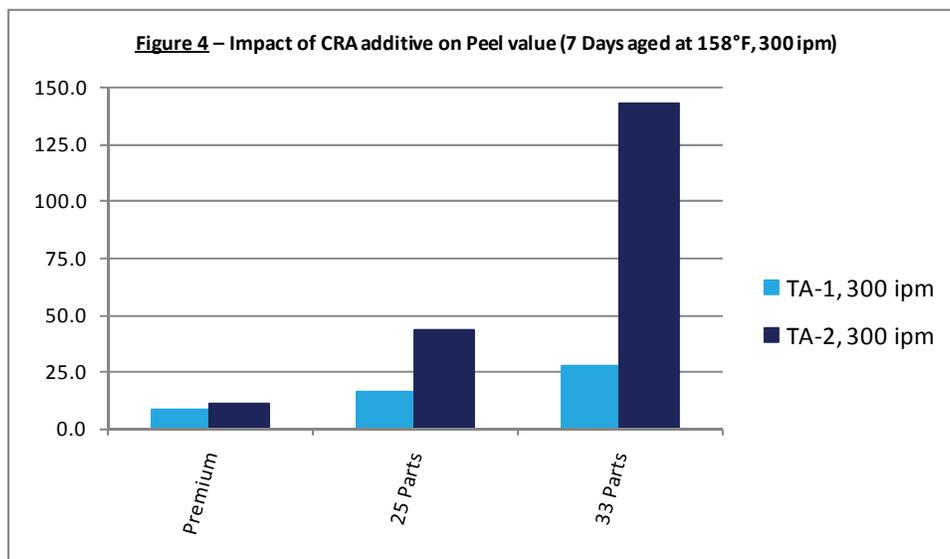
- Selection of cross-linkers in platinum solventless systems can play a major role in determining how your adhesive releases
- There is often more than one candidate out there to fit your needs

CONTROL RELEASE ADDITIVES

Next I'll take a closer look at the impact of adding a control release additive to one of these blends at various levels to see the response with the two adhesives. Using Pt-3 as our baseline chemistry, I generated data using two different blends, Pt-3-25 (25 parts) and Pt-3-33 (33 parts).

While control release additives may be used on their own to create single sided tapes, they are commonly used in conjunction with a premium release blend to create differential tapes. And again, as there are high speed peel applications that utilize differential tapes, many are hand applied.

For the purposes of this portion of our discussion I will be referencing only data generated at 300 ipm, which is commonly referred to as a good approximation of the speed of a hand peel.



This graph demonstrates the following:

- The impact of adding CRA is much greater with adhesive TA-2 than with TA-1
- The increase in peel value is non-linear, increasing exponentially as you increase CRA load

When designing a differential release tape, the behavior of these chemistries with the different adhesives comes into play more. Aside from impacting the peel performance itself, it also directly impacts the differential ratio.

As a quick review, in most tape applications it is important that a good differential ratio is established and maintained. The differential ratio for a two sided tape can be calculated using the equation below:

$$\text{Differential Ratio} = \text{Tight Side Peel Value} / \text{Easy Side Peel Value}$$

Table 4 below shows the differential ratio seen with the adhesives as compared to the baseline premium release blend.

Table 4 – Ratio of Release of CRA Modified Blends Compared to Baseline Easy Release (Pt-3)

CRA Loading	TA-1 Release Ratio	TA-2 Release Ratio
25 Parts	1.92	3.74
33 Parts	3.19	12.29

While a differential made with adhesive TA-1 with a 3:1 requires a CRA load of 33 parts, if this assumption is extrapolated to a new tape made with adhesive TA-2, one will clearly see that the interaction of the adhesive chemistry and CRA are as important as the interaction between the adhesive and the base polymer system.

KEY FINDINGS

- Peel values increase at different rates when CRAs are added depending on the individual interaction between the adhesive and the release chemistry.
- Data generated with one adhesive, even if it is similar in chemical nature to another, cannot be assumed to translate to that adhesive

3. PEEL SPEED

When discussing application, there are two general categories: hand dispensed or machine dispensed.

In the industry a typical peel speed referenced for hand dispensed products is 300 ipm. But when considering machine dispensing, one has to consider what the actual rate of peel or “stripping” is during the final application.

In some of the earlier graphs such as Figures 2 and 3 (pages 4 and 5) there are examples of how peel speed can impact the release performance. When designing a differential release product this property has to be closely observed.

Looking again at our CRA modified blends, let’s see what happens to the release ratios when the peel speed of TA-1 is increased:

Table 5 – Ratio of Release Of CRA Modified Blends Compared to Baseline Easy Release (Pt-3), TA-1

CRA Loading	300 ipm Release Ratio	1200 ipm Release Ratio
25 Parts	1.92	1.58

By increasing the dispensing rate from a hand peel rate of 25 feet per minute (fpm) to a machine dispensed speed of 100 fpm the ratio of release has dropped.

A close examination of the data showed that the peel value of the easy release blend did not move, but the release of the CRA modified did show a drop, resulting in a closing of the gap between the two sides.

This may not be an issue going forward, especially if the peel speed will never exceed 100 fpm. But as some machine dispensing applications can sometime strip at hundreds of feet per minute, this declining differential trend may continue.

KEY FINDINGS

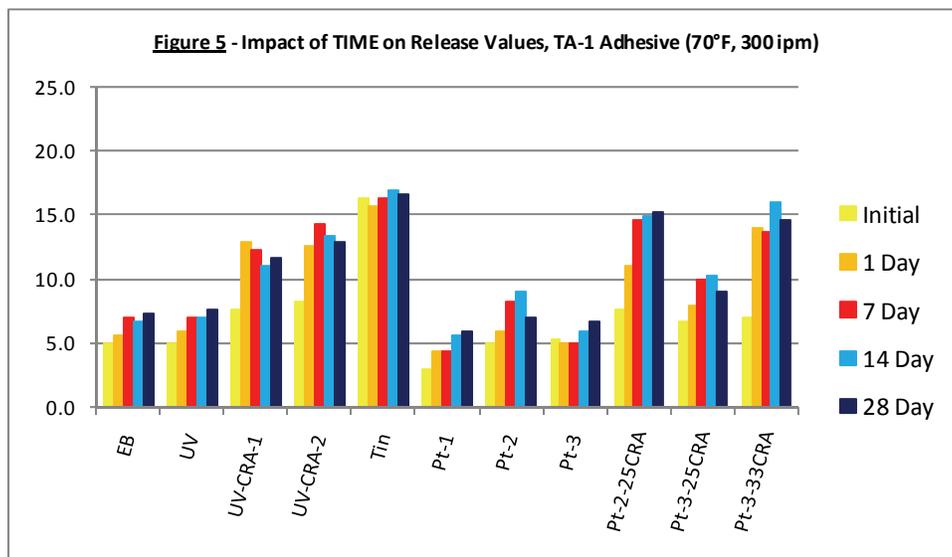
- How a release chemistry performs with a given adhesive can be greatly impacted by the speed at which the adhesive is removed.
- When designing differential release products it is important that test methods simulate the dispensing conditions as closely as possible to avoid adhesive confusion.

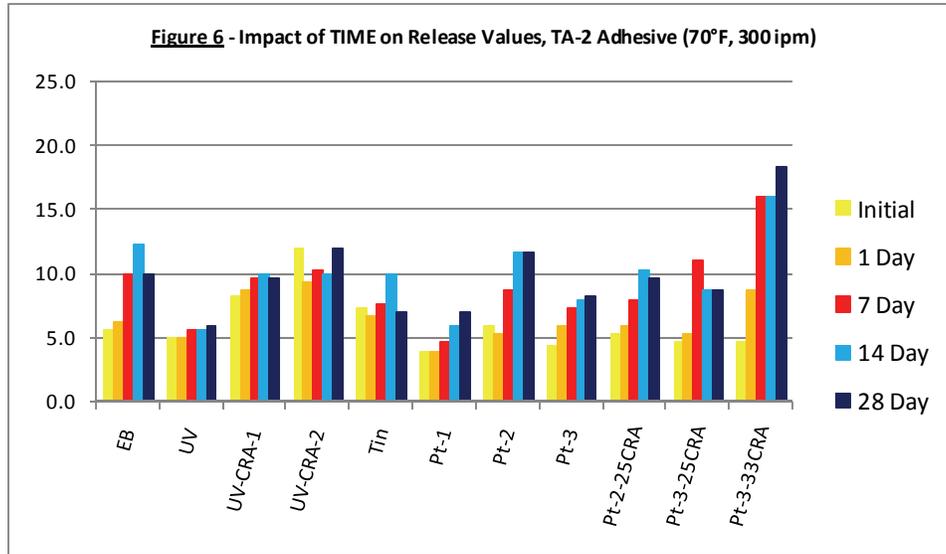
4. AGING TIME

Will the tape you are manufacturing see regular turnover? Are your customer use patterns irregular? Could it sit on a shelf in a store for a week? A month? Six months?

Often it is difficult to predict when the tape you've made will be consumed. That means it's important to understand how it will behave over time.

Too look at this performance in real time, the following data is based on aging done at 70°F in order to simulate room temperature.





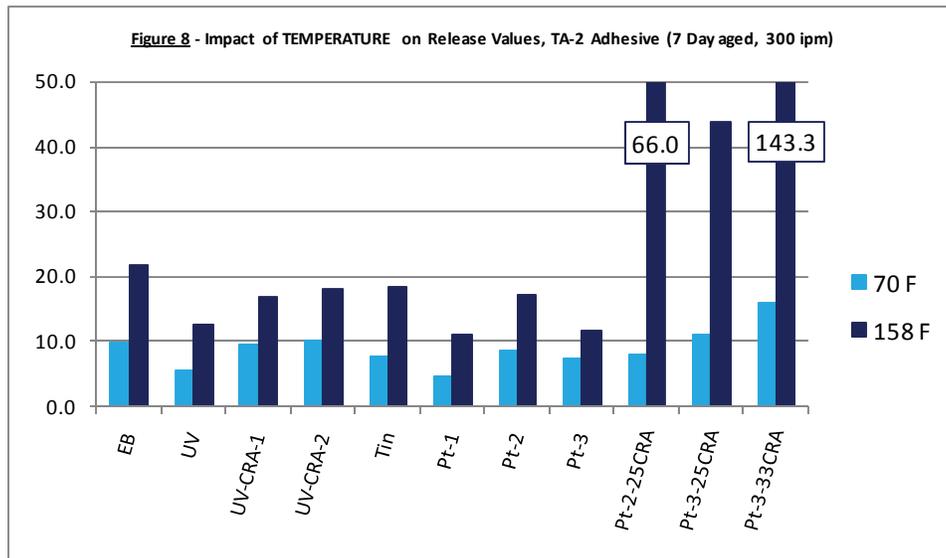
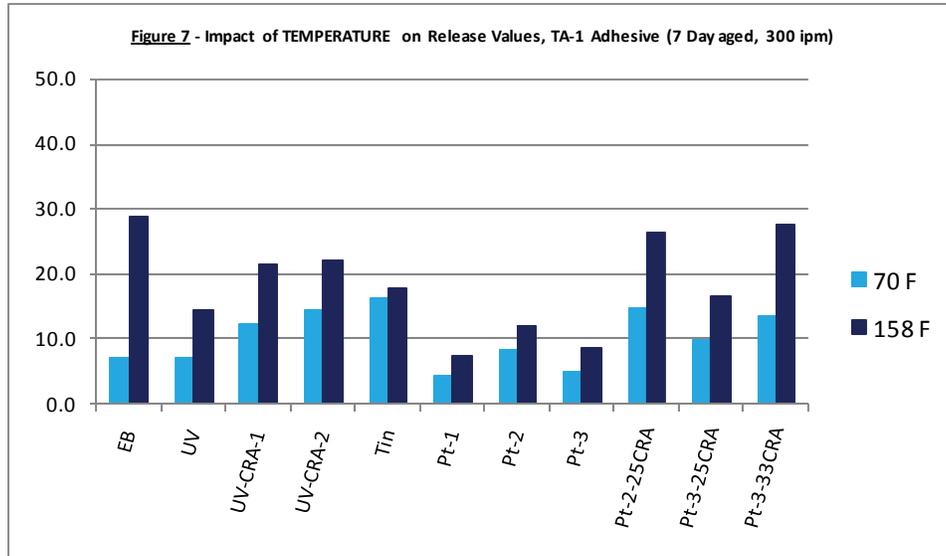
In general the release continues to grow for at least the first 14 days after application of the adhesive. After this point in time the growth rate in release value seems to slow down.

This data was generated at room temperature. But when considering how a product will behave during long term aging, assumption of ideal storage conditions is not a safe one. So to fully understand how a product will behave in storage, one needs to take a look at how this may behave at elevated temperatures.

5. AGING TEMPERATURE

Whether you are shipping your product to a warehouse in Wisconsin in December or a distribution site in Texas can have a major impact on the performance of the tape by the time it arrives at the customer.

The two graphs below offer a look at how a cross section of release chemistries behaves when exposed to higher temperatures.



The obvious trend that jumps out is that every release/adhesive combination increases in peel value when aged at elevated temperatures.

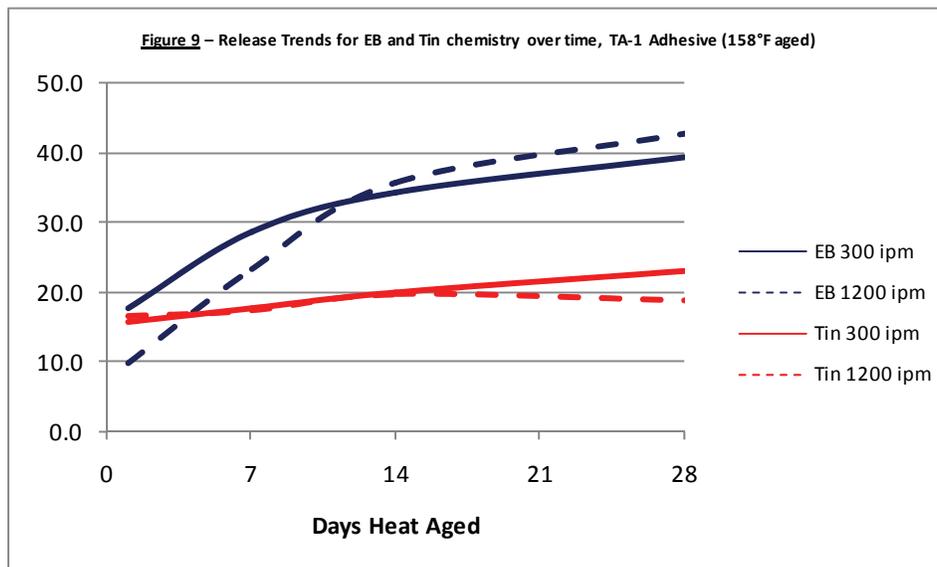
Comparing the data from the two adhesives also serves to further demonstrate the fact that assumptions made with one adhesive system cannot be assumed to translate with another adhesive.

BRINGING IT ALL TOGETHER, Speed, Time, and Temperature

Going back to a comment I made in an earlier section, I observed that the behavior of the EB and Tin systems were atypical with one of the adhesives, TA-1. What was noted was that at higher peel speeds the release of both of these blends dropped, which goes against the general theory of how acrylic adhesives react with these two systems.

But the data point was a single snap shot, a moment in time. Was this a data point that was an outlier? By looking at how these behave when peel speed is varied at an elevated temperature over time, a sense of a trend emerges.

Figure 9 – Release Trends for EB and Tin chemistry over time, TA-1 Adhesive (158°F aged)



There seems to be a change in how TA-1 behaves with both of these blends at 14 days of heat aging:

- Tin system seems to be diverging slightly as it continues to age with the higher peel speed resulting in lower release.
- The EB system seems to be reversing itself, trending towards the more common accepted theory of its behavior at higher peel speeds as it ages.
- The EB system also seems to show a trend of continued increasing release over time, also typical of commonly accepted theory of EB free radicals with acrylic adhesives.

This TOP FIVE list is only just that. There are many different ways an adhesive is stripped, many adhesive types, many substrate options, all of which impact performance.

And there are many other ways in which silicone release blends can be customized to fit your needs, and the ever growing needs of the pressure sensitive tape industry.

SUMMARY

Over the course of this paper, some general trends have emerged:

1. When looking for a premium release, starting with UV free radical or Platinum thermal systems appears to be a good place to start.³
2. Even if the cure method, adhesive, and release polymer type are the same, one can't assume identical performance
3. Understanding how a differential tape behaves under end use production conditions is critical to ensuring you don't experience adhesion confusion or general tight release.
4. Release values will rise over time, but tend to plateau if there is no chemical interaction between the adhesive and release chemistry
5. Products stored at higher temperatures may have a shorter shelf-life, so an understanding of storage conditions important

The simple conclusion here is that nothing is simple, even for that little piece of paper or film that gets tossed into the trash. To successfully deliver your product to the customer, that trash has to be highly engineered, just like your adhesive. And understanding the life cycle of the whole product is the key to ensuring that it is the best piece of trash for your application.

That is something to consider when you get to the point at the end of your next product development cycle and say to yourself, "Ugh, now I need a release liner..."

There is no single perfect release chemistry out there, but there is the perfect one for you.

³ It is always recommended that the user of free radical release liners do aged testing with acrylic adhesives