INTRODUCTION
Reliable sealing of the cover tape is the most important and perhaps least understood aspect of the tape and reel packaging process. Many tape and reel packagers have been sealing heat activated cover tapes since the inception of packaging components in tape and reel, yet the understanding of the basic sealing process variables and how they interact with differing carrier tape base materials is not widely understood.

The recent surge in usage of pressure sensitive adhesive (PSA) cover tapes requires a different knowledge base and process understanding from heat activated adhesive (HAA) cover tapes. This paper will present the basic fundamentals for sealing both heat activated and pressure sensitive cover tapes. The differences between these two cover tape technologies will be explained and highlighted. Before discussing cover tapes, however, it is important to have a brief background of carrier tape materials.

EMBOSSED CARRIER TAPES
Embosed plastic carrier tapes are available in a number of sizes for automated component placement: 8, 12, 16, 24, 32, 44 and 56mm widths are common within the industry today. Other, less common widths of 72, 88, 104 and 120mm, are used for connectors and other large bulky components. These embossed carrier tapes are made from plastic film, and a variety of polymers are used as the base material including:

- polyolefins [HDPE, PP]
- polystyrenes [PS, IMPS, ABS]
- polyvinyl chlorides [PVC]
- polyesters [PET, APET, PETG]
- polycarbonates [PC]

Embossed carrier tapes made from these materials have different physical characteristics, varying in stiffness, impact resistance, toughness, heat resistance, transparency and dimensional stability. Each of these characteristics has advantages and disadvantages as a packaging medium. Selection of the appropriate properties for packaging components, then, depends on understanding how each of these properties will help protect the components to be packaged and make them readily usable on automated pick and place equipment.

It is also important to recognize the different sealing characteristics of the various polymers used to make carrier tape. As a general rule, using the same cover tape and same sealing machine parameters, a polystyrene carrier will require a higher sealing temperature than a PVC carrier, and a polycarbonate carrier will require a higher sealing temperature than a polystyrene carrier, to achieve the same peel force. This is due to the different surface energies of these various polymers.
The entire surface of one side of the film backing is coated with primer and adhesive, providing the user the choice of the seal width and location. This construction provides extraordinary flexibility to the user, but it also presents a number of processing issues which must be carefully considered to ensure that a reliable seal is achieved.

HAA cover tapes need energy in the form of heat to make them work. Until the adhesive is heated to the right temperature, it just won’t seal! This is called the cover tape adhesive’s activation temperature. It must be remembered that the activation temperature is the amount of heat that will create a bond between the HAA and the specific carrier tape to which it is being sealed. The conditions that allow this bonding is called the process window, and consists of the sealing temperature, dwell time, and pressure. The process window will be different for each combination of cover tape adhesive and carrier base polymer, i.e. a different sealing temperature, dwell time, or pressure will be required.

Two very popular HAA adhesive systems are the families of polyethylene vinyl acetates [EVA] and the styrene-butadiene rubber [SBR] adhesives. EVA adhesives seal at lower temperatures than the SBR adhesives, i.e., they have a lower activation temperature to bond to any particular substrate. The SBR adhesives, on the other hand, have greater shear stress resistance than EVA adhesives - they have a higher viscoelastic capacity. Given these two adhesive types, and when both are bonded to carrier at the same peel force, the SBR adhesive will require a higher sealing temperature, but will also be able to tolerate more shear stress than an EVA cover tape.

PSA COVER TAPES
PSA cover tapes require different processing and handling than heat activated cover tapes and are generally considered to be easier to seal than their heat activated counterparts. The PSA adhesive is a synthetic adhesive formulated to remain tacky over a wide range of temperatures, including room temperature. Hence, PSA cover tapes require no heat to seal them to the carrier. To prevent components from sticking to the adhesive, a liner film is added to cover the adhesive in the center portion of the cover tape. PSA cover tapes are slightly more complex in their construction, consisting of as many as four elements:

1. a polymer film backing (usually polyester)
2. a primer layer
3. an adhesive layer
4. a second polyester liner film, centered to expose adhesive only on each edge of the cover tape.

CONDUCTIVE, NON-CONDUCTIVE, AND STATIC DISSIPATIVE PROPERTIES
Both PSA and HAA cover tapes can be found in non-conductive and static-dissipative versions. Some cover tapes are termed anti-static which are usually perceived as being the same as static-dissipative cover tapes. Technically, anti-static refers to a material which does not generate a static charge when rubbed against a second material (triboelectric charging). Static dissipative refers to a material which can bleed off a charge through the mechanism which provides it’s surface resistivity.

A non-conductive material is defined as having a surface resistivity (Rs) greater than $10^{12}$ ohms/square. Static dissipative material is defined as having a surface resistivity (Rs) between $10^{5}$ ohms/square and $10^{12}$ ohms/square. While conductive material is defined as having a surface resistivity (Rs) of less than $10^{5}$ ohms/square.

SEALING HEAT-ACTIVATED COVER TAPES
For any heat-activated adhesive cover tape, as a general rule, increasing temperature, dwell time, and pressure on a given sealing machine will, within limits, increase adhesion (peel). However, for most of the HAA cover tapes available in the marketplace today, temperature and dwell will have a greater affect on adhesion than pressure. The ways these variables interact in the sealing process are of interest to anyone trying to control a packaging process. These will be discussed in detail.

Temperature
When sealing an HAA cover tape, temperature refers to the indicated temperature of the sealing mechanism. Heat-activated adhesives are dry to the touch at room temperature. The absence of any tackiness is the property that permits their ready handling under these conditions. Tackiness must be attained to get the adhesive to “stick” the cover tape to the carrier tape. To accomplish this, energy in the form of heat is used to “activate” the cover tape’s adhesive system. This activation is the process that raises the temperature of the adhesive until it achieves a level of tackiness which allows it to adhere to the carrier tape. The amount of heat
required to activate and properly seal a cover tape depends on a variety of factors:

- The type of cover tape - backing, primer, adhesive and overall thickness
- The type of carrier - polymer type, carbon-filled or plain
- The sealing mechanism design,
- The sealing mechanism's thermal conductivity,
- The intimacy of contact between sealing shoe / cover tape / carrier tape,
- The amount of time the shoe is in contact with the tape.

It’s important to note that the indicated temperature on a sealing machine’s display may not accurately reflect the actual temperature of the sealing surface of the shoe itself, but it is a relative measure of the temperature. This will depend on where the controller’s thermocouple is located with respect to the shoes, shoe design, convective and conductive heat losses, and the metal from which the shoes are fabricated. Once a set of conditions is found for a sealing mechanism of a specific design, the conditions that have been established for it may not transfer exactly to an “identical” machine, but they should be similar. Trying to use those conditions on a mechanism of a different design is much less predictable, and a “new” set of operating conditions may have to be determined to get an equivalent result. This is one reason why it is difficult to precisely compare time, temperature, and pressure settings among different taping machines – we can only make some general comparisons.

Dwell Time
Dwell time describes the cumulative period of time the sealing shoes are in intimate contact with the cover tape. Dwell is measured differently for continuous sealing mechanisms and reciprocating sealing mechanisms. For a continuous sealing machine, where the sealing shoes are in continuous contact with the heat-activated cover tape, dwell depends on the carrier feed rate and the length of the sealing shoe.

\[
\text{Shoe Length (mm)} / \text{Feed Rate (mm/second)} = \text{Dwell (seconds)}
\]

For reciprocating sealers (and for intermittent sealing equipment), where the sealing mechanism makes periodic contact with the cover tape, dwell is a function of the length of time the shoe is forced into contact with the tape, multiplied by the number of times the shoe strikes the tape in any one location.

\[
\text{Contact Time(seconds)} \times \text{Number of Strikes} = \text{Dwell (seconds)}
\]

Thus, for a reciprocating mechanism, ignoring any cooling that takes place between successive strikes, dwell is a cumulative time-at-temperature event.

Pressure
The sealing mechanism, which is commonly called the ‘shoe’ needs to apply a minimal level of pressure to the cover tape in order to get adequate heat transfer and simultaneously achieve intimate contact between the adhesive and the carrier tape. Too much pressure can have negative consequences by forcing adhesive out of the bond area. Most of the sealing equipment being sold today uses compressed air to operate the sealing mechanism, and the pressure can be adjusted. Some equipment, however, uses a fixed spring design, and may not be adjustable. With air-driven equipment, the pressure that is referred to in the sealing process is the indicated gauge pressure, abbreviated ‘psig,’ as compared with the actual, or calculated pressure beneath the shoe. What’s the difference? – “psig” represents the input pressure to a piston in an air cylinder. The piston inside the air cylinder uses the applied (indicated) air pressure to drive the sealing shoe against the cover tape. Different equipment may use different air cylinders, and the area of the piston in these cylinders may differ, giving a different force to the shoe. For example, a 10 psig load on a piston with a 1 sq. inch area will put a 10 pound load on the mechanism.

\[
\text{Input Pressure (psig)} \times \text{Piston Area (square inches)} = \text{Load (pounds)}
\]

To make some comparisons, a 10 psig load on a piston with a 2 sq. inch area would apply a 20 pound load on the mechanism, while the same input on a 0.5 sq. inch piston, would produce a 5 pound load.

Finally, the calculated pressure is the product of the load on the shoe against the cover tape, divided by the area of the shoe’s contact surfaces.

\[
\frac{\text{Load (pounds)}}{\text{Total Shoe Area (sq. inch)}} = \text{Calculated Pressure (psi)}
\]

If the shoe has two sealing sections, or rails, which are 0.020 inch by 1 inch in length, the total contact area is 0.040 sq. inch.

\[
\text{Rail Length (inch)} \times \text{Rail Width (inch)} \times \# \text{ of Rails} = \text{Total Contact Area (sq. inch)}
\]

Given a pressure of 10 psig and a 1 sq. inch piston we get a 250 psi calculated pressure: 10 psig x 1 sq. inch / 0.04 sq. inch = 250 psi

It is absolutely essential to remember that changing either the piston or the shoe size will change the pressure applied to the cover tape, even if the indicated gauge pressure remains unchanged. So, minor adjustments in input pressure, or changes in shoe size, may have a significant effect on the resulting adhesion of the cover tape.

When a sealing mechanism with independent shoes is used, one where each of the shoes is driven by its own piston or
other source of pressure, each part has to be considered separately.

As a practical matter, calculated pressure should be in the range from 50 to 100 psi for reciprocating sealing mechanisms. This pressure is applied only when the cover tape and carrier tape are passed beneath the shoe. The dwell will vary according to the number of times the shoe will make contact with the tapes, which may range from a single strike to as many as 8 strikes. The number of strikes will depend upon the length of the shoes and the index, or tape advance increment. Multiple strikes of this type can assist in maintaining a reasonable tape feed rate, which translates into components packaged per hour, and still keep dwell at a level that insures appropriate adhesive activation.

Continuous sealing mechanisms may require calculated pressures in the range from 10 to 20 psi to permit cover tape into components packaged per hour, and still keep dwell at a level that insures appropriate adhesive activation.

Continuous sealing mechanisms may require calculated pressures in the range from 10 to 20 psi to permit cover tape to pass beneath the mechanism without being distorted by friction in the contact area. You may ask yourself, “If I can seal at 10 - 20 psi in continuous mode, why not so in reciprocating mode?” The answer is simple. Continuous feeding of tapes under the seal head must be done with some pressure to allow heat to be transferred to the cover tape/carrier passing beneath the shoes. Just a bit too much, and the cover tape will pinch between the shoes and carrier, distorting the cover tape and producing a poor seal. The contact between the shoes and the cover tape is not very intimate, but the same amount of energy to activate the adhesive is still required, so the effective dwell is typically greater with a continuous sealer, compared to a reciprocating sealer at the same temperature. As you can imagine, since the tapes are at a standstill on a reciprocating machine when the shoes make contact with them, higher pressure insures a more intimate contact with the tapes, resulting in better heat transfer.

Looking at these first three variables as a three-dimensional model, experience with heat-activated adhesive cover tapes teaches that two of the variables, temperature and time, have less latitude than does pressure. As a result, consistent control of these two variables is probably the most critical part of the sealing process.

**SEALING EQUIPMENT FOR HEAT ACTIVATED COVER TAPES**

**Sealing Modes**

Tape and reel sealing equipment is operated in 3 basic modes of operation: reciprocating, intermittent, and continuous.

In the reciprocating mode, the sealing shoes move up and down during the sealing process. The shoes move up to allow the carrier and cover tape to advance without restraint, then back down after tape advancement is stopped, contacting the cover tape and sealing the tape to the carrier. It is a “step and repeat” action. The distance of each advancement, or step, can usually be controlled on the equipment, so the sealing shoes may contact the cover tape more than once as the carrier and cover tape pass under the shoes. For example, if the step is equal to the shoe length, each point along the seal is contacted only once. We call this a single strike sealing process. If the step is only half the shoe length, each point along the seal is contacted twice, or given two strikes – a two-strike process. The use of multiple strikes can reduce the peel force range (the difference between the maximum and minimum peel force in any peel test). Slight variations in the carrier’s seal area topography result from the embossing processes used to make the pockets. As a result, the sealing shoes may bridge from one high point to another, and any intermediate low areas may exhibit a lower peel force. By using multiple strikes, the shoes can better follow the terrain, resulting in more uniform peel values. A minimum of 2 strikes is desirable, but some equipment is actually provides up to eight strikes!

The intermittent mode is similar to the reciprocating mode. The sealing pressure is released from the shoe prior to advancement, but the shoe is not raised from the cover tape. Hence sealing pressure is applied intermittently - pressure applied when the tape is stopped, and reduced as the tape is moved. This results in the shoe staying in contact with the cover tape during advancement, but with no pressure applied. To a casual observer, it looks like a continuous sealing process, but with a higher seal force applied between steps.

Continuous mode sealing leaves the sealing head in constant contact with the cover tape. The seal is made at a constant pressure during advancement, the carrier and cover tape sliding beneath the sealing shoe. Due to friction between the cover tape and sealing shoe, the amount of sealing force which can be used in the continuous mode is limited. Several problems can result from high sealing forces in the continuous mode. Excess tension can be placed on the cover tape, and the edges of the cover tape can be squeezed out from under the sealing shoes, resulting in wrinkles in the center of the cover tape and a very poor seal. Properly adjusted, however, continuous sealing equipment can achieve component packaging rates of greater than 50,000 components per hour.

**Thermal Conductivity**

While the shoes of most sealing mechanisms in current use are made of tool steel, some are from other materials, notably brass. Since the thermal conductivity of steel is significantly less than brass, the difference can be important in correlating results between differing mechanisms. In the case of these two metals, brass can transfer heat energy faster than an equivalent steel mechanism. This means that the sealing process might be run more rapidly on a machine with a brass mechanism. Wear characteristics and cost, on the other hand, may dictate the material of choice. Stainless steel, however durable, has a much poorer thermal conductivity than steel, and should be avoided.
A secondary facet of thermal conductivity is the capacity of the heater element and its controller. If the mechanism is heated by a cartridge with a capacity which is marginal, it may be “ON” 100% of the time and the temperature of the shoe will be function of heat lost by convection and conduction. In other words, the shoe will vary widely in temperature - a condition which the heater element will be unable to correct. If the cartridge heater is of adequate capacity, but the controller has a great deal of lag in turning on and off, the heater may be alternating between high and low temperature extremes, which may in turn cause significant variability in the adhesion of a heat-activated cover tape. Peeling studies of several meters of carrier and cover tape, sealed at the “same” condition, will show a sinusoidal pattern that reflects the heating and cooling cycles of the system. The heating element must have enough capacity, and the controller must be accurate enough to keep the sealing mechanism at a relatively constant temperature during the sealing process to provide predictable results.

**Carrier Width Issues**
When sealing various widths of the same type of carrier and cover tape combination, it’s not unusual to find that wider widths require slightly more heat to achieve the same peel force. For example, an 8mm wide carrier and cover tape might seal at 130°C. Sealing the same carrier material and cover tape in a 12mm width may require 140°C. As carrier width is increased from 16mm to 32mm, all using the same cover tape, sealing temperatures may continue to edge up. Most of this phenomenon is related to equipment design, and the heat losses that occur from one design or setup to another. In real terms, it is still taking the same amount of energy to effect the bond between the adhesive and the carrier, and if some heat has been lost, then you can either increase dwell and allow more time for the complete activation of the system, or increase temperature to pump the heat into the system faster.

**SEALING PSA COVER TAPES**
Pressure-sensitive adhesive (PSA) cover tapes, unlike their heat-activated counterparts, require no heat to activate the adhesive. PSAs are tacky over a reasonable range above and below room temperature, and will adhere to any acceptable surface with the application of sufficient pressure to bring the 2 surfaces into intimate contact. PSA cover tapes consist of a structure in which adhesive is exposed only at the edges for sealing. Since peel force is a function of the width of the sealed area, and PSA cover tapes have a limited exposure of the adhesive, it follows that there is a limit to the adhesion that can be achieved with this construction. This adhesion is not adjustable by varying the sealing temperature, as would normally be done with a heat activated cover tape.

**Temperature**
In general, PSA cover tapes can be applied at any temperature that is comfortable for an operator, typically 25°C, ±5°C (77°F, ±9°F). Since the adhesive is “active” at these temperatures, no heating is required to achieve a bond to the carrier tape. Once sealed, PSA adhesives can survive continuous exposure at -20°C, or 30 days at 52°C/95% relative humidity, with little or no effect on the adhesion of the cover tape to the carrier. Typical sealing temperatures for heat-activated tapes, 160°C, ±60°C, are not only unnecessary but are undesirable for PSA cover tapes. Heat in excess of 100°C can degrade the performance of the PSA construction, and should be avoided.

**Dwell Time**
PSA cover tapes provide an excellent opportunity for enhanced throughput for any component packaging operation. In addition to the elimination of thermal input, which is a time-dependent function of the sealing mechanism and the thickness of the cover tape, PSA cover tapes can be sealed at rates that are limited only by the speed at which components can be placed into the carrier tape. A properly aligned PSA cover tape can be joined to the carrier tape at rates in excess of 1 meter per second by continuous roller sealing mechanisms or reciprocating mechanisms.

**Pressure**
Pressure is the primary controlling variable for proper application of PSA cover tapes. It is critical to understand that sealing a PSA cover tape requires only sufficient pressure to adhere the cover tape to the carrier. It is important to avoid excessive pressures, which can cause adhesive to be transferred to the mechanical components of the sealing equipment, or to other surfaces of the carrier which may cause problems later, at pick and place.
PSA Cover Tape: Extremes in Pressure

1. All elements prior to applying sealing pressure
2. Intimate contact between carrier & cover
3. Excessive pressure extrudes adhesive
4. Resulting in residue on unwanted areas

PSA cover tape, like any PSA adhesive tape, can be adhered to a surface through the application of pressure sufficient to make intimate contact between the PSA adhesive and the surface. As pressure is increased beyond this point, the intimacy of the contact will increase until no further contact can be achieved, and adhesion will be at its peak. Any pressure applied beyond this level is (a) wasted effort, and (b) has the potential to force adhesive out past the edges the cover tape.

PSA adhesives, depending upon the specific chemistry of the polymers themselves, have differing degrees of cohesive strength. Once this “internal strength” is exceeded, the adhesive may be squeezed out from under the backing, and may adhere to the surfaces of the application mechanism, with later transfer onto other parts of the sealing mechanism or carrier surface. Many feeders eject used carrier via a metal chute to a waste receptacle, and contamination of the interior surfaces of these types of feeders with adhesive residue may cause the feeder to jam.

Any time that a PSA adhesive must contact a surface other than the one to which it is intended to bond, that surface should have a very low surface energy, such as Teflon®, silicone rubber, Delrin®, or other low surface energy materials. Metals, which are typically oxidized at the surface, have particularly high affinities for adhesives, and should not come into direct contact with the adhesive portion of a PSA tape.

SEALING EQUIPMENT FOR PSA COVER TAPES

Tape and reel sealing equipment for PSA cover tapes is operated in 2 basic modes of operation: reciprocating and continuous.

In the reciprocating mode, the sealing shoes move up and down during the sealing process similar to heat activated cover tapes. In the case of PSA cover tapes, the initial adhesion may be enhanced by a multiple-strike sealing process and an elastomeric surface on the sealing shoe.

Continuous mode sealing of PSA cover tapes is achieved by passing the carrier and cover tape between pinch rollers which force the PSA adhesive into intimate contact with the carrier tape. These rollers are in constant contact with the cover tape and the seal is made at a relatively constant pressure during advancement, the carrier and cover tape advancing between the rollers.

Once wound on a reel, the tension on the cover tape will also cause the PSA adhesive to achieve its ultimate wet-out and peel force within a day or so. When wound on a reel with cover tape on the outside of the wrap, the cover tape is placed under slight tension which tends to pull the cover tape into more intimate contact with the carrier. Since the PSA adhesive remains tacky, this tension further assists the adhesive to achieve it’s ultimate wet out and peel force. It is common to see a PSA cover tape peel force increase 10 grams over the first several days on the reel. Once the ultimate wet out has been reached, no additional increase in peel force can occur.

PICK AND PLACE FEEDERS FOR PSA COVER TAPE

Because PSA cover tape adhesive is tacky at room temperature, there are some considerations for pick and place feeders when used for PSA cover tape. Care must be taken not to allow the exposed adhesive to contact stationary surfaces, such as guide pins or pinch rolls. The cover tape should be guided on the backing side or in the center liner film area of the adhesive side. Winding the cover tape adhesive side out on the take-up spool helps prevent the adhesive from sticking to the spool flanges. If the adhesive must come in contact with a surface, low surface energy materials such as Teflon® or Delrin® can be used.
COMMON FACTORS FOR BOTH HAA AND PSA COVER TAPES

Seal Width and Position
As with any adhesive tape, the width of the seal will determine the total adhesion, or peel force, necessary to remove the tape. For most of the tape industry, adhesion is characterized in terms of peel force per unit width, for example, pounds/inch, ounces/inch, kilograms/centimeter, and so forth. Therefore, the width of the seal will have a significant effect on the force required to remove it. For example, assuming identical cover tapes and sealing conditions, a 1mm seal width will require twice the force to remove the tape by peeling than a 0.5mm width. The seal width for HAA cover tapes is determined by the width of the shoes of the sealing mechanism. If the width of the shoes are not uniform throughout their length, or if they are misaligned in such a way that they form a slightly offset pattern at the overlap point, the peel force will vary according to the seal width, which can create problems during the pick and place operation. Components may be catapulted from the tape pockets by the uneven peeling action as the peel force changes between high and low values. For this reason, maintaining a uniform seal width is highly desirable.

For heat activated cover tapes, the seal width and position is determined by the width of exposed adhesive at the edges of the cover tape. No adjustment of the seal width or position is required.

Cover Tape Tension
One frequently-overlooked aspect of applying cover tapes is the tension necessary to guide the tape onto the carrier for sealing. This is typically accomplished through machine designs incorporating idler rolls or pins over which the tape flows, including a final guide which brings it into position directly over the carrier tape, immediately ahead of the sealing mechanism’s contact point. The lowest possible tension should always be used when guiding cover tapes. Whenever tension is applied to a cover tape, some elongation may occur. Since most of the cover tapes in the global market utilize polyester films - polyethylene terephthalate [PET] - as the backing, elongation may be as much as 3% without causing permanent deformation. The application of too much tension causes two changes to occur. One is stretching the cover tape by some percentage, which is tension-dependent (applied force). The other, less obvious effect, is the necking or narrowing of the tape, a reduction in width and thickness, by a similar percentage. The volume of the cover tape is essentially unchanged between the unstressed (relaxed) and stressed (stretched) conditions, so that any increase in length is offset by a reduction in width and thickness.

Sealing cover tape which is under any significant tension can result in later problems with delamination in HAA cover tapes. Remember that the cover tape is typically applied to the carrier while both are in the same plane, essentially flat...
and parallel to each other. If the cover tape is applied in an elongated state, shear stresses will occur in the adhesive bond line when the cover tape attempts to return to its unstressed length. As long as the stresses are minor, the adhesive has the capacity to cope with them and nothing visible happens — the tape remains where it was sealed. If the stress is too great for the heat activated adhesive to hold, however, the adhesive will delaminate from the carrier.

PSA cover tapes have the ability to absorb more stress than a HAA cover tape, due to the adhesive remaining tacky and more visco-elastic. The general rule for tension is to keep it as low as possible. Since no taping equipment made today incorporates a means to measure tension, this needs to be done “by feel” more than by anything else.

When wound on a take-up reel, the cover tape (which should be the on the outer surface as wound on the reel) is at a slightly larger radius on the reel than the sealing surface of the carrier. This causes the cover tape to be under additional tension just due to being wound on the reel. This tension pulls the cover tape against the carrier and helps the adhesive hold the cover tape onto the carrier. Cover tape should never be wound to the inside on a reel as this places the cover tape in compression and works against the adhesive.

**Cover Tape Tearing**

Occasionally, problems may occur with heat activated cover tapes tearing during detaping on the pick and place machine. Such tearing is usually caused by improper sealing of the cover tape. The polyester backings used for cover tapes can tear if the backing is nicked or punctured. This is especially true if the nick or puncture is at or near to the edge of the cover tape. As previously mentioned, it is important to position the sealing shoes slightly inboard of the edge of HAA cover tapes. The sealing methods used for PSA cover tape are less likely to damage cover tape edges than the methods used for HAA cover tapes. In addition, the laminated structure of PSA cover tapes makes them more resistant to tearing. These two factors in combination result in PSA cover tapes being much less susceptible to tearing at pick and place than HAA cover tapes.
FACTORS THAT AFFECT PEEL
Many of the issues discussed in this document will have an affect on cover tape peel mechanics – peel force, peel range, minimum and maximum peel forces, etc. The objective for any component taping operation is to provide components in tape and reel for automatic placement on circuit boards. Product packaged in tape and reel will be judged by how easily it functions on the pick and place equipment. In actuality, pick and place equipment effectively conducts a 100% inspection of taped product. Every mis-pick or line stoppage is a serious problem. The best way to prevent problems at pick and place is to provide product that peels as smoothly as silk. The smoother the peeling operation on a feeder, the less likely that components will either be rotated within the cavity or catapulted from it as the tape is peeled. Smooth peeling is best accomplished by tight peel ranges. The more you can minimize the peel range, the less vibration the peeling process will produce. As vibration is minimized, many mis-pick-causing problems will be reduced.

EIA-481
The bible for taping components for automated handling is the set of Electronic Industries Association standards EIA-481 [1]. This set of documents defines the requirements for taped components, establishes limits on the upper and lower peel forces that are deemed acceptable, and defines how those peel forces should be measured. Briefly, 8mm carrier tapes should have peel forces between 10 and 100 grams, and all other tapes, 12mm through 56mm, must be between 10 and 130 grams. Although it may seem that a higher peel force will be more certain to keep the components in the pocket of a carrier tape, the fact is that it takes very little force to accomplish this task. Components taped in carrier pockets never have the opportunity to “peel” the cover tape from over them. The only force that components can exert on cover tape is to put a tensile stress on the seal, i.e. pushing it straight up from the pocket. Failure in this mode is unlikely to happen. Peeling a cover tape is really a controlled event, where pulling the tape nearly back over itself at an angle of 165° to 180° causes a very shallow crack to progress at the interface between the adhesive and the carrier tape, or, for some of the heat-activated cover tapes, within the adhesive layer of the cover tape. These two forms of peeling are described, respectively, as adhesive failure and cohesive failure. The latter type, cohesive failure, always leaves a tell-tale track of adhesive residue on the carrier. The force that you measure as peel force represents a multitude of microscopic events in which the tape is pulled back, the adhesive is stressed to the point that it fails to adhere to the carrier, the crack propagates a bit and relieves the stress, the cover tape slack is taken up and the whole process repeats itself – again and again. In a perfect world, the peel chart would be a straight line, one without any variation. Small variations in the adhesive, in the backing, in the carrier tape surface, and in the peeling force all combine to cause variability, resulting in the variations recorded on a peel force test chart.

SUMMARY AND CONCLUSIONS
So, what peel force should be the targeted? First, we know that a narrow range is important for smooth peel. The higher the average peel force, the broader the range will be, so try to keep the peel force as low as possible to avoid large variations in peel force due to range. Second, industry standards and purchasing specifications require minimum peel forces greater than 10 grams, the minimum in the EIA standards. Experience with delamination in some of the early heat-activated cover tapes has left some people with the impression that a midpoint in the range of the standards is a good place to be - 55 to 70 grams. But peel forces of this magnitude are too high to allow really tight ranges. Average peel forces of 25 to 40 grams with minimums of 15 to 20 grams are high enough to hold the heaviest of components in their pockets and provide lower ranges for smoother peels.

All of the variables described in this paper will have some effect in any cover tape sealing operation. "Identical" equipment may exhibit very similar results. However, they may not be as "identical" as you might expect, and the results may differ measurably. By observing the conditions of the process, and by controlling each of the variables to the greatest extent practicable, you may expect to improve the consistency of your tape and reel sealing process. Attention to the details – temperature, dwell time, pressure, machine maintenance and alignment – will go a long way in making sealing of either HAA or PSA cover tapes more reliable.

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