Biography

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Publications/Papers: 1980 papers only:
Pressure Sensitive Tapes for the Electronics Industry ASME
Splicing Materials and Methods: TAPPI
Repulpability of Splicing Materials and Test Methods: TAPPI
Energy Curable Adhesive Systems: AMP Inc.
beam curable Imaging Systems for Hybrid Micro Circuits: Sanyo, Japan, ITT and TI, USA
Tapes for preferential masking during Metal Plating: Airline Plating Conference
Splicing Materials for $CaCO_3$ Low Binder Coatings on Gravure Papers: Haindl Paper GMBH Germany, and Timavo, Trieste

The title of my presentation is "Pressure Sensitive Tapes to Prevent Corrosion on Metal Surfaces".

To tell the truth about it, tapes really don't do much to prevent corrosion; but they do assist in many ways as an industrial tool allowing you people to apply corrosion preventing coatings to metallic surfaces. So we thought we might have a little fun with sticky tapes and, at the risk of insulting your intelligence, talk a little bit about what tapes are in general.

(Backing Slide)
You can see here in front of you that we, the industry, make pressure sensitive tapes out of a number of materials. The backing is the part that is not sticky and, as you can see, we make tapes out of paper, we make tapes out of cloth, we make tapes out of foil; and foil, as the industry tells us, is any kind of metal that is 6 mils or thinner. We make tapes out of green pool table felt and whatever else you might like to try. So you have seen in your business and in your day-to-day activities, I am sure, tapes made out of all of these different materials and maybe some others.

Let's take a look at the next slide and see what adhesives are made of. Generally, the pressure sensitive tape industry makes adhesives out of three different kinds of chemistry. When we say rubber resin, we mean, of course, natural rubber which is chemically pretty much isoprene; but we also think of all the synthetic rubbers available today: butadiene styrene, butadiene acrylonitrile, and some of the new block copolymers. Shell Co. has something called "Kraton". Many different kinds of synthetic rubbers provide some very interesting characteristics.

First of all, rubber resin adhesives can be very sticky. They stick to your fingers. They stick to most surfaces tenaciously - right away; but they are not very long aging. They do tend to oxidize and dry-out and in a matter of a relatively short period of time lose holding power.

The acrylate adhesives, on the other hand, tend to be permanent -- whatever that word may mean. People ask us what is the difference between the word acrylic and the word acrylate; and one of our smart marketing guys said "the difference is that one is a noun and the other is an adjective". And that is really what they are, so when we banty the words acrylate and acrylic around, this is typical of what we mean.

Acrylates are esters of acrylic acid that has reacted with an alcohol. Although they do tend to be a little bit sensitive to water, they are not soluble in water; but when we have high concentrations of moisture, the acrylate adhesives do not do too well. Again, to quote our marketing man, "When any of us get involved with mixtures of alcohol and water, we tend to get a little bit unglued also". This is what happens to acrylate adhesives.

Silicone adhesives, on the other hand, are very much like rubber adhesives except you substitute silicon atoms for the carbon atoms that you have in rubber molecules; whether they are natural or synthetic rubbers. Silicones are characterized by high strength at elevated temperatures - but not very tacky to begin with. So the industry (and their are many of us in the industry) has these same three kinds of adhesives for a variety of applications.

Let us just take a look at some of the chemistry that is involved in the acrylate adhesives. They are reaction products of acrylic acid and one of the alcohols. The first (Slide) one you see is something you might call 2-ethyl hexylacrylate. Depending on where you went to school, you might call it something else.

The second one as you can see has two methyl groups attached. We call that 2-5 dimethyl hexyl acrylate; so these would be products that are made from acrylic acid and 2 ethyl hexyl alcohol or 2-5 dimethyl hexyl alcohol. These are products that are tacky or sticky by them-

selves. They do not require any wood rosins or other additives to make them sticky, but they do have very interesting chemical resistance.

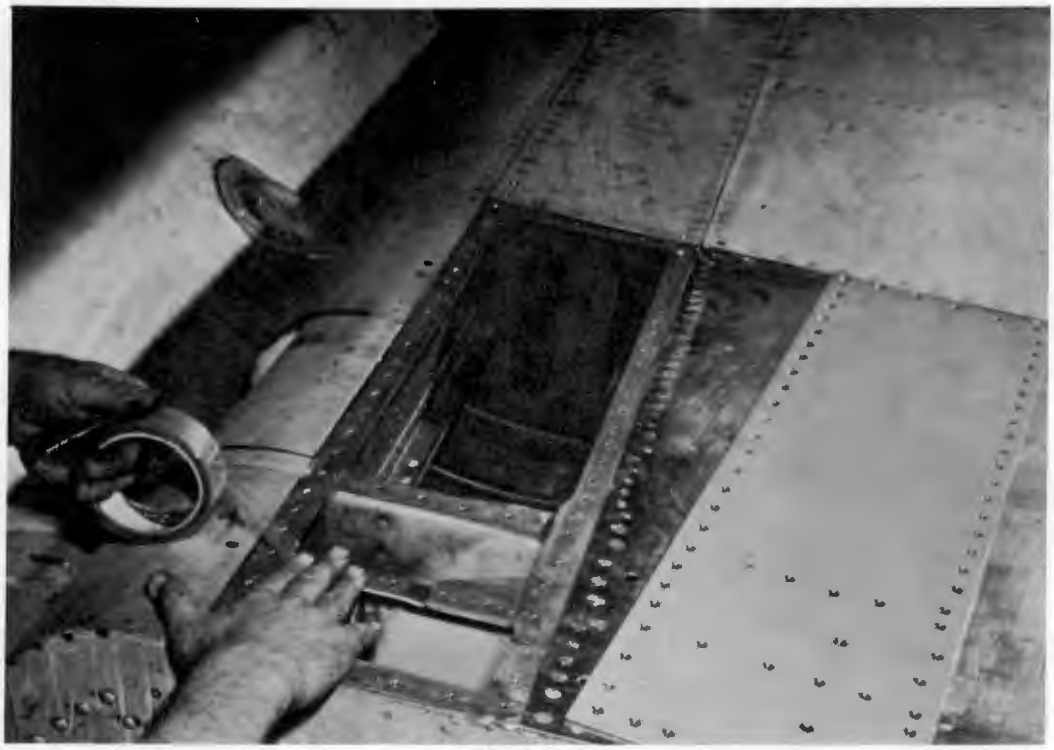
Let's take a look at one more. Typically, acrylate adhesives are copolymerized. They are copolymerized with acrylic acid; so if you look at the bottom line, you will see that in the middle, we have (Slide) the acid carboxyl functionality of the typical organic acid as well as the acrylate ester formulation.

They are copolymerized with acrylic acid so are not totally, in many cases, esters, but are copolymerized with the acrylic acid.

Here is the one exception where pressure sensitive tapes really do (Slide A) act to minimize metallic corrosion. This is a picture which shows the use of a polyester film with a pressure sensitive adhesive on one side to separate two dissimilar metals to minimize galvanic corrosion.

This is a piece of tape that is being put down on part of the (Slide A) air frame which is subsequently covered with a skin surface. The significant thing here is that the chemical resistance, in this case, of an acrylate adhesive makes it permanent, non-aging, and not subject to drying-out. This is a piece of tape that will last pretty much for the life of the aircraft & separate those two metals, effectively preventing galvanic corrosion.

We think it is important to have an adhesive system which is permanent. This is why we use the acrylate adhesive systems. We also think it is necessary to have a backing material which is dimensionally stable over a wide temperature range. This is why we use polyester film backings. And when I say we, I mean the pressure sensitive tape industry, not just necessarily our particular company.



Slide A

Slide B

Slide C

Slide D

Pressure sensitive tapes really contribute a great deal toward the prevention of corrosion as they assist you in applying corrosion resistant coatings.

This is what is called an apron taper. This combines a masking tape (Slide B) and a piece of paper used in the taping of an aircraft.

This is not really a slide on corrosion, but it is the interior of a C-5A. (Slide C)

There are 13 different colors in the cockpit of this airplane. You see it masked, so that paint can soon be applied. Tape and masking paper are very effective industrial tools in allowing you to do this kind of job.

This is a very interesting picture. It is strictly paint masking, but of course, the chemistry of paints changes every day. Paint (Slide D) is applied to the aircraft in order to prevent metallic corrosion. The tape is simply an industrial tool which allows you to apply paint where you want paint to go and to keep paint away from where you do not want it.

Rubber resin adhesives, typically used in masking tapes, allow you to mask-off an aircraft, or ship, or military vehicle and pull that tape off after the job of applying corrosion prevention coatings is completed. Without pressure sensitive tapes, you really can't do these jobs totally.

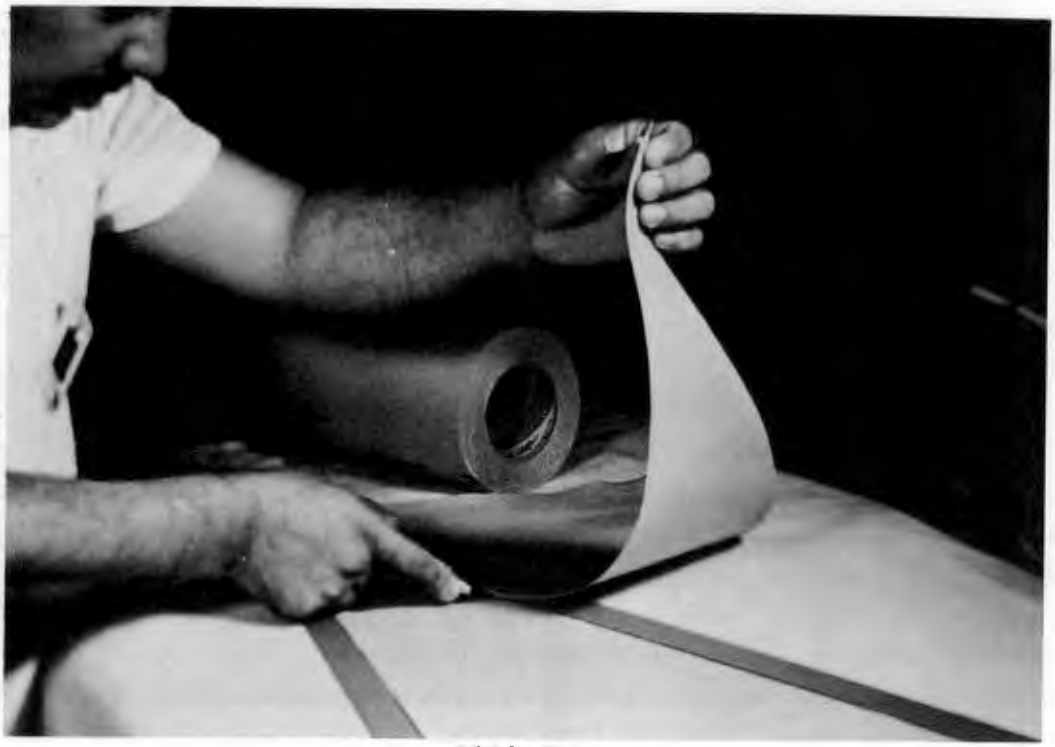
This is a helicopter and the picture (Slide E) simply shows a stenciling operation - once again, the utility of a pressure sensitive tape is an important industrial tool - allowing you to apply a corrosion prevention material.

This is another picture that shows that the pressure sensitive (Slide F) tapes can be die cut in odd formations and shapes. This is a triangular section being applied on the canopy of the airplane as a masking material prior to painting.

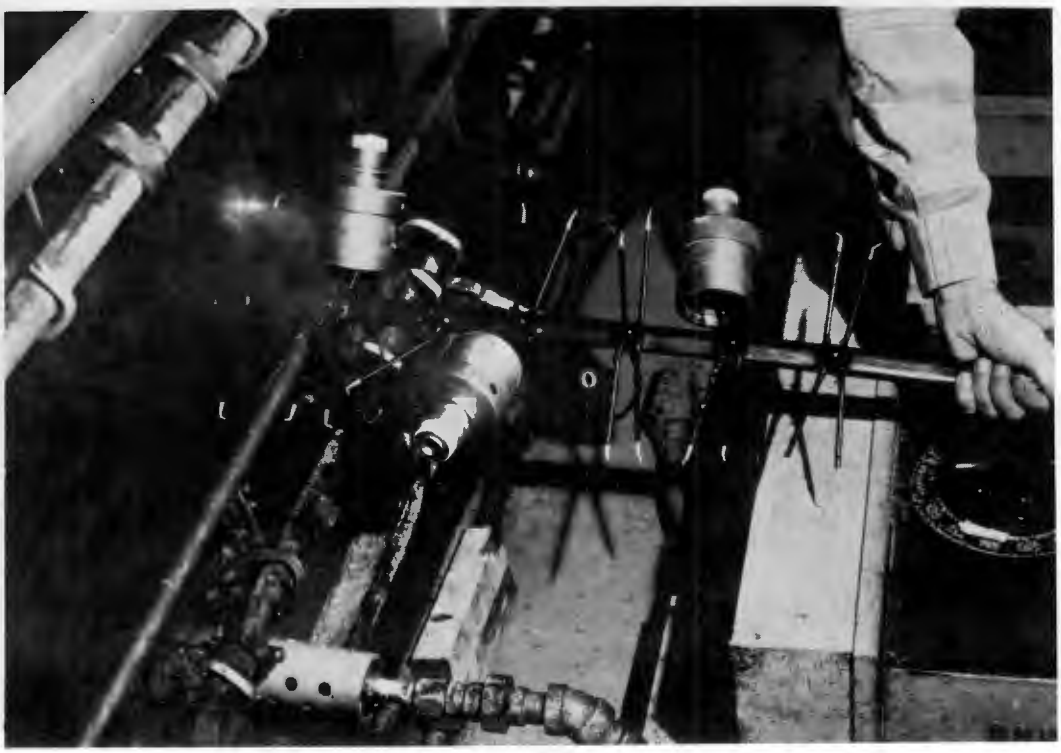
Here is something relatively new in the pressure sensitive tape (Slide H) industry. It is a shot of a plasma spray; and what we are showing here is that pressure sensitive tapes (and not the typical roll of masking tapes that would never withstand a situation like this) can be designed to do the unusual. There are pressure sensitive tapes made out of aluminum foil backing, glass cloths, and laminates and combinations of the two that will withstand a plasma spray operation and allow you to spray the plasma coating on one surface and keep it off areas you do not want coated. This particular shot was taken at Tinker AFB.

This is a bit mundane, also, but when you are applying corrosion prevention coating, for example, hard chrome, there are certain (H) areas of the parts which do not require chrome to be applied. If you look carefully, you will see small areas of yellow tape. This is a polyvinyl chloride tape which is put around the parts in those areas where you do not want chrome plating to be applied. The solution is to get an industrial tape with chemical resistance to do the job.

Slide E



Slide F



Slide H

Slide I

The formulation of vinyl tapes is something that our industry has worked on for many years. We use special plasticizers in the formulation of the backing. There are both monomeric and polymeric plasticizers, but they all have the chemical resistance for use in plating baths - and provide masking to prevent chrome from being applied to certain areas of the metal part. So when we think of a piece of vinyl chloride film, we are thinking about something much less sophisticated than the specially formulated backing on vinyl tapes. The chemistry of plating tapes is complex - the chemistry of the adhesive, and the chemistry of the backing. They do allow you to do a plating job and apply a corrosion inhibitor.

This is a series of pictures where again we are stretching the point a little while talking about corrosion inhibition. From time to time we have to take the old paint off and reapply a new coat of paint to improve corrosion inhibition.

This is a picture of a 707 (Slide I). This gentlemen is putting masking tape on the windows of this aircraft. This particular masking tape happens to be a metal foil. He is actually attaching the tape only to the frame around the edge of the window, because the acrylic adhesive that we use on this tape does stick quite well to the acrylic windows. Therefore, the adhesive surface is not in contact with the window, but is actually blocked-off and covered by paper. This gentlemen is putting on these pre-cut window masks and attaching the adhesive only to the framework of the window.

Now let's look at paint stripping. This is a rather dim picture of an aircraft. (Slide J) This shows the use of metal foil tape prior to the paint stripping operation. The chemistry of the acrylate adhesive resists the alkaline paint strippers. The aluminum foil has enough resistance to the alkaline paint strippers to last during the process. The adhesive is such that after the paint stripping operation, the tape will come off cleanly without adhesive residue on the aluminum metal.

Slide J

Slide K

Slide L

Slide M

This picture (Slide K) shows a different aircraft, but obviously, this is an engine intake that has a polyethylene film which has been adhered with tape. Then again, we are counting on the chemical resistance of the combination of the metal foil tape and the adhesive to resist the paint strippers.

Here is a typical shot that you ladies and gentlemen have seen many times (Slide L) where the paint stripper is being sprayed on the airplane. The plastic film is held on with a pressure sensitive industrial tape which has sufficient chemical resistance to allow the old corrosion inhibiting material to be selectively removed before applying the new.

This is a roll of pressure sensitive tape that is being applied to an (Slide M) acrylic canopy that is being formed. Now it doesn't have much to do with corrosion, but nevertheless, it does show another example of pressure sensitive tapes having good chemical resistance.

Tapes have been used for many years as erosion inhibitors, particularly on helicopters where polyurethane tapes have been applied to the leading edge of rotor blades - main rotor blades as well as tail rotor blades. I have had a couple of tours in Viet Nam with an Aviation Battalion, and we literally kept aircraft flying simply because we had tapes that could be used on aircraft in order to prevent both rain and sand erosion.

There was a time a few years ago when we had the Berlin Corridor which was controlled by the Russians and the maximum flying altitude allowed in flying from West Germany into Berlin was 10,000 ft. As you know, there were very difficult weather conditions many times. I think that Pan American kept their aircraft flying simply by being able to cover the leading edges of the wings with erosion inhibitor materials which were really pressure sensitive tapes - sticky on one side with a resilient polyurethane material as the backing.

There is a rather strange use of pressure sensitive tapes that we in the industry don't really support. That is the use of a pressure sensitive tape to measure the effectiveness of coatings you put on a piece of metal. There are two specifications, one Federal and one Military, that prescribe the use of pressure sensitive tapes to measure the anchorage of a coating which has been applied to metal. We in the industry do not think that these are very effective because there are so many variables involved in how the tape is applied, how long it is on, how quickly and rapidly you can pull it off and at what angle the tape is removed, that we think we may not be measuring anchorage with validity. So this use of pressure sensitive tapes, from the tape industry viewpoint, is not typically recommended although very very widely used.

Tapes have been used as sacrifical corroders. For example, we have made tapes out of zinc foil with a permanent pressure sensitive adhesive, and applied them on certain military vehicles. We have also put such tape on aircraft and on trucks and allowed the "tape" to sacrificially corrode away, thereby protecting the surface to which it is applied. This again is quite a remote and unusual use for pressure sensitive tapes.

We have all heard about mothballing airplanes and mothballing military equipment. The Marine Corps for many many years had a facility in Barstow, California, where vehicles were stored. Pressure sensitive tapes have been used as a preservation material for many many years in this type of application. The Navy and Air Force utilize this preservation technique on aircraft near Tucson, Arizona, also as both corrosion preventors and corrosion inhibitors. On some aircraft that have been stored in the mothball fleet for 10-15 years, the tapes can be pulled off, and with a minimum amount of cleanup and maintenance, the aircraft is virtually on its way. So, we believe that pressure sensitive tapes have really done quite a good job in helping to preserve military equipment for a number of years and eliminate, or certainly minimize corrosion that would have taken place because the item had been in storage.

I would now like to talk to you about some of the technologies evolving in the pressure sensitive tape field. For many many years people have said we certainly would like to have a tape that sticks well to aircraft, vehicles, or to a cardboard box for that matter, and then, at the snap of a finger, the tape should pull off easily and cleanly. The industry has said for many years that this is impossible. But no longer, because of some very interesting new chemistry.

Due to this interesting, new technology, we now have energy-responsive adhesives that will allow you to have a tape that is very sticky, and then, but subjecting it to ultra violet or to electron beam radiation, you can kill the tack to whatever level you want. So when you are using tape as a corrosion inhibitor, or if you are using a tape as a packaging material, or if you are using tape as a masking material, or for whatever purpose, we now have in our industry the technology to give you a very sticky tape and then have it literally fall-off when you want it to. All of this can occur without adhesive residue, and without excessive expense.

This is actually a silicon wafer (Slide N) which has been etched with circuitry that will go into a hybrid microcircuit. To process this wafer, a pressure sensitive tape is used to hold it as it is being sliced, sawed or diced. After the wafer has been cut into many small pieces, the individual die can be picked off easily because one can detackify the tape down to where it has no tack. It was strong enough to hold the wafer during processing and then detackifiable so the individual die can be picked off with a vacuum probe or by a needle cluster coming up from underneath.

(Slide O) This is a blown-up picture of a 3" diameter silicone wafer which has circuitry and has been diced and sawed through. You can see two of the little die which had been individually removed. This is the
(Slide P) machine that does the sawing and cutting and you can see here again the pressure sensitive tape down near the bottom, sticky side up, holding the wafer as it is being sawed. The adhesive is then de-

tackified so the individual pieces can be pulled off.

(Slide Q)This is a similar application which involves the back side of the silicon wafers being polished. Again, a very sticky tape holds them down but we have the ability to detackify the adhesive so wafers will literally fall off.

Another thing our industry is doing which we thought you might be interested in is in the area of measuring hydrogen embrittlement. There is some new interesting technology in the pressure sensitive tape area that allows one to measure quantitatively the amount of hydrogen entrapped in a structural member, and therefore, estimate the amount of hydrogen embrittlement that has occurred because of that entrapment.

The patent for this process is held by McDonnell-Douglas and tape is used as a tool. In the determination, a patch, similar to a "Band-Aid" is made. The "bandage" portion of the patch is a coating of Neodymium metal on a smooth substrate. The "tape" portion of the "Band-Aid" is a neutral, high temperature tape of low permeability. (usually including aluminum foil).

The patch is placed over the area selected for the test, and secured in place with the tape. The test piece is then heated to drive hydrogen out. The hydrogen reacts with the neodymium metal forming a visible color change at the reaction site. The patent states that by measuring the reaction site and applying the proper calculations, a close approximation of the hydrogen content can be calculated. This helps to predict whether, or how much embrittlement has occurred and what can be expected in terms of the strength of the member.

The old days of the twenty five cent roll of paper masking tape to help paint an aircraft and put a coating on it that will resist corrosion have left.

We are not the only company that makes pressure sensitive tapes, and we think we have a very strong, vibrant industry. We hope that pressure sensitive tapes do provide a useful tool for your people in whatever phase of corrosion prevention and control you work.