Skinning
Causes and Remedies

Extract from Tony Van Dyk's speech to SCANZ Conference 1999

Waterbased paint is liable to skin on the insides of pails and tins. The surface of the bulk paint doesn't normally skin, but a layer of paint on the lid and exposed upper sides of the pail, can dry out and skin.

Skinning of waterbased paints in "plastic" pails has been a problem since the introduction of plastic pails. At Resene we've had sporadic reports of skinning dating back to the introduction of plastic pails. Research and trials have been conducted periodically over the last two decades to try and find a solution for skinning. Some years it didn't seem to be much problem at all. Other years, we would get some complaints, do some work, not find any answers, and the problem would seem to go away about the same time that we gave up! From industry contacts and comments from customers, we've heard that other companies have also conducted trials to test for skinning.

Research at Resene up to about a year ago continued to show variable and contradictory results. Typically we would pack off paint into several types of pails and leave it in a cold, dark corner of our warehouse for a while. When we examined the pails we would generally find only minor skinning. We couldn't reproduce the gross skinning that some of our branches found. When we repeated trials we rarely got the same results. One time we might see a bit of skinning with some pails, but other times we would see hardly any skinning.

Some paints seem to skin more easily than others - low build, higher solids and lower VOC paints, are most likely to skin. Skinning is worse in summer; and some regions, such as Christchurch, find more skinning than others.

Tests using water

Over the last couple of years a number of different theories have been tested.

- We made better seals by putting sealant into the seating and by taping up the lids onto pails.
- We tested different pails and types of plastic.
- We tried washing pails and lids with detergent before they were filled.
- We asked one of our pail suppliers to try different mould release agents.
- Different paints were tested.
- Pallets of paint were stored in different stores and locations.
- Diffusion fluxes of water and gases through the plastic lid and pail sides were calculated.

Sometimes a treatment gave improvement. For a while we thought the location on a pallet might be a factor. It seemed that pails on the top row and those on the outer edges were more prone to skinning. But we couldn't reproduce the results. Other times the location or treatment made no difference. Sometimes most samples were OK, other times most skinned. Washing and mould release agents didn't seem to make any difference. We couldn't tell if one sort of pail was any worse or better than another.

Lower ullage

Tests conducted in mid 1998 using water showed that the Relative Humidity can drop below 50% during a heating cycle. Waterbased paints usually dry within a few hours at Relative Humidities under 70%. Drying conditions in pails can last for several hours. It was not surprising that paint would skin.

The bulk water in the pail took at least 2 to 4 days conditioning at a particular temperature to approach equilibrium. But we noted that the air in the ullage space heated up much faster, usually in about 20 minutes.

From these results and observations we thought we had solved the skinning problem. Smaller ullage pails should give shorter and weaker drying cycles.

The trouble with smaller ullage was that there was less room to mix the paint in. So we reckoned that recessed lids would solve this. Pails with recessed lids would give lower ullage when fitted and should also give shorter and weaker drying cycles. Overfilling should produce similar results. While it wasn't a practical solution, it was something we could test experimentally to verify the new theory.

We tested recessed lids with low ullage. We tested overfilled and underfilled pails. But the results were inconsistent: Not all experiments gave the results expected.

At this point, we realised that we had to work on real paints to develop a better understanding.

Tests using paint

Our experimental method was developed further to quantify the amount of skin formed.

- We tested different paints.
- And systematically tested ranges of temperature steps.
- The time for skin to form was determined.

The experimental method was standardised to first condition pails of paint stored in AS1580 101.5 Routine Laboratory Conditions.

Paint was conditioned for at least one week, and usually for much longer. The paint was mixed and transferred to new pails. The pails were inverted and shaken for 30 seconds to coat the lid with paint. Pails were placed in an incubator at predetermined temperatures for 24 hours, and in some cases several days. Any skin formed was washed off into 500 micron test sieve. The skin was collected, spun and squeezed to remove surplus water and weighed.

The results of this testing were:

- The quantity of skin formed was found to increase with increasing temperature.
- The skin was largely formed within one day. In fact the skin is usually formed within the first 4 hours in the incubator. A longer time in the incubator did not produce more skin.
- There is also a threshold temperature for skin formation. Below the threshold temperature skin does not seem to develop. Several products were tested and found to have different threshold temperatures for the onset of skinning.

- Less ullage resulted in more skin while more ullage resulted in less skin. Different pail types and designs resulted in more or less skin formation. In part this seemed to be related to the amount of ullage.
- Some paints skinned more readily than others. Some paints had lower threshold temperatures for skinning.
- Paints did not skin when stored at constant temperature. Pails of several types and batches of paint have been stored in the lab under Routine Conditions for 4 months without any skin forming.

It was evident that skinning was happening outside equilibrium conditions. When the outside temperature increases, paint on the lid is hotter than paint in the pail. This creates a water vapour gradient inside the pail. The concentration of water vapour is higher near the lid than it is near the paint below. Water is pumped out of the paint on the lid as long as it is significantly warmer than the paint below.

Water can be rapidly lost from warm paint on the lid and transferred to cooler paint below. The greater the temperature difference, the faster water is lost from paint on the lid. Greater water loss results in more skin.

Solutions trialled

Cool storage

Storage in sunlight can cause skinning. Daily temperature cycles, draughts, stock movements, combined sometimes with direct sunlight, can produce temperature fluctuations of more than 15 degrees C. Cooling is OK, but the heating part of these cycles is liable to cause skinning.

Some parts of the country, such as Christchurch, frequently have large daily temperature swings of 15 to 20 degrees. We believe this is the reason why Christchurch have reported more skinning than other regions.

Storage cool results in less skinning. Cold, dark warehouses are best. From experiments in the incubator and lab, paint stored cool and away from sudden temperature changes, should remain free of skin indefinitely.

Insulated pail and pallet covers:

When insulated, the pail still heats up to the same ambient temperature. But it does so more slowly and temperature differences between the pail lid and paint in the pail are smaller.

Insulated covers for whole pallets can cost several hundred dollars, but they protect against sudden temperature changes, drafts, and direct sunlight. We have trialled them and found them useful in some of our branches and continue to use them today.

Plastic liners

A further variation on the pail insulation idea was to insert plastic sheets in between the lid and the paint. A sheet of plastic was placed over the filled pail and the lid fitted on top. A variety of types, thicknesses and textures of plastic sheet liner have been tested. This form of insulation was found to reduce skinning by about a factor of four. The mechanism is the same as before, but done internally. Paint coats the plastic sheet liner rather than the lid. The lid still heats up in response to ambient temperatures. The air gap between lid and plastic liner acts as an insulator and acts to reduce the

temperature of the paint on the liner. Some skin may still form, but it forms on the plastic liner rather than on the lid.

This was trialled with Cashel Street Resene with some success. However, the plastic liners were disposed of at store level, so the paint was liable to skin once it left the shop if not stored at a cool constant temperature.

More paint on the lid?

The explanation of variable results with water led to the idea that retaining more paint on the lid might reduce skinning.

There are several parts to this idea. The first is simply to retain a thicker layer of paint on the lid. Water would still be lost, but with a bigger reservoir there was more chance that the paint layer would remain liquid during the drying cycle. Another aspect is that a thicker layer of paint will respond more slowly to external heating. Temperature differentials will change more slowly and will be smaller, resulting in smaller fluxes of water out of the paint layer.

One way to retain more paint on the lid is to attach a layer of gauze or felt to the lid. Gauze glued to the lid was found to retain paint and prevent skin forming. Only traces of skin formed on the uncovered flanges. Various textures and paint retaining measures have also been found to substantially reduce skinning.

In many storage conditions it doesn't matter what the paint is contained in. As long as temperature changes are small and slow, skinning is unlikely to happen. Also certain types of paint: high build and texture coatings, and low volume solids types, hardly ever skin in pails.

The explanation we've found for skinning is really quite simple. We all know that water evaporates from a warm surface, and condenses on a cool surface. A pail of paint in a warmer environment creates just these conditions. Water leaves the warmer surface and condenses on the cooler surface as long as the temperature imbalance lasts. That is, water will leave the paint on the lid and condense on the surface of the bulk paint. As the water leaves the paint on the lid, it will start to dry, forming a skin.

We've applied for a patent which describes methods of retaining a thicker layer of paint on the lid to reduce skinning. Preventing the conditions which cause skinning is the best solution. But storage conditions are largely beyond our control. We can formulate paints to be more resistant to skinning, but we would impair their performance and drying properties.

Research continues on better textures and on adding textures to the sides of the pail. Pallet covers will still be used where skinning continues to be a problem. After years of development a new improved version of the skinning reduction technology is due to be incorporated into Resene packaging in the near future.