TECHNICAL BULLETIN – TB257

ENVIRONMENTAL EFFECTS ON WATERPROOFING MEMBRANES

2nd September 2024

INTRODUCTION & SCOPE

When products are designed and tested for performance, it is done within a set of specified conditions to allow direct comparison between products and batches. The standard conditions for laboratory testing are generally set between 20 and 23 degrees Celsius and 50-55% relative humidity, with the substrates used for the test substantially dry or at equilibrium with laboratory conditions.

This situation is divergent from real world conditions where temperatures range from low single figures to 40^{0}C plus, and humidity from less than 10% on hot dry days to 100% in rainy conditions. As such, when the membranes are being installed in the field, it is incumbent on installers to adjust for conditions, and not simply proceed when the environment is unsuitable.

In this bulletin, we will examine some of the issues that can arise from not following the recommended installation conditions. These conditions may have resulted in difficulties and failures in the past.

AMBIENT VS SUBSTRATE

There is a misunderstanding that only the ambient temperature + moisture (%RH) needs to be considered, but this is not the case. There are two conditions to consider: the air temperature/% RH and the substrate condition, temperature, and moisture level.

In areas exposed to direct sunlight, particularly in warm weather, the substrate condition is commonly several tens of degrees warmer than the air, especially if it is a darker shade. If the surface is hot to touch, then there is a problem. If the substrate temperature exceeds 40^{0}C then the working/application time will be significantly reduced, and other premature drying issues can follow.

Conversely, in cold weather, the substrate is colder than the air, and this can easily be observed touching external concrete on a cool day, particularly in the morning. The air can be 5 to 10 degrees warmer than the surface, and there will be an even bigger difference if there has been frost. ARDEX applies the general rule that 100C is the cut-off substrate temperature.

Moisture is the final part of the puzzle, and it is nearly always true that masonry on ground or exposed will have different moisture levels to the air around it. Where the air is dry, the substrate surface will be dry too, but deeper down in the material this may not apply, especially slab on ground or below grade situations. When the air is wet, depending on how long and how much rain has fallen, or how humid the room is, the surface will be high in moisture, but not necessarily deeper into the material; an example is a masonry roof or verandah exposed to the weather or a wet area surrounded by dry areas.

These considerations mean the surface needs to be examined and checked for temperature, and moisture testing is always a sound idea when there is suspicion of dampness.

COLD CONDITIONS

Cold conditions apply once the temperature falls below 20°C with progressive deterioration in drying and curing down to 15˚C and then 10˚C. The latter figure is the effective cut-off for many products because below 10°C, the physical changes and chemical reactions related to drying and curing are retarded or even stopped completely. For example, materials containing Portland cement (part of cement-polymer liquid membranes) and epoxy resin, display delayed hardening and cure, and in the case of Portland cement, the reaction grinds to a halt at approximately 5˚C.

While materials such as epoxies or polyurethanes can start reacting again when they warm (assuming nothing has been lost or disrupted), materials that use or contain water as part of the cure are another matter. Cement paste, or a water-borne liquid membrane, can lose its water slowly due to evaporation or absorption into the substrate surface while not curing. In the case of cement, the hydration reaction is stymied, and the cure is incomplete, while for the membrane, the film may not coalesce properly and leave voids and holes. A secondary effect for membranes is that the surface might skin. Still, inside the membrane, it can remain a paste and not cure properly, remain soft, or be susceptible to water re-solvation/extraction of the unhardened polymer fraction when exposed to water (an effect commonly misnamed as ‘re-emulsification’).

An even worse scenario is if the material freezes (≤0˚C), which creates ice crystals that destroy the structure of both polymeric materials and the wet cementitious matrices. Examination of the packaging will usually indicate whether a liquid material is subject to freezing problems.

Liquid materials, particularly resinous products, also tend to become more viscous in cold conditions. This makes them difficult to mix and degrades their workability, flow out, wetting, and self-healing properties.

Hot Conditions

At the other end of the spectrum, hot conditions, in the first instance, produce problems with pot life and working time for the applied membranes. Two-part systems are prone to rapid hardening and loss of workability because the heat increases the rate of reaction; compounding this in two-part resin systems, initially heated materials (where the materials are stored in the sun and not in the shade) when combined, promote a rapidly increasing positive feedback loop in the cure, which is a heat-producing reaction (exothermic) making it suddenly go hard.

When applied to a surface which is hot itself or working exposed to the sun, ironically results in some of the same sorts of issues as cold weather, as well as making its own unique problems. The membrane can rapidly skin on the surface which then traps moisture inside leading to prolonged softness; this can be a worse issue than the cold version because the skin formed is normally less likely to moisture. The membrane can flash dry and not coalesce properly, leading to pinhole porosity, or the water can actually vaporize and bubble out, creating a pinhole.

The hot substrate can rapidly draw water out of a water-borne material. For a cement-containing system, this loss of water degrades the cure. Workability when being applied is often reduced because of moisture loss or partially going to gel, which leads to peeling and stringing, poor healing, and compromised film porosity.

A point that catches the unwary is working indoors with picture windows, which allow direct solar heating and can act as a greenhouse, making the room hot and stuffy. The ambient conditions can easily mirror the external shade conditions where the building is not properly enclosed.

WIND AND AIRFLOWS

In an external environment, wind is a constant factor that needs to be considered for any sort of installation that involved liquid materials.

Dry and hot winds produce rapid and flash surface skinning, mud cracking, and reduced workability.

Cold dry winds create a form of wind chill on damp surfaces because they produce a degree of evaporative cooling on the surface. So, in addition to removing moisture, they also tend to drop the working surface temperature even further.

Surface drying can also be a problem where fans are used for internal situations and they blow directly onto the surface of the membrane and not simply just provide ventilation.

Winds also carry debris and dust which can become trapped or incorporated into the membrane or contaminate the surface as it is being applied.

RAIN AND HIGH HUMIDITY

When the humidity starts to approach 100% RH, the water coalesces, and rain starts to form and then falls. Rain is almost always predicted by the Weather Bureau and there is no excuse for being caught out by wet weather.

Rainfall can occur at any time of year, but in Australia, there are periods when it is more likely to fall.

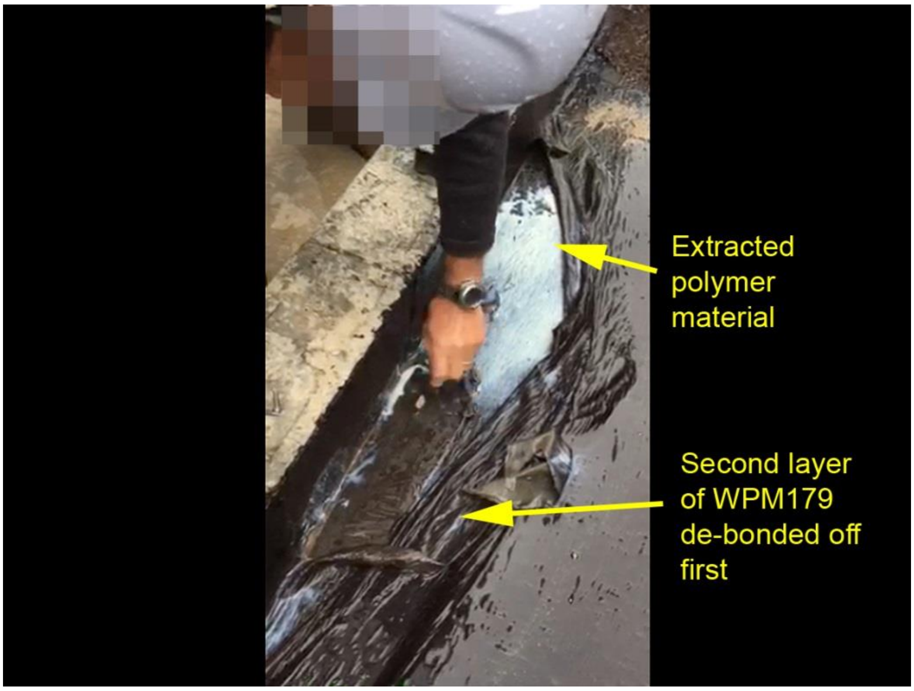
For example:

- The Northern Territory, Northern Western Australia and North Queensland have monsoonal climates and heavy rain falls in the summer months, while the cooler months are the 'dry',
- In eastern NSW and SE Queensland the rain tends to fall in the late summer and autumn,
- Tasmania, Victoria, and the SW of Western Australia have cold damp winters,
- Heavy rain associated with thunderstorms after a 'change' on hot southern Australia days, or when topical lows or cyclones threaten,
- Snow and rainy sleet in the alpine areas.

Another related effect is the development of wet mists, fogs and dew which leave a sheen of moisture on exposed surfaces. This is a consequence of reaching the dew point where the air can no longer hold the moisture as a vapour, and it then deposits out as a cloud and the moisture settles on surfaces that it touches. Another classic example of this is the dew that forms on cold external objects, on otherwise clear nights.

The effect of moisture falling onto uncured or partially cured membranes is variable. Whilst moisture cure urethanes can actually cure faster when dampened, epoxy resins can be inhibited because the water affects the amine catalyst. Water falling onto water borne membranes and cement containing ones, results in the material not drying, and if soft enough, being diluted and even washed away. Strong enough rain can produce physical damage to the surface such as cratering and pinholes and leads to water being trapped in and under the membrane. Where water lands on the surface between coats of multiple coat systems, this typically disrupts the performance of the second layer applied.

This problem can be seen in the image below, where the first and second layers of the membrane have not physically welded together because water has accumulated between them. The white material is hydrolyzed and remobilized water-borne polymer extracted from the second layer (so-called re-emulsification), where it sits on the water-covered first layer.



In near marine environments, onshore winds carry water droplets and salt deposits, which tend to coat surfaces with a damp, sticky film.

Humidity is moisture held in the air as vapour. There is an equilibrium between water evaporating out of a surface and entering the air and vice versa.

We have already stated that low humidity (warm air and drying winds) results in rapid moisture loss from a membrane, but high humidity, greater than 70%, starts to impede the exchange of moisture and slows down drying.

Above 85% humidity waterproofing materials such as ARDEX WPM300 display retarded drying and slower cure (although this water borne epoxy can eventually cure under water). In an external environment where the humidity is high (for example near coastal environments or rain pending), the surface drying properties of applied materials can be poor, leaving them susceptible if water falls or condenses on the surface.

Working in enclosed spaces without ventilation also can create a situation where the localised humidity increases, and then retards the drying properties of applied products. This can be seen in waterproofed bathrooms in cool and damp weather, where the applied membrane remains soft, or extremely tacky for several days. It can also happen with some cement-based materials as well.

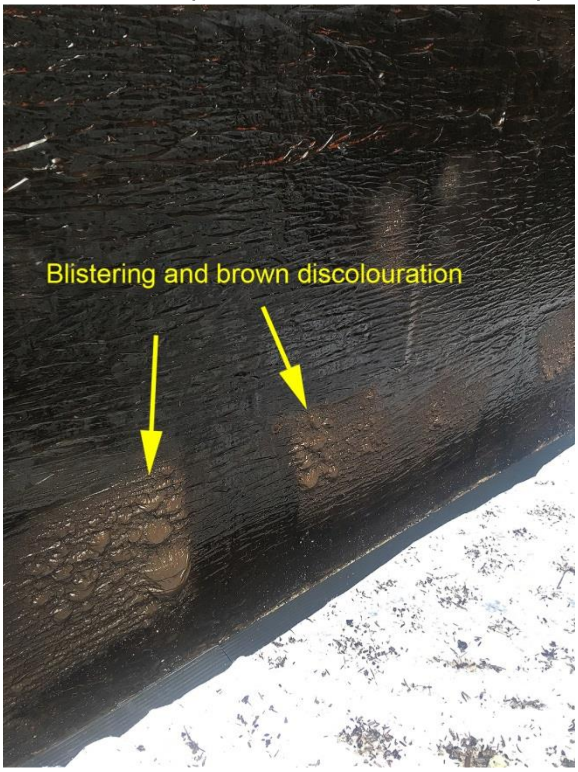
SUBSTRATE MOISTURE

The final part of the issue is substrate moisture. Where a surface is damp, this compromises the performance and adhesion of many types of membranes unless they are specifically designed to be a moisture barrier. But, even some materials, such as epoxies and urethanes can have limitations as to how wet a surface can be, since moisture can interfere with the cure or ultimate bond.

Another effect can be that the moisture penetrating through the drying membrane delays the drying process and possibly impedes the cure, but it also produces blisters, bubbling, or, in some extreme cases, pinholes as it escapes through the drying film.

There are two common types of blisters associated with membranes.

a) Water vapour that is mobilised by sun exposure. The sun falling on the surface heats and causes the water to vaporise and generates a blister. When the surface cools back down, the water vapour coalesces and the blister subsides, however the membrane has been stretched and damaged regardless.
b) Water filled blisters that arise from hydrostatic pressure. In this case we are usually referring to below grade areas where ground water can be present, or the situation where moisture can develop a head of pressure due to the height of the water column. A latter example being water saturated masonry walls, such as blockwork were the upper surfaces or top edge is exposed to rainfall which then penetrates and percolates down. An example is shown below.



This image shows water blisters in a membrane not designed to resist hydrostatic pressure, and water accumulating in the wall structure due to rainfall on the top.

In this situation, a membrane system (positive side waterproofing) requires a hydrostatic moisture barrier as the primer to suppress the moisture, or the substrate has to be left to dry out sufficiently.

SOLUTIONS TO AVOID THESE SORTS OF PROBLEMS

Temperature extremes are difficult to avoid; scheduling works in expected weather extremes should be avoided, but if there is no choice and they are not accounted for, then problems tend to follow.

In hot weather,

- Avoid working in the heat of the day. Work in the evening, early morning, or at night. The substrates will take some time to cool after extreme highs.
- Shade the working area(s).
- Keep all products stored in cool conditions and outside the direct sun.
- Do not add water to products that are not intended to be diluted.
- Mix smaller quantities at a time to reduce self-heating.

In cold weather,

These situations are more difficult to deal with than hot conditions.

- Keep all products stored out of the cold, especially products not intended to be frozen
- Warming materials to around 35^{0}C can help, but they will go to the substrate temperature rapidly when applied.
- Use heated tents or enclosures around work areas.

High humidity and wet weather,

- Installation when rain has recently fallen, is currently falling, or is expected to fall has to be avoided where possible.
- Check the weather forecasts. Don't work in the rain; take extra precautions after extreme rainfall.
- Use tents or protection to cover areas to be worked on.
- Remove water accumulated from rain and allow the area to dry.
- Use fans or driers and ventilation to remove moisture and lower humidity.

Damp substrates,

- Use an appropriate moisture barrier as a membrane or membrane's primer.
- Make sure that below-grade drainage is adequate.
- Prevent water from getting into building elements in the first place (protection of parapets).
- Test for moisture content.

General considerations,

- Several thinner coats of most membranes are superior to one or two overly thick coats. This allows for more effective drying and curing overall.
- Aim for the correct film thickness and select the correct product for the application

REASON FOR REVISION-ISSUER

Change of slogan and address