

TECHNICAL BULLETIN – TB130

SOURCES OF GROUT DISCOLOURATION REAL AND PERCEIVED

Date: April 17th 2020

INTRODUCTION & SCOPE

One of the most common complaints that ARDEX and other companies in the dry powder construction chemical industry receives is discoloured and patchy cementitious grout. The response of the complainant is nearly always that the grout is faulty, but this simplistic assertion ignores the fact that ARDEX has a Quality Control regime (ISO9001) which is intended to pick up this type of issue. When we receive the dry grout powder to test, we always find that it mixes normally and dries to a consistent colour. Therefore, with the exception of a few unusual circumstances, the problem is related to something which has happened on site. There can be a number of causes of these phenomena and this bulletin will look at the issues involved.

COLOUR DOES NOT SEEM TO MATCH SAMPLES

NATURAL MATERIALS

The grouts are made from materials including cement and coloured oxides. These are based on natural substances and there can be a degree of variation in both the raw feed stocks and hence finished product. This can lead to slight variations in the colour of the grout itself, and the colour quality control at manufacture is actually a narrow range of values, not a single fixed colour measurement.

VISUAL PERCEPTIONS

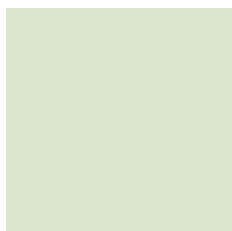
In some cases, there is a visual illusion where the colour of the grout does not seem to be right when adjacent to the tile. For example, ARDEX supplied a grout product that came in two different shades of white. Though both looked white, one in fact was slightly blue-grey (blue gives better contrast), but this was not always apparent till put up against a white tile. It is a good idea to try and compare the tiles and grout at the time of purchase.



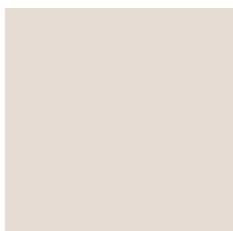
These two examples show what effect can occur with a faintly blue-white grout such as white against different coloured tiles

It is also important to recognise that fluorescent, incandescent and natural light will all change the perceived colour of an object. The most accurate colour comparisons are done under sunlight, but it may be necessary to compare samples under the light in use at the site.

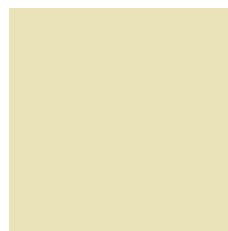
Here are three examples of the same colour but what can happen when viewed under different lighting conditions.



Under fluorescent lights



Natural light



Under incandescent light

SAMPLE SWATCHES

The printed colour swatches on the grout packaging are for information only and are restricted by the printing process and may vary from the mixed colour.

The powder grout in the bag is usually a pale colour which is predominantly due to the cement. The mixed colour is darker and different in tone, so the dry unmixed powder shall not be used as an indication.

SHELF LIFE

When grouts have exceeded their recommended shelf lives, the changes in the cement component due to ageing can result in unpredictable colour effects. Some colourants may also alter with time.

Grout passed its shelf life shall not be used for this reason, as well as possible problems with cement curing.

NON-UNIFORM JOINT DEPTH

When tiles are laid and properly bedded, the adhesive is squeezed between the tiles into the grout lines. Part of the process is to clean the excess adhesive out of the grout lines preferably whilst it is still soft. However, it is not unusual for

this not to happen, and then the next day, the grout is placed into the gaps and finished.

Another effect which occurs, is that because the adhesives are supposed to be applied with a notch trowel and the notch lines are rarely completely collapsed to make a continuous adhesive bed, you have an alternating pattern of adhesive and voids under the tile. Heavier beds applied with larger notch trowels make both situations occur more easily.

What happens next is shown in the attached photo of a complaint, and the explanatory schematic diagram. As the grout dries at varying thicknesses in the grout lines, the chemical reactions for cement occur differently, in part because thinness vs thickness changes the way the water stays in the grout to react the cement, but also due to the differing properties of the adhesive vs any voids and exposed substrate. Where the grout is thinner it dries lighter, and where thicker dries darker. This pattern is then reflected in the grout and you end up with a set of zebra stripes in the grout lines. The intensity of this coloration pattern varies but is easy to spot with darker grouts.

Figure 1.

An example of light-dark shading in grout lines due to apparent varying thickness of grout

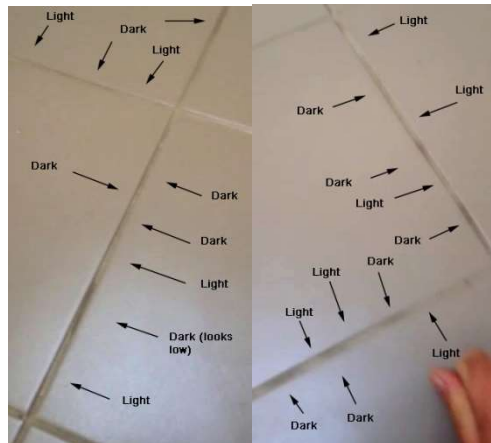


Figure 2.

Schematic diagram showing how the light dark shading effect occurs

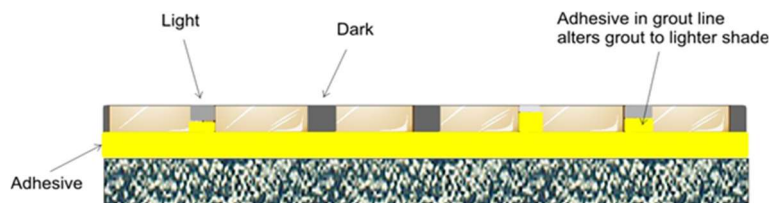
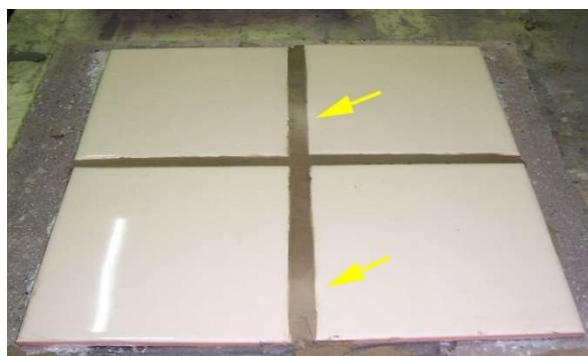


Figure 3.

An example of grout shading deliberately created in a laboratory trial, by not fully removing the adhesive from the notch lines. The areas of thin grout are arrowed. Note that the horizontal line of grout is correct color. This test grout came from another site complaint



UNEVEN TILE GLAZE ON EDGES

This can result in variations in colour due to differences in moisture absorption by the tile. This can be limited by misting the edges of the tiles with a fine water spray prior to grouting.

INSTALLATION & SITE MOISTURE ISSUES

The grout application can have a bearing on the final colour due to both practice and site conditions.

OVER-WATERING

The grout is designed to be mixed with a certain ratio of water to form a soft paste of roughly creamy consistency that holds its shape like traditional toothpaste. Examples of mixed grout are shown in the next page.

Where the installer has added too much water, this can alter the colour due to both alterations in the cement properties and separation of the colouring oxides from the mix. Also, the excess water takes longer to dissipate from the grout leading to apparent darkness, however the final resultant grout can be paler than expected, and streaky or blotchy in appearance.

There is no simple remedy to this problem other than re-installation.

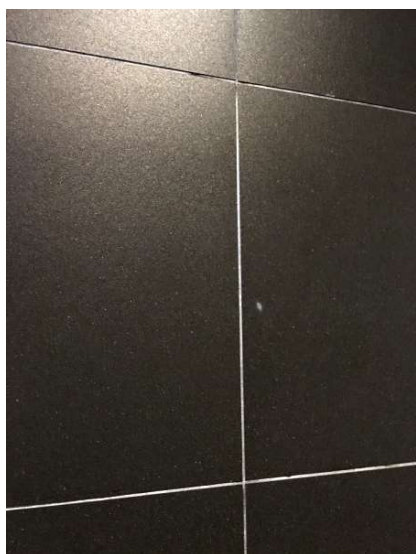


Figure 4a.

An example of over-watered black grout. Note the white bleached colour typical of grout where too much water is added.

Careful examination will also show track marks due to variable grout thickness, likely a result of failure to clean grout lines of excess adhesive.



Figure 4b

An example of the same grout mixed with the correct amount of water and cleaned using a fabric cloth with minimal wash water. Colour is correct and consistent. No tracking can be seen because grout is constant thickness because excess adhesive removed from grout lines.

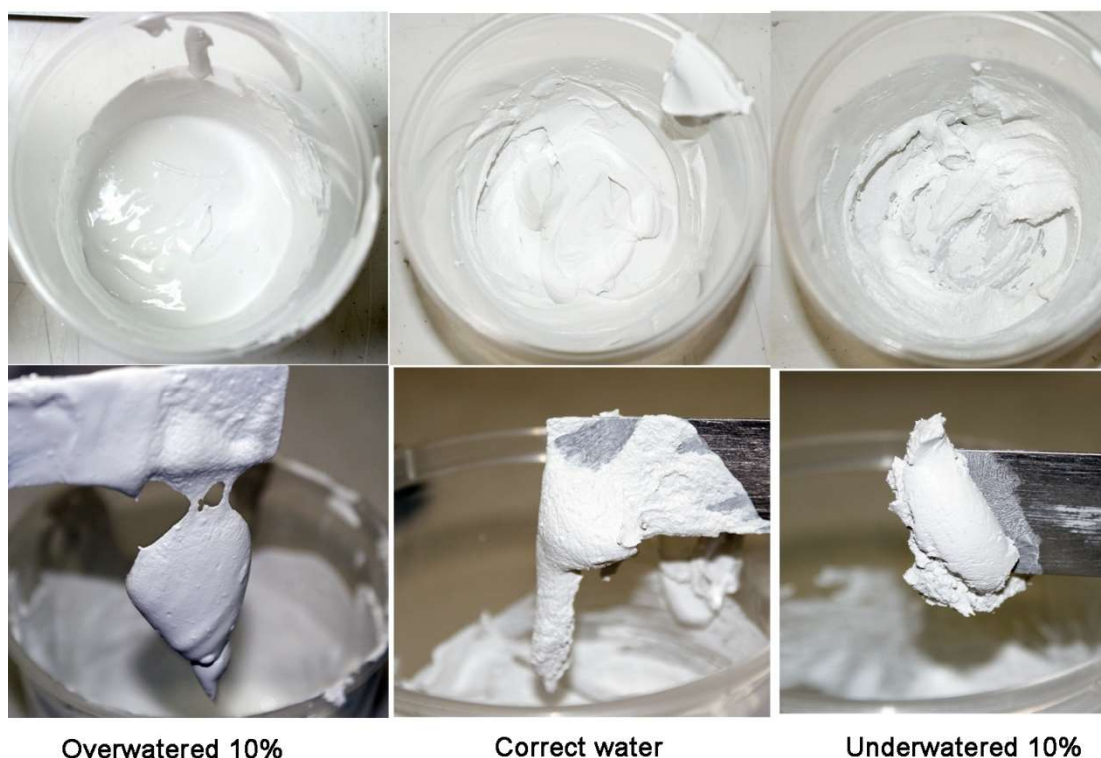


Figure 5. Examples of mixed fine-grained grout.

The 'Goldie Locks effect': the one on the left is too thin and flows and runs, the one on the right is too thick and gritty, and the one in the middle is just right with some slump.

POOR MIXING

If the grouts are badly mixed, then the colours can be variable because the colourants are not properly dispersed through the grout.

Ensure grouts are thoroughly mixed before application and mixing should be sufficient to ensure water is absorbed. The grout powder is added to water and mixed to achieve a consistent paste, let stand for 3 minutes, restirred and then applied.

CONTAMINATION

As trivial as it may seem, ARDEX has seen examples of grout colour complaints that resulted from using dirty mixing buckets. Always use a clean bucket, and drinkable water. We have also seen problems where coloured brushes and pads with leachable dyes are used to clean the grout.

GROUTING TOO SOON AFTER FIXING THE TILES

If the grout is installed onto adhesive that is not dry, then the extra moisture in the system can alter the colour due to changes in the cement component cure. This is a more extreme version of failing to remove the tile adhesive from the grout lines before applying the grout.

EFFLORESCENCE

Efflorescence (which means "to flower out" in French) is the loss of water (or a solvent) of crystallization from a hydrated or solvated salt to the atmosphere on exposure to air. This is a physical condition that occurs where water soluble salts rise to the surface, and then when the water evaporates, the salts deposit out as a powdery or crystalline crust.

There are two types of efflorescence:

Primary Efflorescence

"Primary efflorescence is named such, as it typically occurs during the initial cure of a cementitious product. It often occurs on masonry construction, particularly brick, as well as some firestop mortars, when water moving through a wall or other structure, or water being driven out as a result of the heat of hydration as cement stone is being formed, brings salts to the surface that are not commonly bound as part of the cement stone. As the water evaporates, it leaves the salt behind, which forms a white, fluffy deposit, that can normally be brushed off".
(<http://en.wikipedia.org/wiki/Efflorescence>)

These salts mainly come from cement-based substrates such as the floor slab, adhesives or grouts.

Secondary efflorescence

Secondary efflorescence is named such as it does not occur as a result of the forming of the cement stone or its accompanying hydration products. Rather, it is usually due to the external influence of concrete poisons, such as chlorides or mobile carbonates. This 'saline' solution is absorbed into the concrete, where it can begin to dissolve cement stone, which is of primary structural importance. Virtual stalactites can be formed in some cases as a result of dissolved cement stone, hanging off cracks in concrete structures. (<http://en.wikipedia.org/wiki/Efflorescence>).

In areas of high-water table and rising damp these salts can come from the ground water and contain chlorides and sulphates.

Grout

Efflorescence is typically associated with the grout lines due to these being more porous than the tiles although the efflorescence may have come from other cement-based sources.

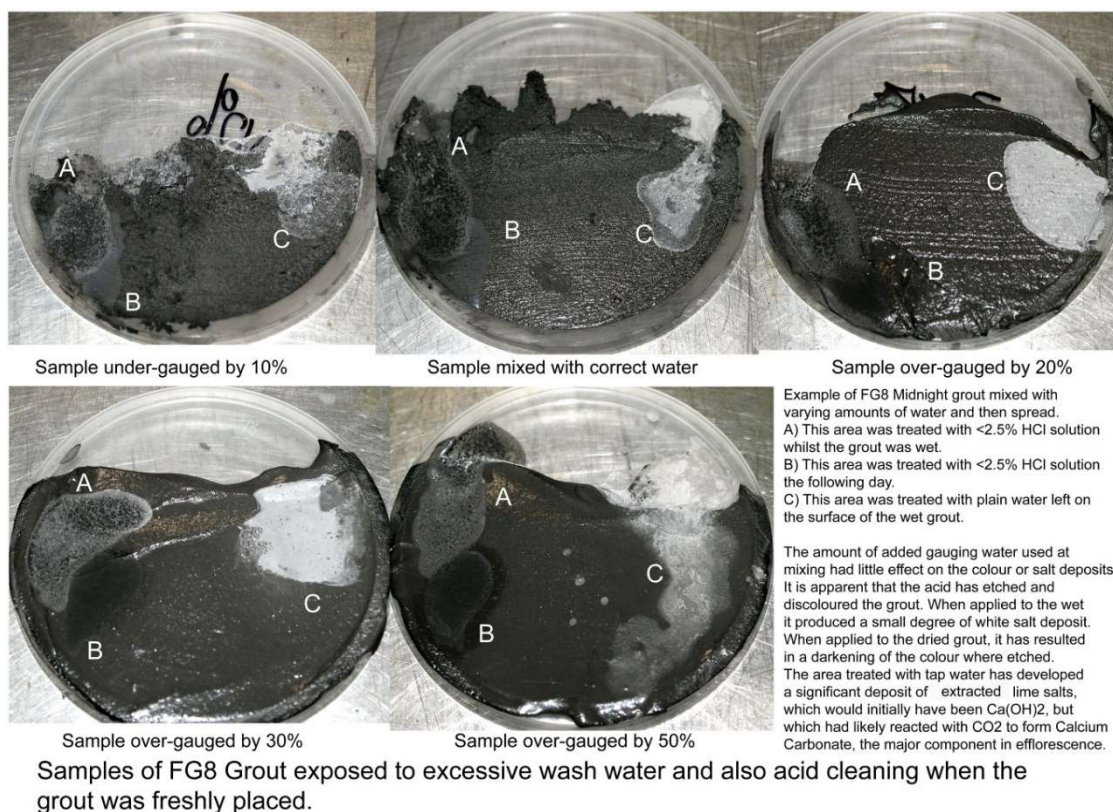
With grout, efflorescence is typically whitish in colour and results from soluble calcium salts being deposited. It can be blotchy or produce an overall light colouration. Primary efflorescence occurs immediately and secondary occurs at a later date.

Dark coloured grouts are more likely to show efflorescence due to colour contrast and *all* cement-based materials can show efflorescence.

Efflorescence occurs due to several conditions and is made worse by cool temperatures and overall dampness; therefore, winter and coastal or very humid environments are more likely to show efflorescence.

Sources

Where the tile installer has used excess water in both mixing the grout and also clean up, soluble salts can be leached from the grout cement (this also applies to the tile adhesive) and then deposits on the grout surface as drying occurs. This is seen below in Figure 6.



Cool temperatures at the time of installation both prolong cement curing and also retards water evaporation. This can increase the likelihood of efflorescence.

Where there is ground water, rising damp or damp slab, soluble salts can move with the ground water, or be leached from the slab, tile adhesive or grout and deposit on the grout, since this is the most porous area for evaporation to occur. Efflorescence may also appear on porous tile surfaces (e.g. terracotta) and brickwork. Ground water and rising damp are beyond the scope of this bulletin but should be addressed as they lead to other more serious problems.

Rainwater running down tiled facades between the masonry walls and the tiled surface can generate significant efflorescence on the grout lines. Run off can also create efflorescence on the edges, but also within the field of decks and verandas (Figs 7a-b and 8).

The tile grout has been applied too soon after the tile adhesive which has not fully dried. The moisture from the tile adhesive then leaches through the grout carrying soluble salts which deposit at the surface.

The slab or screed was not dry, or insufficiently cured and then moisture travels up through the grout. A source of unexpected water can occur in external situations where water has not been removed from unfilled grout lines in newly tiled surfaces, after rain has fallen, but also if water has penetrated under the tiles and sits in adhesive voids. This problem is not only an issue for cement-based grouts but can interfere with the performance of epoxy grouts too.

Figure 6a-b below shows some examples of secondary efflorescence where the grout is not the causative source.

Solutions

- I. Stick to the correct water mixing ratios during installation.
- II. Check that the slab or screed is properly cured and dry. Slabs typically take 28 days to cure, though drying is typically 25mm per month (1mm per day) of slab thickness. Screeds take around 7 days to cure, and dry around 1mm per day.
- III. Check that rising damp is not present.
- IV. Try to work at temperatures above 10°C and have adequate ventilation to promote water evaporation.
- V. Allow adequate curing times for the tile adhesive.
- VI. Where rising damp occurs a subfloor membrane may be required.

Cement derived efflorescence can be washed off by several processes -

- I. Where it is light, use of a **white** nylon bristle brush can loosen the powder enough to be vacuumed up.
- II. Where the efflorescence is slight to medium, scrubbing with a white bristle nylon brush and several water washes should progressively remove the deposits.
- III. A more aggressive method is to use white vinegar (commonly around ~5%-10% Acetic Acid) which will neutralise the deposits and dissolve them. Thorough water rinsing is required afterwards.
- IV. Use a commercial efflorescence/contaminant remover following the product instructions such as ARDEX ACP23 or ARDEX ACP25.
- V. Medium to heavy efflorescence may require more vigorous methods of cleaning and *should not be done as a regular practice*. This involves using a dilute solution of Hydrochloric Acid (<5%) and a stiff white nylon brush. The acid will need to be *neutralised* afterwards either by household ammonia or 10% Sodium Carbonate solution (10gms washing soda dissolved in 100ml water). This is then followed by water washing to remove the residues.

WARNING – WHEN USING HYDROCHLORIC ACID, IT IS COMMERCIALY AVAILABLE IN APPROXIMATELY 32% SOLUTIONS WHICH ARE HIGHLY CORROSIVE AND ALSO RELEASES IRRITATING ACID VAPOURS.

(HYDROCHLORIC ACID MAY ALSO BE CALLED MURIATIC ACID OR SPIRITS OF SALTS).

NEVER ADD WATER TO ACID WHEN DILUTING THE ACID. ALWAYS ADD ACID TO WATER WITH STIRRING.

WEAR SAFETY EYE WARE, PREFERABLY GOGGLES. IF THE ACID GETS INTO THE EYES, WASH IMMEDIATELY WITH FLOWING WATER FOR 10 MINUTES AND SEEK URGENT MEDICAL ATTENTION.

WEAR PROTECTIVE RUBBER GLOVES.

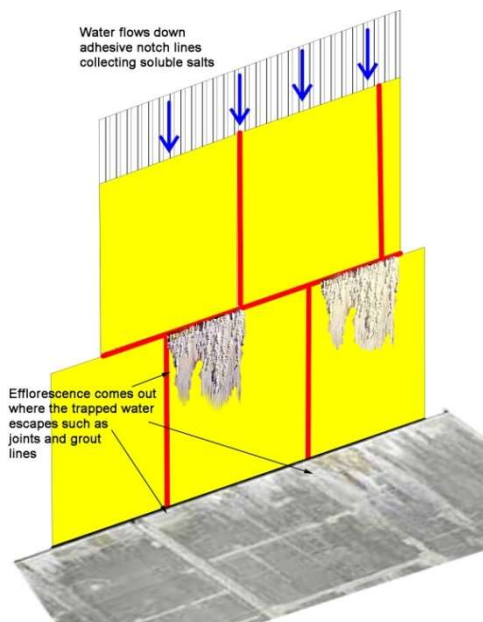
SUPPLY GOOD VENTILATION TO REMOVE ACID FUMES.

THIS ACID WILL READILY ATTACK UNPROTECTED STEEL, ALUMINIUM AND MAY ALSO MARK STAINLESS STEEL. IN ADDITION, SOLUTIONS MAY REACT WITH CONTAMINANTS IN SOME TILES (SUCH AS UNGLAZED TERRACOTTA AND BRICK) AS WELL AS ATTACK CONCRETE PAVERS, TILES AND CEMENT MATRIX TERRAZZO.

NEVER USE SULPHURIC ACID FOR THIS PROCESS.

Figure 7a-b.

An example showing how secondary efflorescence can develop in a masonry wall due to movement of moisture under the tiles, and in contact with cementitious materials. This problem is not caused specifically by the grout.



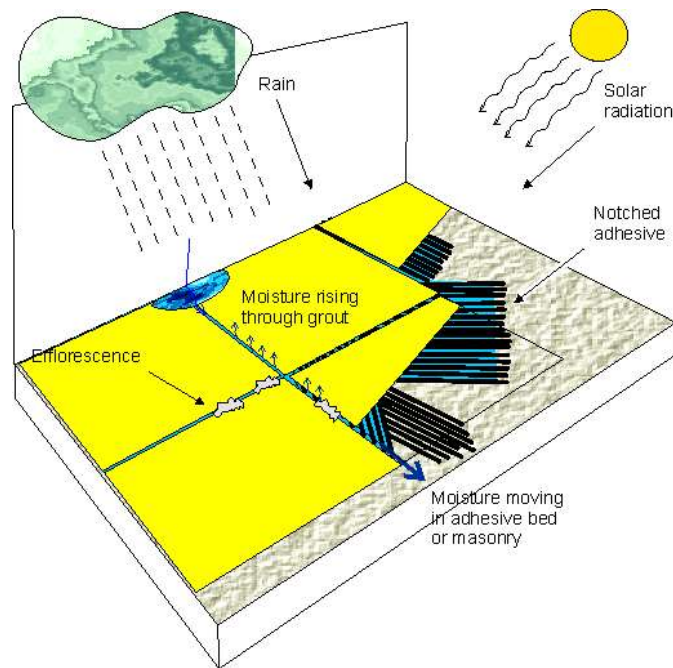


Figure 8. Another situation where water trapped in adhesive voids moves down the falls, or even ponds, and collects soluble materials. Solar heating of the tile surface drives the dissolution more aggressively and then encourages re-deposition of the salts rapidly where the water can escape.

DISCOLOURING UNDER SEALERS

Where a sealer has been applied too soon after the grout has been installed, the moisture from the grout, and probably the adhesive can rise to the surface under the sealer and produce colour variations and patchiness.

The grout and adhesive must be allowed to cure and fully dry for at least 14 days before sealers are applied.

COLOUR LEACHING IN POOLS

Where a coloured grout has been used in a pool or chlorinated pond, the chlorine acts as a strong oxidiser or bleaching agent and will over time fade the grout colour. Therefore, ARDEX does not recommend the use of coloured grouts other than whites in these situations.

Note: Bromine compounds used in spas are even more aggressive than chlorine chemicals.

MOULD GROWTH

Mould and algae are ancient forms of plant and well adapted to survival. Black mould can grow on the grout surface where the installation is dirty, the area is dark and ventilation poor.

The simplest solution is to clean the surfaces regularly and have adequate air movement to allow moisture to disperse.

POST INSTALLATION CONTAMINATION

Dirt and other rubbish can change the grout colour due to settling on the grout before it dries, or from dirty tools and/or work areas. Always ensure tools, mixing containers and work areas are clean before starting the job.

Never add extra colourants or other additives not approved by ARDEX as these can alter the grout properties in unpredictable ways.

A usual situation we have seen concerns brown staining from the chemicals that extract from eucalyptus leaves that sit on tiled surfaces, especially when left for longer periods in damp conditions.

CLEANING

Cement based grouts are porous even when they contain additives such as Grout Booster. As a result, they can discolour over time with cleaning, and this is particularly noticeable where the grout is a light colour.

Use of excessively concentrated acid when cleaning will cause severe discolouration and decomposition of the grout.

Use of concentrated bleaches will have the same effect as pool chlorine.

Domestic and some commercial cleaners contain acidic components (such as Phosphoric Acid and Sulphonates) and others contain organic acids such as Acetic Acid (vinegar), Citric Acid and citrus oils, and other types such as Lactic Acid. These chemicals when used incorrectly or excessively, result in colour shifts and patchiness, but also chemical attack of the cement and decomposition of the grout. It is preferable to use neutral detergent cleaners such as ARDEX ACP21.

WEATHERING OF EPOXY GROUT

Epoxy grouts used externally tend to gradually chalk when exposed to UV light (though this is not a significant problem in pools). This whitish powder can be removed with a stiff brush. Light coloured epoxies can also develop a degree of yellowing in external environments (see below), or when exposed to excessive water whilst uncured. These weather effects are an intrinsic property of epoxy materials and have to be taken into consideration when these products are to be used in external environments. Specialised epoxy resins which eliminate or minimise these problems are being used in ARDEX grouts such as EG15.

UNUSUAL ISSUES

We will finish the discussion of grout colour issues with some other unusual situations, but ones we have seen more than once.

Orange-brown shading

This has occurred from time to time with lighter coloured grouts, and the shading is darker next to the tiles and then lightens towards the centre of the grout line. Detailed investigation revealed the source of this problem was migration of iron oxides from the incompletely fired tile biscuit migrating into the grout and tinting it a rusty orange colour. The solution was to not buy cheap tiles.

Whitish deposits appearing at the edges of metal tiles and trims

This is another usual situation that can arise when the base metal of aluminium tiles is exposed to the high alkalinity of the cement in the grout leading to the formation of aluminium hydroxides. Where the tiles are anodised and this coating is intact, corrosion is unlikely, but if the bare metal is exposed this can be a problem. As a side issue, grout with sand in it can and has scratched the surface of metal tiles when being applied/removed and led to disfigurement.

Rust deposits appearing at the edges of metal tiles

Rust can appear at the edges of tiles made from poor quality stainless steel when used with cement-based grouts. This is a case of simple corrosion of the iron component of the steel.

Blue-green deposits on copper containing tiles or in contact with plumbing

This is a similar situation to the grout being in contact with other metals. In this case the oxide/hydroxide/carbonate is blue green and is composed of copper salts; a type of the verdigris familiar to anyone who has seen weathered bronze statues.

Some epoxy grout issues

Yellow-orange staining of epoxy grouts

We have observed a number of cases where white epoxy grout (types that contain some reactive diluent solvent) which was used for grouting tiled benches and splash backs and has come into contact with particle board or MDF. The solvent in the grout appears to have leached lignins or other organic materials such as the binder resin from the cut edges of the composite into the grout edges. This resulted in the grout changing colour to a pale yellow. Ideally there should be no grout at the junction between the tiles and the wood, and this should be a sealant joint.

Yellowing in any lighter coloured grout can also be the result of using excessive amounts of clean up water and also some chemicals used in it that are too concentrated, but also UV exposure from sunlight. In these cases, the surface is usually the effected part and a grout scraper can be used to remove the surface of the grout to expose the original colour underneath.

Note: Epoxy grouts that have aged in storage (past their shelf lives) can show yellowish shading when mixed because the amine catalyst becomes darker brown as it ages. This is normally clearly visible when the materials are opened for use.

Green-blue staining of epoxy grout in contact with copper

Another usual situation can occur when copper containing tiles are in contact with epoxy grouts and water is present. It appears the copper reacts with the amine catalyst to create a form of the intensely blue copper tetraamine complex around the edges of the metal. We were first alerted to this situation by a person installing copper coins as the tiles into the epoxy grout.

RESOLUTION OF THE PROBLEM

When conducting a grout problem investigation, and any of these problems are present, the first thing to do is mix any available unused material on a piece of board or in a cup, with the correct amount of liquid and then confirm that it dries correctly and there are no colour variations or issues.

Clearly if it dries a consistent colour and is hard and sound then the grout itself is not the problem. When the mixed material is correct in appearance, then the argument that site issues are involved is clearly a valid conclusion, and not faulty grout.

If the grout still is patchy or there is some other problem, then further investigation may well be needed, and the material returned for examination. Examples of several such investigations of grout colour/patchiness complaints since 2009 are shown in Fig.9 on the next page.

When the grout is not at fault, then it becomes necessary to examine the entirety of the installation and its surrounding environment to look for other causes.

Corrective actions for problematic grout that cannot be cleaned effectively may be required, such as;

- Removal and replacement with the original grout type,
- Replacement with an epoxy or pre-mixed grout or even,
- The use of an epoxy grout paint.

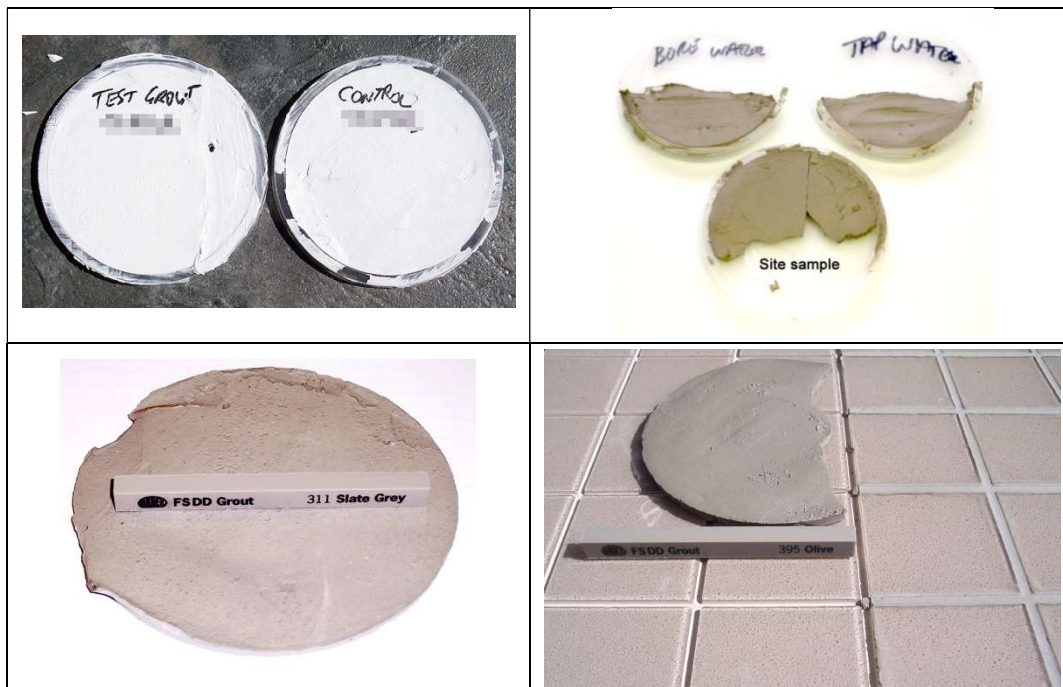




Figure 9.

Examples of grout from site complaints to check colour fidelity. As can be seen, the samples are consistent colour, including the sample mixed with bore water.

In one case, it can be seen the shade of the grout samples had not displayed any significant change in four years.

IMPORTANT

This Technical Bulletin provides guideline information only and is not intended to be interpreted as a general specification for the application/installation of the products described. Since each project potentially differs in exposure/condition, specific recommendations may vary from the information contained herein. For recommendations for specific applications/installations contact your nearest ARDEX Australia or ARDEX New Zealand Office.

DISCLAIMER

The information presented in this Technical Bulletin is to the best of our knowledge true and accurate. No warranty is implied or given as to its completeness or accuracy in describing the performance or suitability of a product for a particular application. Users are asked to check that the literature in their possession is the latest issue.

REASON FOR REVISION – ISSUER

PERIODIC UPDATE

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