TECHNICAL BULLETIN

WATER CHEMISTRY FOR CEMENT BASED ADHESIVES AND GROUTS IN TILED SWIMMING POOLS

INTRODUCTION & SCOPE

The purpose of this bulletin is to provide an initial understanding the effect of some of the chemicals used in swimming pool water have on cement based adhesives and grouts used with ceramic tile finishes. The chemicals of concern are the Calcium based and the Sulphate based compounds that affect the mineralogy of the tile grouts and adhesives. While this bulletin is primarily related to tile finishes in immersed conditions, overflow and frequent wetting in the adjacent splash zones around pools may also show these effects.

CALCIUM HARDNESS

Hardness is said to be a measure of the Calcium and Magnesium dissolved in the water.

Pool water is said to be ***hard and non-aggressive*** when the Calcium level (expressed as Calcium Carbonate) exceeds, or can be maintained at over 200mg/L. In this situation Calcium is ***not leached*** from cement based materials and the tile adhesives and grouts will remain in good condition.

Where the pool water has low (<90 mg/L) Calcium levels, it is said to be ***soft and aggressive*** towards cement based materials. Calcium may be leached from the tile adhesives and grouts to such an extent that the grout is removed from joints between tiles and the tile adhesives may be weakened sufficiently to allow debonding of tiles.

High levels of Calcium may lead to lime scale (Calcium carbonate) deposits building up in the pool plumbing system. To prevent these deposits occurring, the pool water Calcium hardness levels have been recommended to be in the range 90 - 200 mg/L.

It is has been noted that when the water has low Calcium hardness and low bicarbonate alkalinity levels, the pH value may still be high (indicating overall alkaline conditions) and the water is still aggressive to cement based products. This may be corrected by using a water treatment that adds Calcium salts to the water.

The chapter on Calcium hardness in GB65 - 1998 (see references) indicates that the water supply in most Australian cities is soft, except in Perth, Adelaide and some country areas. Melbourne water is said to be particularly soft. The importance of correctly maintaining the pool water chemistry should always include the Calcium and Sulphate chemistry .

THE SULPHATE EFFECT

The effects of soluble Sulphates on cement based mortars and grouts are dependent on the Sulphate concentration. BS 5385.4 - 2015 states that the maximum permitted concentration of soluble Sulphates is 300 mg/L (expressed as SO_3 equivalent to 360 mg/L SO_4).

Sulphate weakens cement based products by changing the original cement crystalline form to an expanded, mechanically weaker crystalline form. This leads to deterioration within the cement based grouts as the expanded structure becomes more susceptible to chemical attack and physical stress.

Cement based products form strong bonds to the substrate and within adhesives and mortars by reacting (hydrating) with water and forming crystals that lock into the pores at the substrate (concrete) surface or interlock with each other in mortars and adhesives. These crystals may be considered as mechanical anchors and the bonding formed is very strong. Chemical alteration by the sulfates in the pool water changes these crystals to long thin needle-like shapes that are weaker than the original crystalline shapes.

Where both low concentrations of Calcium compounds and high concentrations of Sulphates occur, the corrosion effect is accelerated.

ACIDITY

The pH is a measure of the acidity or alkalinity of pool water and the ideal value is 7.5 with the normal range between 7.2 and 7.8. The scale ranges from 0 to 14 where acidic conditions are indicated at low values below 7, and alkaline conditions are indicated by high values above 7. The value 7 is set at the reading of pure water which is said to be neutral, neither acidic nor alkaline. The pH may vary in a pool with the effects being sore eyes or itchiness, accelerated corrosion and possibly

scale formation, reduced effectiveness of chlorine sanitisers and increased cloudiness of the water, especially when the pH is below 6.8 or above 8.5.

The importance of the pool water pH is that it is an indicator of the pool quality and how some of the pool chemicals will be acting. To raise the pH, the procedure is to normally add Sodium Carbonate or Bicarbonate, and to lower the pH, add Sodium Bi-Sulphate or Hydrochloric Acid. Repeated additions of the Bi-Sulphate will lead to the chemical attack on the cement based adhesives and grouts previously noted above. However low levels of Calcium in the pool water are not indicated by the pH readings as previously noted.

RECOMMENDATIONS

The recommended water chemistry balance in **pools with ceramic tile finishes** is as follows:

Total alkalinity range recommended 80 - 200 mg/L

pH range 7.2 - 7.8

Calcium Hardness range 150 - 200 mg/L

Sulphate range < 200 mg/L

While these values may be slightly different to what many operators would regard as normal, we emphasise that these values are related to ceramic tile finishes that have been fixed (adhered) and grouted with cement based products. The values given here are in the recommended ranges to prevent corrosion of the cement in the adhesives and grouts.

The Australian Standard references do include the information regarding the effects of the chemical compounds noted in this technical bulletin. However those standards also apply to other types of pool finishes and care must be taken to ensure that the appropriate range is used in tiled pools.

We would also advise that excessively high levels of Chlorine can have a negative impact on cement based materials, and Brominated materials as used in spas are very aggressive and attack grouts and adhesives.

ADHESIVES AND GROUTS

This bulletin makes passing reference only to the types of adhesives and grouts that are suitable for use in swimming pools.

Essentially polymer fortified, cement based adhesives and grouts are normally suitable and have been used successfully for many years. Increased durability has been achieved by replacing standard grey Portland cement with more Sulphate resistant, white cements; while the polymers used have increased bond strengths and resistance to turbulence in the water, as well as reducing the permeability of the adhesives and grouts. Reduced permeability reduces the flow of water through the cement based adhesives and grouts hence slowing the effects of out of balance pool water.

DUNLOP recommends the DUNLOP UNIVERSAL TILE ADHESIVE or DUNLOP TILE ALL for fixing tiles in swimming pools.

For grouting in swimming pools the DUNLOP recommendation is DUNLOP COLOURED GROUT in white mixed with DUNLOP PRIMER AND ADDITIVE. White grout is recommended to avoid colour bleaching which occurs with the oxides in coloured grout.

The increasing use of epoxy based grouts is noted as pool operators see the effects of out of balance pool water.

Notes

Always refer to the product data sheets for specific usage details.

The information contained herein 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 the product application.

Users are asked to check that the literature in their possession is the latest issue.

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REFERENCES

The guidelines published by Standards Australia currently used are:

GB65 - 1998 Residential Swimming Pools – selection, maintenance operation (originally published as HB65-1998);

HB241 - 2002 Water Management for Public Swimming Pools and Spas

Other interesting references include:

British Standard BS 5385.4 – 2015

Code of Practice for tiling and mosaics in specific conditions;

Design and Construction Process for Swimming Pools published by The Tile Association in the United Kingdom (circa 2002);

Factors Affecting Grout Performance in Swimming Pools by Mike Wheat, Technical Director, Norcros Adhesives U.K. published in Tile Today Issue 33, pp58 - 64.

While the above references all provide excellent detail of all the chemicals used in pools, these details do not appear to provide ***adequate emphasis on the importance of Calcium or Sulphate concentrations in tiled pools.*** This is understandable given that these guidelines are meant for all types of pool lining materials, such as vinyl and fibreglass, in addition to tiles. Many types of pool lining (other than tiles) do not have the same chemical requirement as cement based adhesives and grouts, hence the guidelines are not followed or are maintained at rates that allow the cement based adhesives and grouts to remain in good condition.

Therefore consideration must be given to ensuring the pool water is maintained in a non-aggressive condition to allow cement based adhesives and grouts withstand the effects of the pool water and the chemicals used that come into contact with the tile finish. More detailed discussion on Calcium hardness can be found in,

Ballim Y (2012) Postgraduate Lecture: *Physical and Chemical Deterioration Processes*. School of Civil & Environmental Engineering. University of the Witwatersrand. South Africa

Felixberger J.K. (2008) *Damage when tiling swimming pools and its avoidance*. QUALICER 2008. *X World Congress on Ceramic Tile Quality; Castellón (Spain)*; [general Conferences, Papers, Posters, Panel Debate].

GLOSSARY

Alkalinity—Refers to the presence of soluble alkaline materials that are included in the pool water to buffer it against acidity. Typical alkalinity modifiers are Sodium Carbonate ('washing soda") or Sodium Bicarbonate ('bicarb' or 'bicarb of soda'). Where the alkalinity rises too high, the pH also rises and Calcium compounds start to precipitate as scum lines.

Calcium—This is a short hand for compounds of Calcium such as Calcium Carbonate ("lime scale").

Calcium Hardness-Is another form of shorthand to describe the concentration of Calcium and Magnesium compounds in the water (the two are treated as one combined entity). The hardness is controlled by soluble or partially soluble Calcium and Magnesium compounds (present as Carbonate and Bicarbonate) levels and pH.

Hard water– Contains high concentrations of Calcium and Magnesium compounds, usually Calcium and/or Magnesium Carbonate. These metal cations are relatively insoluble so as Carbonates and so it is relatively easy to have hard water where they are available. Typically water obtained from limestone source areas is 'hard'. Note that water can have high alkalinity, but low or high hardness.

pH-This is unit of measurement to indicate whether the water is acid, alkaline or neutral. The range is 0-14 with tap water having a range 6.7 to 7.4 for most cases.

pH is defined as a measure of the concentration of acid (H+) or alkali (usually expressed as OH-) in the water. Alkaline water containing Carbonates is more complex measurement.

At pH 7 the water is neutral and the acid and alkali counter balance each other—$H^+ + OH^- = H_2O$. Distilled water is neutral.

Soft water-Contains low levels of Calcium or Magnesium salts. Sodium Carbonate was traditionally used to soften hard water for washing purposes—hence the name 'washing soda'. Soft water is required for soaps to work correctly. In a concrete pool situation, where the water is too soft, it will scavenge Calcium from the cementitious components in the pool (i.e. concrete shell, grouts and tile adhesives) which over time damages the cement base in these items.

Sulphate– Spelled as Sulfate in American usages. This is an anion based around the parent compound Sulphuric Acid. Common Sulphates are Sodium Sulphate and Sodium Bisulphate which can be used acidifiers, or Aluminium Sulphate ('Alum' used for clarifying the water). Sulphate in pool water can attack the cement components in a pool, damaging them by forming Calcium and Magnesium Sulphate (gypsum and 'Epsom Salts') and also corroding metal fixtures.