TILED SWIMMING POOLS, FOUNTAINS AND SPAS TECHNICAL DESIGN MANUAL

LATICRETE Technical Services Department

Cover Photo: Water pool and fountain at night
Photo Courtesy of Tatiana Popova

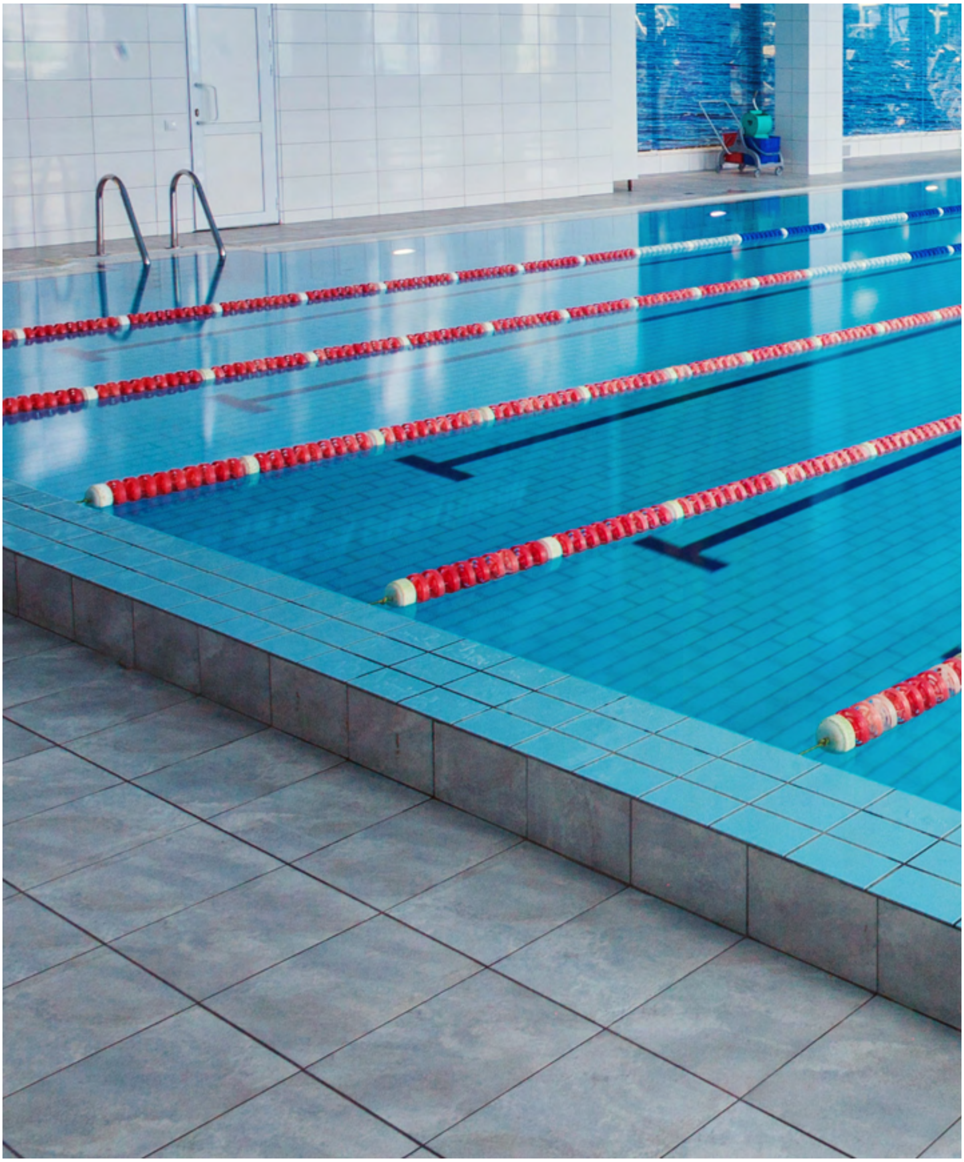
Contents

Contents (continued)

Contents (continued)

Contents (continued)

Section 1: Introduction



1.1 Preface

LATICRETE International, a manufacturer of ceramic tile, stone and thin brick masonry installation systems, has long recognized the need for a technical manual to provide guidelines and recommendations for the design, specification and installation of tile and stone in swimming pools, fountains, water features and spas. Technical advances in materials, manufacturing, and construction methods have expanded the role of tile and stone in this application type since the development of adhesive mortars in the 1950's. In keeping with their position as an industry leader, LATICRETE International is publishing this first edition of the Tiled Swimming Pool, Fountain and Spas Technical Design Manual to make state-of-the-art information and technology available to architects, engineers, construction professionals, tile contractors, and manufacturers of ceramic tile and stone. It is the goal of this publication to encourage new ideas, research and technology for the purpose of improving the future of submerged installations of tile and stone.

1.2 History of Tile and Stone In Swimming Pools and Fountains

The use of swimming pools, fountains and water tanks can be traced back to the ancient world. The Great Bath at Mohenjo-daro (in the south of what is now Pakistan) may well be the earliest example of a swimming pool in the world. This pool is approximately 40' (12 m) long and 23' (7 m) wide with a maximum depth of 8' (2.4 m) and had two staircases leading into it. This pool was constructed of brick which was laid over a thick layer of bitumen (natural tar) which acted as a waterproofing. On top of the tar was a gypsum plaster that acted as the finish coat.[1] This structure dates back to sometime during the third millennium BC (or between 2000 and 2500BC).

Evidence of the first use of tile and stone in pools, fountains and water features dates all the way back to the Roman Empire. Tiled fountains and bathing pools have been found in the ruins of Pompeii and Herculaneum. These tiled fountains and bathing pools were installed with ancient methods, have withstood the test of time (along with volcanic eruption and pyroclastic flow) and are still in place today.

Figure 1.1 – Stone water feature found in the ruins of Pompeii.

Figure 1.2 – Mosaic and Sea Shell fountain found in the ruins of Pompeii/Herculaneum.

The first recreational pools began to appear during the mid 1800's in England and the popularity of these "status symbols" increased significantly in the United States after WWII ended. With the evolution of materials and installation methods, swimming pools have become less of a status symbol and more of a way to stay cool in the summer. According to the Association of Pool and Spa Professionals (APSP) there are 10.4 million residential and 309,000 public swimming pools in the United States[2] and many more all over the world. The materials used to create these pools include concrete, fiberglass, steel, and vinyl and many of these have a tile or stone finish within the pool, fountain, spa or water feature.

Pools and fountains now range in size from a few square feet (m^2) to the world's largest swimming pool located at Citystars Resort in Sharm El Sheikh, Egypt. This pool covers a staggering 23.9 acres (1,042,000 ft2 or 96,800 m2) and holds an incredible 80,000,000 million gallons (302,883,000 L) of carefully filtered and sanitized sea water.

Aerial view of the pool at Citystars Resort in Sharm El Sheikh, Egypt

1.3 Why Use Tile and Stone In Swimming Pools and Fountains?

Swimming pools, fountains, spas, potable water tanks, and any other vessel which are designed to hold water for extended periods, or permanently, are ideal for the use of tile or stone. Historically, man has desired to create pools and fountains that are both beautiful and durable. Tile and stone installations can easily provide both of these qualities. Swimming pools are subjected to one of the most aggressive environments a tiling system has to endure, and a properly installed and maintained tile or stone installation should last the life of the pool structure. Tiled swimming pools are regarded as not only aesthetically pleasing but also as being one of the most chemically inert finishes.[3]

It is important to make sure that the tile or stone chosen for each swimming pool or fountain project is suitable for use in submerged installations. Swimming pools will often be exposed to different types of chemical treatments, varying pH levels, exposure to direct sunlight, regular usage, and other environmental factors. Porcelain tile, glass tile and certain other tiles which are specifically manufactured for submerged installations are the perfect choices. These tiles typically have a very low absorption rate, are impervious to pool chemicals and are available in a myriad of sizes, shapes, colors, and textures. The design potential with tile is virtually unlimited!

Stone is often utilized to provide a more natural look to a swimming pool or fountain installation. Granite, marble, slate, river rock, limestone and other stone have been used in fountains for many centuries, and more recently, in swimming pools around the world.

It is equally important to make sure that the tile and stone are installed with high quality setting and grouting materials manufactured by LATICRETE International, Inc. LATICRETE manufactures a variety of underlayments, membranes, thin-sets, grouts, and sealant that are ideal for use in permanently submerged applications. In fact, LATICRETE has been successfully used in these types of installations for over 50 years!
Where the tile is placed, along with the color and pattern, are the choices of the pool owner or design professional. Tile can be installed over the entire area of the pool and/or pool deck, just on the walls of the pool, just on the pool bottom, or along the water line or coping. Anywhere that tile or stone is placed it will provide a long lasting and beautiful finish.

1.4 Summary of Manual Content

Section 2 – Types of Pools and Fountains
This section provides a brief overview of the types of swimming pools, fountains and spas that are used around the world today. These include in-ground, above ground and suspended pools and a brief description of the construct of each.

Section 3 – Types of Pool and Fountain Construction
A more in-depth overview of the different types of pool and fountain construction that are used and how each type of construction is placed and how each type of construction relates to a tile or stone installation.

Section 4 – Pool Project Design Considerations
Information about the different building codes, structural considerations, movement and movement joints, and construction considerations for swimming pools and pool decks.

Section 5 – Selection of Pool Tile or Finish
Considerations for choosing the proper tile, and where it can be placed in a swimming pool or fountain. Different types of tile, including porcelain, stone and glass mosaics, are referenced as well as different types of alternative pool finishes.

Section 6 – Tile Installation Preparation and Equipment

How to properly prepare and inspect the substrate prior to installation of tile or stone in a swimming pool or fountain installation. There is also a brief description of equipment and tool considerations.

Section 7 – Pool/Fountain/Spa Tile Installation

A comprehensive overview of the tile installation methods including leveling, waterproofing, thin-setting, grouting, sealant application, and post installation.

Section 8 – Pool Deck and Natatorium Tile Installations

A comprehensive overview of the tile installation methods, including leveling, waterproofing, thin-setting, grouting, sealant application, and post installation.

Section 9 – Specifications for Swimming Pool/ Fountain/Spa Installations

Individual specifications for installation of tile in concrete, steel/metal, and fiberglass shell pools, fountains and spas.

Section 10 –Swimming Pool/Fountain/ Spa Detail Drawings

Individual details showing the installation of tile for different application types, as well as drain and pipe penetrations for pools and pool decks.

Section 11 – Pool Water and Tile Installation Maintenance

A brief description of the general standards for fill and drain rates, opening and closing a pool, water treatment, inspection and repairs for tiled swimming pool.

Section 12 – Appendix

Troubleshooting pictorial, case study, glossary, frequently asked questions, and resource guide.

1 http://www.harappa.com/indus/8.html

2 https://www.liveabout.com/facts-about-pools-spas-swimming-safety-2737127

3 Gray, Fred (2006). Correctly Installing Tile in Swimming Pools. Footscray West, Victoria, Australia: SPLASH EXPO Conrad Jupiters.

Section 2: Types of Pools and Fountains

2.1 In-Ground

There are three types of in-ground pool constructions: fiberglass, vinyl, and concrete. Each type of in-ground pool needs a pump, filter, drains, returns, plastic piping, and a chemical feeder.

Fiberglass pools are noted for their relatively quick installation, non-abrasive finish that resists staining, and inert composition that inhibits algae formation. Fiberglass pools are manufactured in a variety of shapes and sizes and are shipped to the installation site in one piece. Once the pool is in place and leveled, heating, filtration, and other systems can be installed and set up. The installation crew then backfills the site and fills the pool with water. Fiberglass pools are rarely tiled completely, but many do have a decorative band installed around the waterline of the pool. The use of a 100% solids epoxy setting material (e.g. LATAPOXY® 300 Adhesive) is required for installation of tile to fiberglass.

Vinyl-lined pools, known for their smooth, stain-resistant surface, are a very popular choice for in-ground pools. Design options are typically limited, but they are less expensive than fiberglass or concrete pools. Depending on the soil composition, once the excavation is complete, a wall system is constructed of wood, poured concrete, steel, or polymer. Bottom material might be of packed sand that is free of stones or poured concrete. Once the vinyl liner is installed and the heating, filtration and other systems are set up, the site is backfilled and the pool is filled. Liners usually have to be replaced about every 10 years, depending on usage and geographic location. Tile should not be installed in a vinyl lined pool.

A concrete pool is, by far, the most popular choice for in-ground pools. Concrete pools can take several weeks to construct and set up, but the design possibilities are endless. There are basically 4 choices when choosing the type of concrete pool construction.

Concrete Block – In concrete block pool construction, a floor foundation is poured and a concrete block wall is constructed to the desired shape of the pool. After the filtration attachments are inserted into the structure the walls are typically reinforced with deformed steel bars and all internal cavities of the block are solid filled. Once the shell is completed the pool can be tiled or finished in any number of ways.

Poured Concrete – In poured concrete construction, a form is typically created using plywood in the desired shape of the pool. The pool floor is poured first and the walls are constructed on top of the floor, around a steel reinforcing web. The cavities in the forms are filled with a high density concrete specifically designed and mixed for pool construction. A vibrating tool is utilized to fill any cavities and honeycomb voids and to make sure that the steel reinforcing is completely encapsulated. Once the forms are removed and the concrete is allowed to cure for a specified length of time, the pool can be tiled or finished using another method.

Gunite – In Gunite pool construction, a wood form is created and installed inside the excavated pool hole. The shape and size of the wood form is made larger than the desired finished pool by the thickness of the walls. Steel reinforcement is constructed and installed at pre-determined distances based on local construction code requirements. This steel reinforcement is suspended away from the wood form which helps keep the reinforcement centered within the wall and away from the bottom of the drainage material layer underneath the pool. The Gunite concrete is then pneumatically sprayed onto and around the steel reinforcement and wood form to the desired thickness of the pool walls. The Gunite mix (cement and pool aggregate mix) is delivered down a hose as a dry mix under pressure and blended at the spray head with potable water. The Gunite operator is responsible for maintaining the proper water to powder ratio to get the maximum strength from the concrete. Once sprayed in place the interior of the pool is troweled and formed to straighten the interior walls. Once cured, a Gunite pool can be tiled or finished using another method.

Shot-Crete – In Shot-crete pool construction, the preparation of the form and steel reinforcement is similar to Gunite. The main difference is the way that the concrete is delivered and applied. Shot-crete arrives at the site as a ready-mix concrete from the batching plant and is delivered in a cement truck. Quality of the concrete is determined at the batching plant during mixing and the spray operator has no control over the final quality of the concrete. Once cured a shot-crete pool can be tiled or finished using another method.

Finished cost of a concrete pool will vary depending on region, landscaping, construction type, and design. A concrete pool requires an interior surface finish which, with the various colors and textures to choose from, is limited only by your imagination. Concrete finishes typically need resurfacing about every 10–15 years. However, tile installations in a properly maintained swimming pool or fountain can last a lifetime.

2.2 Above Ground

Above ground pools function much the same way as an in ground pool but at a fraction of the cost. There are two types of above ground swimming pools – pools with hard sides and pools with soft sides.

Hard sided above ground pools are normally round or oval and are available in a variety of sizes and depths. They have a sheet metal frame which has a one piece flexible metal wall fixed to it with a sheet metal rail attached to the top for stabilization. A vinyl liner is then inserted and attached to the top rail to contain the water. Although cheaper than a soft side above ground pool, a metal sided swimming pool requires more elaborate ground preparation and is considerably more difficult to assemble.

Soft sided above ground pools are normally available in both round and the more popular rectangle shape. Although they have been around for some time, soft sided above ground swimming pools have become increasingly popular over the last 25 years. Like their metal wall predecessor, they are also available in a variety of sizes and depths. In fact, due to their strength and durability, they are quite often custom built in extremely large sizes for use in commercial applications. Soft sided pools can be placed on any surface, grass, dirt, concrete, even sand or gravel, and will normally tolerate up to 3" (75 mm) out of level. The pool liner material is similar to that used for bullet proof vests and therefore is extremely durable and puncture resistant. The average family can normally assemble a soft side pool in a relatively short amount of time and can move it as often as needed.

Both types of above ground pools require a filter and an electric pump to circulate the water and a ladder to get in and out of the pool. Other desirable accessories may include an automatic pool cleaner, an automatic chlorinator, a pool heater, lighting or a swimming pool slide. Due to the types of construction materials and the flexibility of the walls, tile is never used in above ground pools.

2.3 Suspended Pools

Pools and fountains do not necessarily have to be located in or on solid earth. In fact, many pools and fountains are located above ground level, either within a structure or on top of a structure, and are supported by the structure itself. This type of pool or fountain must be designed with critical factors in mind; the pool cannot leak and the structure must be able to support the total weight of the pool, the water and occupants within the pool. If the pool is located indoors then the structure must also be designed and constructed to handle the excessive humidity created by the pool, and the chemicals used to sanitize and maintain the pool. In most cases, the pool mechanical room is located in a room below the pool level to better utilize gravity in the circulation of water.

Tile is a common feature inside of a suspended pool or fountain, and can be installed within the entire pool and deck area or just in a band around the waterline.

Figure 2.1 – Suspended pool on an upper floor of the Swissôtel in Chicago, IL.

2.4 Spa / Therapeutic

The use of spas, hot tubs and therapeutic pools has been consistently rising for several decades as new and less expensive manufacturing techniques have been established. Many of these installations contain tile. Some of the differences between a pool and a spa, hot tub or therapeutic pool are temperature (these vessels typically contain hot water or water that is routinely heated), and size (many of these vessels are designed to hold a small number of occupants). The construction of spas, hot tubs and therapeutic pools commonly consist of stainless steel or fiberglass. Water treatments are similar to what is used in a swimming pool (Bromine is the preferred treatment for hot water) but the increased temperature can have an impact on the effectiveness of these treatments and how they react with fittings, tile or stone, plumbing, etc... We will cover the methods of swimming pool and fountain construction in greater detail in Section 3 “Types of Pool Construction”.

[1, 2, 3, 4] http://www.homehelp4u.net/services/concrete_pool_construction.php

Section 3: Types of Pool Construction

3.1 Poured Concrete

One type of in ground pool construction type is cast-in-place, reinforced concrete; in other words, concrete is poured around steel reinforcing (rebar) inside wooden formwork. Concrete placed or pumped on-site over steel reinforcing with floors and walls, contained by formwork, is generally used in large commercial pools, elevated pools or on-grade pools where poor sub-soil conditions exist.

Pool bottoms and walls should be cast monolithically in order to avoid cracking and reduce the need for extra movement joints. In poured concrete pool construction a mold is created using wood or plywood which will encase the finished pool shape. High-density concrete, specifically designed for pool applications, is then poured into the forms. A vibrating tool is used to make sure that the concrete fills all of the cavities and completely encapsulates all of the reinforcing steel. Once the concrete has set, the forms can be removed and the concrete allowed to reach full cure.

Typically, this form of construction requires a greater level of surface preparation for a tile installation than a pneumatically applied concrete (e.g. Gunite or Shot-crete). Vertically formed surfaces are especially prone to thin layers of weakened portland cement (laitance). Care should be taken to ensure that the concrete surface has a proper screed finish and no laitance or other condition that may inhibit bonding of a waterproofing membrane mortar bed or tile adhesive mortar. Any type of form release agent, curing compound, sealer, or other contaminant must be removed prior to the direct adhesion of any tile or stone. The use of concrete additives, such as super plasticizers allow for low water-to-cement ratios but can induce bleed water and increase the possible occurrence of laitance. Concrete which has been treated with a crystalline waterproofing must be properly prepared prior to the installation of tile and stone. The concrete surface will have to be mechanically profiled to create a more textured surface and to open up pores in the surface of the concrete to promote adhesion of tile and stone installation materials. Please refer to LATICRETE Technical Data Sheet (TDS) 142 "Installation of Tile or Stone Over Concrete with Crystalline Waterproofing" for more information. It should also be noted that concrete which has been treated with a crystalline waterproofing does not require a waterproofing membrane. However, if a separate waterproofing is specified, we would recommend the use of HYDRO BAN® Cementitious Waterproofing.

Cast-in-place concrete is more likely to experience shrinkage cracks after placement so proper placement and installation of reinforcing steel will help to reduce the occurrence of this type of cracking. The proper placement of a waterproofing/anti-fracture membrane (e.g. HYDRO BAN®, HYDRO BAN XP, HYDRO BAN Quick Cure or 9235 Waterproofing Membrane) will prevent any shrinkage cracks from transmitting through to the tile layer. It is important to note that waterproofing membrane, used in a submerged installation, must cover the entire inside shell of the pool or fountain.

There are certain considerations which must be taken into account before the installation of a membrane or tile/stone can commence;

- Type of Concrete
- Floor Flatness
- Concrete Curing
- Cracks
- Contamination

Type of Concrete – Concrete used in swimming pools and continuous submersion projects should be specially designed for this type of application. The concrete should be mixed to provide a high density, low porosity finished product and not have a water to cement ratio greater than 0.48. The concrete shell for a salt water pool or fountain should be poured using sulfate-resisting cement. The use of this type of concrete will help to protect the structural, reinforcing steel in the pool shell and prevent serious problems in the future.

Floor Flatness – Typical horizontal concrete applications must be finished to a floor flatness (F_F) of 25 or greater. A floor flatness of 25 roughly correlates to 1/4" in 10' (6 mm in 3 m). Measurement of F_f is done using ASTM E1155 "Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers" and American Concrete Institute (ACI) "Standard Specification for Tolerances for Concrete Construction and Materials".

Age of Concrete – Concrete pool shells must be cured for a minimum of 28 days and a minimum time interval should be allowed between each successive stage of the project to ensure full cure. These time intervals will vary by temperature and weather conditions, and should only be reduced if an adequate design solution is provided.

Cracking – Any cracks in the concrete shell should be effectively repaired prior to the application of any finish material on the sides and bottom of the pool or fountain and on the pool deck. The use of a superior waterproofing/anti-fracture membrane (e.g. HYDRO BAN®, HYDRO BAN XP, HYDRO BAN Quick Cure or 9235 Waterproofing Membrane) will provide protection not only against cracks in the concrete shell from transmitting through the tile installation, but also provide waterproofing as well. This keeps the water in the pool where it belongs!

Contamination – Keep in mind that poured concrete pool or fountain shells utilize wood forms during the construction process. In order to remove these forms after the concrete has set the installers spray the inside of the forms with either old motor oil, diesel fuel or a proprietary material that helps inhibit bond. Unfortunately, some of this form release agent may be left on the concrete surface as residue. As effective as these materials are at preventing bond of the concrete to the wood forms, they can be equally effective at inhibiting bond of a screed, membrane, tile, stone, or other finish coating to the concrete surface.[1] The proper removal of these contaminants and subsequent surface preparation will be covered in greater depth in Section 6.

Refer to Section 4.5 for more information on critical design elements (e.g. water stops, vapor retarders, hydrostatic relief valves, etc…) which are required to be installed or planned for prior to or during installation of the concrete.

3.2 Gunite/Shot-crete

The construction of a pool or fountain using the Gunite or Shot-crete installation method begins with the forming of the shell using wood or plywood forms. These forms are made larger than the actual, finished pool size by the thickness of the walls and must be substantial in construction. The area inside the forms is then lined with #3 (0.375" [9.5 mm]) steel reinforcing, usually on one foot (300 mm) centers (as noted in NSPI construction manuals or as dictated by local building code or as specified). The steel reinforcing is suspended away from the formwork by a device which keeps the reinforcing steel centered in the completed wall assembly, and away from the bottom of the excavation.

The pool recirculating system, and any other integral mechanics, are allowed for in the finished walls and floor of the pool or fountain prior to the installation of the Gunite or Shot-crete.

While Shot-crete and Gunite are pneumatically applied concrete, they both have differences in the way that they are mixed. In Gunite installations the "mix" is delivered down a hose as a dry mix under pressure and terminates at the spray head. As the dry mix leaves the spray head it mixes with water, which is being delivered under pressure through another hose attached to the spray nozzle, and is applied onto the wood forms and around the reinforced steel.
The Gunite dry powder is a combination of portland cement, sand, fly ash (in many cases), and possibly some very small pebbles.
In conditions that require faster setting of the concrete, some calcium or a proprietary material, designed for the purpose, is added to accelerate the curing.

The powder and water must be mixed to a critical ratio or the resulting concrete can lack strength. Therefore, the Gunite installer must be fully experienced with the installation process and have complete control over the amount of water being used. Once the concrete has been placed in the pool, the interior of the pool is "straightened" by a team who use steel trowels and forms to float the wall to the proper finish.

Figure 3.1 – Gunite being sprayed and finished in a residential pool.

Shot-crete, while also pneumatically applied, is slightly different than Gunite. Shot-crete is mixed at the concrete production facility and delivered to the job site in a cement truck already mixed. The quality of the concrete is determined at the ready mix plant so the nozzle operator has no influence over the final strength of the concrete. Shot-crete pools tend to use less concrete than Gunite pools but can provide superior strength per volume.

Both methods of applying the concrete need special attention to the application, as the reinforcing steel may provide a barrier that can lead to cavities forming behind the re-bar. Rebound, or gravel in the mix rebounding off the wood forms or steel reinforcing, may also occur and can lead to a differential strength of the concrete. Whether Gunite or Shot-crete, both nozzle operators must be experienced and aware of the potential strength issues if the concrete is not placed as required by the pool's designer or engineer. Once the concrete has set for a minimum of 14 days at 70°F (21°C) the form work may be removed and the exterior side of the pool wall is filled with a suitable drainage material.

The design considerations for waterproofing and ceramic tile or stone installation over a Gunite or Shot-crete pool are:

1. Allows for the easier construction of continuous monolithic wall and floor elements characterized by a generally mandatory rounded cove. This may make it difficult to install larger format tile or stone.
2. Reduces or eliminates movement joints in the pool shell. Typically, Gunite pools do not require movement joints in the shell because the tendency for cracking from thermal movement is reduced. However, movement joints in the tile surface are required to accommodate thermal and moisture movement of pool tile when the pool is emptied for maintenance. For more information on movement joints, please refer to the Tile Council of North America (TCNA) Handbook for Ceraminc, Glass and Stone Tile Installation EJ171, for more information.
3. Gunite and Shot-crete pools generally require less preparation for subsequent finishes due to the spray on surface texture providing mechanical keys (for the thin-set), and also have no laitance.
4. Lower water to cement ratio also means less susceptibility to drying shrinkage cracks.
5. Greater freedom of pool structure shapes is achievable over traditional formed structures and, as such, can be more difficult to produce precision tile or stone finishes.
6. Generally requires a screed or render for subsequent applications of membrane, tile or stone.

Tile can be installed over a concrete shell by following methods; ES-P601, ES-P601D and ES-P602. (found in Section 9 – Specifications and Section 10 – Details, as well as at www.laticrete.com/ag).

3.3 Concrete Masonry Units

While concrete block swimming pool construction is used infrequently, it is more often used as a fish pond or water feature construction method and is a viable alternative to more costly and expensive construction methods. The depth of concrete block construction is typically no deeper than 3' (1 m). In this type of pool or fountain construction, the bottom of the pool is created by pouring concrete around steel reinforcing to the outside dimensions of the pool footprint. The concrete is allowed to cure for a specified time and then steel reinforcing is constructed for the concrete block walls. The concrete block is installed over the steel reinforcing using a high strength masonry mortar and allowed to cure. The block is typically filled with concrete to create a solid structure for the pool.

Once the shell is completed, the pool may have a mortar bed (e.g. 3701 Fortified Mortar Bed, Quick Cure Mortar Bed, 3701 Lite Mortar, 3701 Lite Mortar R, or 226 Thick Bed Mortar gauged with 3701 Mortar Admix) installed over the block wall and concrete floor, waterproofed with a high quality waterproofing membrane (e.g. HYDRO BAN®, HYDRO BAN XP, HYDRO BAN Quick Cure or 9235 Waterproofing Membrane), and then tile is installed with a high quality adhesive mortar (e.g. 254 Platinum, 257 TITANIUM™ or MULTIMAX™ LITE) designed to be used in submerged installations. The use of a superb, stain and chemical-resistant grout (e.g. SPECTRALOCK® PRO PREMIUM GROUT) and 100%silicone sealant (e.g. LATASIL™) will finish this tiled pool installation. A waterproofing membrane and tile or stone can also be installed directly to the floors and walls without a mortar bed (refer to ES-P601D found in Section 9 – Specifications and Section – 10 Details, as well as at www.laticrete.com/ag. Other finishes include spray-on, fiberglass strand reinforced coatings, vinyl liners, renders created from mixture of white cement and finely ground white marble dust (i.e. Marbleite or Marcite), or even painted.

Check with local building code for limitations or allowance to see if this type of pool or fountain construction is acceptable and what limitations may be in place.

3.4 Steel Shell

Figure 3.2 – steel pool shell being installed in Uruguay.

Stainless steel has become a widely used material for the construction of spas, pools and fountains. Stainless steel is an ideal material for spas, pools and fountains because it is durable, strong, chemical-resistant, moisture-resistant and stain-resistant. Stainless steel will not crack, blister, delaminate, or lose strength over time and can be fabricated into any size and shape. It can literally last forever!

The manufacturer of the pool or spa cuts high grade stainless steel panels, to the desired sizes and shapes, in a specific pattern. Around a steel frame, the pieces of stainless steel are welded together with a material that will inhibit rusting or corrosion at the seams, thus forming the completed pool. The proper welding process would depend upon the exact type (austenitic, ferritic, martensitic, or duplex) and grade of stainless steel. Holes and other penetrations are cut into the steel to allow for filtration, circulation, lights, water jets, and drains at specific points. The plumbing, lights and other equipment may also be mounted prior to shipping.

Figure 3.3 – Tiled steel pool shell.

The spa or pool is then transported to the installation site and permanently installed. While the stainless steel finish is easy to maintain it may not be aesthetically pleasing to the owner. With this possibility in mind, tile is an excellent way to create a unique and functional design alternative. Tile can be installed over a steel shell by following two methods; ES-P603 and ES-P604 (both found in Section 9 – Specifications and Section 10 – Details as well as at www.laticrete.com/ag) and can be done at the factory or after the spa or pool is installed.

3.5 Fiberglass Shell

Fiberglass is the last type of pool construction that we will mention. Fiberglass is a sprayed-on resin material that provides a smooth and durable surface. Fiberglass pools are manufactured in a factory, to a standard size and shape, and then shipped to site on a truck. A crane is required to place the pool into the pre-excavated ground (often lifted directly over a house), the plumbing is then connected, and tile is installed at and above the water line to protect against oxidation. Once the tile mortar has cured the pool is filled with water as it is back-filled against the pool shell. The top edge of the pool is typically covered with concrete to protect it and help prevent oxidation in this critical area.

Fiberglass pools are the least common type of pool structures because size and shape are determined at the factory, the size of the pool is limited to what will fit on a truck, and the initial cost is higher than that of a concrete pool.

Figure 3.4 – A fiberglass pool shell waiting installation of tile.

The fiberglass shell must be rigid and meet minimum deflection ratings of L/360 for tile and L/480 for stone. Tile is installed using a 100% solids epoxy (e.g. LATAPOXY® 300 Adhesive) for maximum bond to the fiberglass shell, and grouted with a high quality grouting material (e.g. SPECTRALOCK® PRO Premium Grout). Tile can be installed over a rigid fiberglass shell by following method; ES-P605 (found in Section 9 – Specifications and Section 10 – Details as well as at www.laticrete.com/ag).

[1] Gray, Fred (2006). Correctly Installing Tile in Swimming Pools. Footscray West, Victoria, Australia: SPLASH EXPO Conrad Jupiters.

[2] Gray, Fred (2006). Correctly Installing Tile in Swimming Pools. Footscray West, Victoria, Australia: SPLASH EXPO Conrad Jupiters.

† United States Invention Patent No.: 6881768 (and other Patents).

Section 4: Pool Project Design Considerations

4.1 Tile Industry Standards

The Tile Council of North America (TCNA) provides an installation method for the proper installation of tile in swimming pools, fountains and water features. TCNA provides Method P601 for swimming pools and Method B417 for tile tubs, fountains and curbs which can be found in the current version of the TCNA Handbook for Ceramic, Glass and Stone Tile Installation. To obtain a copy of the current TCNA Handbook for Ceramic, Glass and Stone Tile Installation please contact TCNA at 100 Clemson Research Blvd., Anderson, SC 29625, +1.864.646.8453, visit www.tileusa.com or by e-mail at **literature@tileusa.com**.

The American National Standards Association (ANSI) provides guidelines for tile installation and requirements for product testing and performance in the American National Standard Specifications for the Installation of Ceramic Tile (A108 and A118). To obtain a copy of the current American National Standard Specifications for the Installation of Ceramic Tile please contact TCNA at 100 Clemson Research Blvd., Anderson, SC 29625, +1.864.646.8453, visit www.tileusa.com or by e-mail at **literature@tileusa.com**.

Please refer to International Residential Code, International Building Code and/or United States Consumer Product Safety Commission Publication No. 362 "Safety Barrier Guidelines for Home Pools" at https://www.cpsc.gov/s3fs-public/pdfs/blk_media_SafetyBarrierGuidelinesResPools.pdf for more information, or, contact your local building officials for swimming pool codes and requirements.

LATICRETE International also provides installation methods and details for swimming pool and submerged installations and is available at **www.laticrete.com/ag**, method ES-P601, ES-P601D, ES-P602, ES-P603, ES-P604, ES-P605, ES-B417A, and ES-B417B.

4.2 Structural Considerations

It is not unusual for people to look at an in-ground swimming pool and see nothing more than a hole in the ground, filled with water where people relax, have fun and enjoy life. But there is much more to it than just a "hole in the ground". Out of sight is a solid foundation on which the pool is created, along with plumbing, lighting, and sanitation equipment. For swimming pools, fountains and water features located above grade within structures, there are more structural considerations to take into account.

Loads – The following aspects must be taken into account during the load calculations process; pool filling, alternating thermal loads, internal stress of the concrete pool shell with regard to the reduction of shrinkage cracks, support of other structural components during construction, and loads resulting from normal operation of the pool.

It is easy to forget, and therefore, not to take into consideration, the weight of water and the effect this weight has on the structure containing that water. Water weighs 8.34 pounds per gallon (1 kg/L). For an average size swimming pool of 15' x 30' x 5' (4.5 x 9 x 1.5 m), the weight of the water comes to approximately 140,400 pounds (63,700 kg). For a 164' x 82' x 6.6' (50 x 25 x 2 m) Olympic size swimming pool the weight of the water comes to over 5,500,000 pounds (2,490,000 kg). No matter how you look at it, these are tremendous weights which create a constant force on the structure of the pool. If the pool is in-ground, the soil and the traffic (live) loads in the area immediately surrounding the pool must be taken into consideration. A properly designed and compacted drainage layer under the pool and a backfill with suitable soil, which is properly installed and compacted, is very important to the long term success of the pool.

A pool, fountain or water feature located on elevated floors within, or on a structure means the proper detailing of the pool is not only critical to the pool structure but also to any spaces located underneath the pool. First, the structure must be designed to handle the weight; and second, provide waterproofing protection to any spaces below or adjacent to the pool.

Buildings with elevated swimming pools must be designed to accommodate the excess live load provided by the weight of the water within the structure of the pool. For example, a pool that is 15' x 30' x 5' (4.5 x 9 x 1.5 m) and contains water that weighs 140,400 lbs (63,700 kg) equates to a live load of 312 psf (1,532 kg/m^2) for just the water. Most commercial buildings are designed for a live load of 70 – 130 psf (344 – 640 kg/m^2) so the design professional must take into consideration the weight of the water, on top any additional anticipated live load minus the water. If the pool is in a room that is 30' x 60' (9 x 18 m) and the designed live load is 70 psf (344 kg/m^2) then the room has a total live load capacity of 126,000 lbs (57,270 kg). The weight of the water itself exceeds the designed live load of the structure and does not include any other anticipated live loads.

Consideration for excess dead load should also be taken into consideration. In most cases the mass of the structure and its supporting members, and therefore, the dead load, are increased to handle the excessive loads created by the water.

Requirements of Design – Swimming pools, fountains and water features are complex in nature. Although they appear to be simple (essentially a vessel filled with water) they are far more than that. These pools have to take into consideration the proper design and, placement and installation of the plumbing, electrical/lighting, and, if the pool is indoors, proper air circulation and dehumidification.

Swimming pools, fountains and water features should also be waterproofed to keep the water within the vessel and from causing damage to surrounding areas. The proper placement of a suitable waterproofing product is essential to keeping water where it belongs. Swimming pools located in elevated floors or on the roof of a building may require the placement of a "sandwich" type waterproofing membrane. Typically, this sandwich type membrane is an alkali-resistant, bladder type product and is placed between pours of concrete to provide a permanent barrier against water penetration to the structure below.

Deflection – Systems over which tile or stone will be installed, shall be in conformance with the International Building Code (IBC) or applicable building codes for the desired application. Historically, for ceramic tile and paver applications, the maximum allowable deflection should not exceed L/360 under total anticipated load; and, for stone the maximum allowable deflection should not exceed L/480 of the total anticipated load.

The ceramic tile industry abides by the following note on deflection: the owner should communicate in writing to the project design professional and general contractor the intended use of the tile installation, including in-service loads or information to allow a project design professional to calculate such. Project design professional and general contractor must make necessary allowances for the expected live load, concentrated loads, impact loads, and dead loads, including the maximum allowable loads during construction and maintenance.

The tile contractor shall not be responsible for problems resulting from any structural subfloor installation not compliant with applicable building codes, unless structural subfloor was designed and installed by tile contractor, nor for problems from overloading. As tile is a finish applied to and relying upon the underlying structure, an inadequate substructure can cause a tile failure.

4.3 Types of Structural Movement

Swimming pools, fountains and water features are structures, and, like all other structures are subjected to different types of structural movement. Thermal movement, moisture expansion and contraction, and, differential movement are typically experienced in this type of construction.

Thermal Movement – All building materials expand and contract when exposed to changes in temperature and moisture. There are two (2) factors to consider in analyzing movement caused by thermal variation: 1) the rates of expansion of different materials (also known as the linear coefficient of thermal expansion), and, 2) the anticipated temperature range exposure. The primary goal in analyzing thermal movement is to determine both the cumulative and individual differential movement that occurs within the components of the pool assembly, especially above the water line.

While a pool is filled with water, the area below the water line will see little in the way of thermal movement. Any changes in temperature are minimal and slow. The structure of the pool, and any tile installed in the pool, be able to adjust with this temperature change. However, the tile or stone installed between the water line and the coping can see significant changes in temperature in a very, very short amount of time. For instance, if a dark colored tile or stone (which can reach temperatures in excess of 120°F [49°C] in direct sunlight) is suddenly exposed to water at 72°F (22°C) then an extreme amount of thermal contraction can occur. As the tile is allowed to dry then thermal expansion occurs again. Movement caused by thermal expansion and contraction can create problems with a tile or stone installation, including cracking and/or loss of bond. Extreme thermal contraction can also occur when a pool is drained and allowed to remain empty and dry for extended periods of time. In open-air pools and fountains, higher alternating thermal loads may occur due to weather conditions.

The thermal expansion of tile is determined using ASTM C372 "Standard Test Method for Linear Thermal Expansion of Porcelain Enamel and Glaze Frits and Fired Ceramic Whiteware Products by the Dilatometer Method." For certain types of tile the following test method may be used; ASTM C484 "Standard Test Method for Thermal Shock Resistance of Glazed Ceramic Tile." The coefficient of thermal expansion for all elements of the installation system, including substrate, must factor into the calculation for the total anticipated movement.

Moisture Movement – As noted earlier, building materials (including concrete) will experience changes when exposed to varying amounts of moisture. Typically, building materials will expand as they gain moisture and contract as the moisture leaves the system. Tile is one such building material. It would be important to check with the tile manufacturer to see if their product is suitable for use in submerged installations. Tile with a low absorption rate (<3%) would be better suited for use in submerged installations, especially in climates where freeze/thaw occurs (see Section 5.1 for more information).

Differential Movement – Differential movement is another factor to take into consideration when installing tile or stone in swimming pools, fountains and water features. Most of the forces that act upon a building will act upon a swimming pool installation; live loads, dead loads, thermal expansion and contraction, seismic loads, creep, and settling must still be accounted for and factored into the design and construction of these structures and the differential stresses exerted by these forces must be alleviated in movement joints.

4.4 Movement Joints

Controlling Stresses with Movement Joints –
Movement joints serve to allow changes in the shape of the overall construction (e.g. thermal movement, settling, shrinkage and swelling of the concrete structure, etc…) as well as displacements against each other to occur without causing damage to the pool shell, or to the tile or stone installation. Arrangement, dimensions and formation of the movement joints depend on many factors, including expected changes in shape of the structural components and their tile or stone cladding.[2]

Guidelines for Movement Joints – As a guide, when no project specific movement joint design exists, for submerged installations of tile or stone, movement joints can be installed every 8' to 12' (2.4 to 3.6 m) in each direction in the finish layer and installation system. Movement joints should also be placed where tile work abuts restraining surfaces (e.g. perimeter walls, steps, etc…), where dissimilar surfaces meet, at any change in plane, and around pipes or penetrations. Movement joints should be placed over all designed joints in the shell of the pool, fountain or water feature, and these joints should be carried to the surface of the tile or stone installation directly in line with their original placement in the shell. Depending upon the size and construction method of a pool shell, some of the joints in the structure may require a special type of water stop filler material. This material will allow for a significant amount of movement to occur in the structure of the pool but will not allow water to escape through the joint.

It is important to make sure that the project architect or engineer shows locations and details of movement joints on project drawings.

Figure 4.1 – Indoor water park wading pool with clearly defined movement joints.

Movement Joint Treatment – Movement joints should be treated with a suitable sealant and installation should be done in conjunction with TCNA Handbook for Ceramic Tile, Glass and Stone Tile Installation EJ171 "Movement Joint Guidelines for Ceramic, Glass and Stone." The performance requirements of certain special locations, such as swimming pools, dairies, food plants, etc…, may exceed the minimum requirements of the sealant specifications. Therefore, follow recommendations of experienced manufacturers as to specific sealants suitable in the job environment. In some of these environments, a program for regular maintenance of sealant in joints may be required[3]. In most cases, the use of a 100% silicone (e.g. LATASIL™ used with LATASIL 9118 Primer) or urethane sealant will be recommended for submerged installations.

4.5 Swimming Pool/Fountain Construction Considerations

We will take a look at both in-ground and elevated swimming pool construction considerations

Structurally, in-ground swimming pools can be exposed to all sorts of conditions and forces that can have a profound effect on not only the long term success of the pool, but also on any tile or stone installation in the pool or on the pool deck.

The ideal site for placement of an in-ground pool, fountain or water feature is level with good quality soil. In many cases the site is not level and there are subsoil problems. These problems can include too much rock (ledge), poor soil type, improper compaction, high water table, or the need for the removal of soil and replacement with compacted fill. The need to have the soil inspected can be very important to make sure that the pool will have no structural problems in the future. A proper soil inspection can also provide information on where the best area to place the pool would be.

The steps to in-ground pool construction are as follows;

Layout and Positioning – Layout and positioning should be conducted with the assistance of a qualified, licensed surveyor. The surveyor can make sure that the placement of the pool is within guidelines for distance from the boundaries and also if the boundary adjacent to the pool is in the correct position. In other words, survey the entire property to make sure you are not excavating outside of the property lines. Pool boundaries are marked with paint prior to the commencement of excavation and are typically larger than the actual finished dimensions of the pool.

Excavation – ALWAYS CHECK FOR UNDERGROUND UTILITIES PRIOR TO DIGGING. Once the boundaries are marked it is time to bring in the heavy equipment to dig the hole. Following the pool specifications and drawings, the excavation contractor will dig the hole to precise requirements (usually slightly larger than the finished pool size). Unless a large volume of dirt is needed on site for leveling or other purpose, then most of, or all, of the dirt removed from the hole will be transported off site. A hole dug out for a 15' x 30' (9.5 x 4.5 m) pool can yield as much as 130 cubic yards (100 m^3) of earth.

Hydrostatic Pressure Relief Valve – During the excavation process it would be important to see if any ground water appears in the excavated area. Negative hydrostatic pressure and hydrostatic pressure under a swimming pool, fountain or water feature can have a significant effect on the pool structure and any finish within the structure. If there is a high water table, and no means have been created for relieving this pressure, then special considerations must be made and appropriate designs engineered[4]. If ground water is a possibility then the proper installation of a hydrostatic relief valve can help to eliminate potential problems down the road (e.g. finish delamination, floating pool, and more…). In many cases, a hydrostatic pressure relief valve is installed even if no ground water appears in the excavated area during construction. This will help to deal with any unforeseen or unanticipated problems that may occur in the future. Changes in the natural movement of water (caused by the excavated area in the ground), landscaping changes and the disposal of water when the pool has to be emptied for maintenance should all be anticipated during the design and construction of a pool or water feature.

Proper use of a hydrostatic pressure relief valve can also prevent a less common but potentially significant problem; the floating swimming pool. If there is a high water table or the potential for the hole in which the pool is placed to fill with water then there is the possibility that the pool can float right out of the ground when the pool is emptied. This is possible because anything can float (ships were actually made out of concrete during World War I and World War II). The mechanics of how something is able to float are very simple; as stated by the Archimedes Principle, if the weight of the water displaced by an object is greater than the weight of the object, then the object will float. For example, if a ship weighs 100 tons (90,700 kg) but displaces 120 tons (109,000 kg) of water then the ship will float; conversely, if the same ship displaces only 80 tons (72,600 kg) of water then the ship will sink. So, an empty pool can float if it weighs less than the water filling the hole beneath it! This is why it is rare to see a totally empty swimming pool in areas where the water table tends to be high.

Vapor Retarder – Another functional design element that must be utilized is a high quality vapor retarder. This material, typically a heavy gauge polyethylene sheet product or a reinforced polyolefin, is placed underneath a pool to prevent moisture vapor from entering into the system. Indoor swimming pools, fountains, spas and water features (especially on or below grade) should not only have a vapor barrier below the pool and deck, but also on the walls and ceilings to prevent moisture from penetrating into adjacent rooms or into the structure of the building. A high moisture vapor emission rate under a pool can have significant effect on the tile or stone installation, especially when the pool is emptied for maintenance.

Water Stop – As mentioned earlier, water stops are used within the concrete shell for large pools, fountains or water features. These water stops are designed to provide waterproof integrity in areas where a gap in the construction is required (e.g. movement joints or between wall and floor concrete pours – see Figures 1 and 2) in the pool shell. Typically, pools in excess of 40 – 50 ft (12.2 – 15.2 m) in any dimension require some type of movement joint through the pool shell and, therefore, require a water stop in the joint. These water stops are usually made of latex, neoprene or polyethylene and are placed as the concrete is being poured, so they become integral within the concrete.

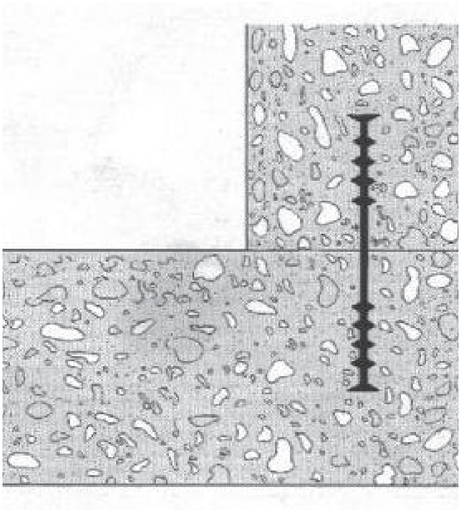


Figure 4.2 – Typical shape and placement of water stop where floor and wall join in pool construction.[5]

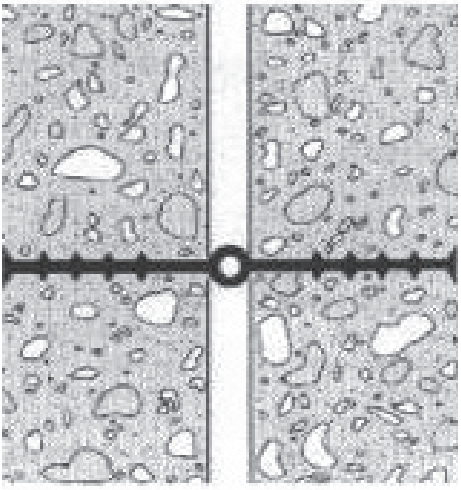


Figure 4.3 – Typical shape and placement of water stop where floor and wall join in pool movement joint.[6]

Figure 4.4 – Typical water stop materials.[7]

Plumbing – Water in a swimming pool needs to circulate through a filtering system to remove dirt and debris, and to evenly distribute the pool chemicals. For in ground pools, fountains and water features most of the plumbing for the pool drains, pump system and filters have to be installed prior to the pouring or spraying of the concrete. The main drain(s) are usually located in the lowest point of the pool, so the entire contents of the pool will flow to the drains. The drain is tied into the pump system for easy draining or fast circulation of the water in the pool.

Figure 4.5 – Typical drain position and steel reinforcement prior to gunite application of concrete.

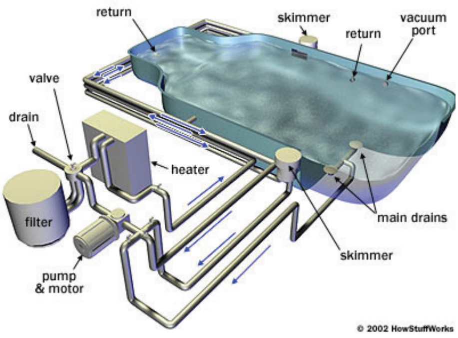


Figure 4.6 – Cut away view of a typical pool pump and filtration system.[7]

The filter system incorporates specially made filter sand or diatomaceous earth (a fine powder made from the chemically inert, fossilized remains of sea organisms called diatoms) as the filter medium or a cartridge type filter. In most regions, regulations dictate that all of the water in the pool (or its equivalent volume) must pass through the filter in a certain amount of time – typically between 30 minutes and six hours.

Figure 4.7 – Return port in a concrete shell pool[8].

Lights and Electrical – Like the plumbing, the lighting and electrical installation must be done prior to the pouring or spraying of the concrete pool shell. In most cases, swimming pools and fountains are constructed with underwater lights. These lights are essentially used so swimmers and parents/supervisors/observers can see what their surroundings at night and, to a lesser extent, for aesthetic appeal. An incandescent light is sealed into a watertight fixture which is located in a niche in the pool shell. The electric wire runs into the fixture through a special seal which is designed to keep water away from the electrical elements. Fiber optics are becoming more and more popular in pools because they do not have to be embedded within the pool structure.

Electrical work for swimming pools and submerged applications was finally included in the National Electrical Code (NEC) Article 680 in 1968. Electrical work done in pools before this time may be of sub-standard quality. Modern light fixtures are designed to last for decades, however, poor water chemistry can weaken or degrade the fixture, gasket and fasteners which hold it together. Failure to inspect these fixtures and replace as necessary could result in costly damage to pool users or property. Modern lights are also designed to be used only while submerged to prevent overheating and should never be turned on when the pool is empty.

Observation Portals and Windows – Like plumbing and lighting, the placement of observation portals and windows is done prior to the pouring or spraying of the concrete. A structural engineer should be utilized to design how the window should be placed in the pool shell without compromising the strength and integrity of the pool shell, and to specify how the window frame should be mounted to the steel reinforcement.

The manufacturer of the window can dictate exactly what type of frame and sealant should be used based on several factors (e.g. size of the window, depth in the pool, size of the pool, and purpose of the window, etc…). The frame must be made of a non-porous, non-corrosive material and is, in most cases, stainless steel. A high quality silicone sealant is the most frequently used material to provide waterproof integrity between the window frame and pool shell. Proper inspection and maintenance of the sealant, window frame and pool shell are vital to ensuring that leaking does not occur in this critical area.[9]

4.6 Pool Deck

Almost every pool, especially pools which are located in ground, have a pool deck. These decks can be of any size, from just a few feet (1 – 2 m) extended from the edge of the pool to huge areas used for entertaining and aesthetic appeal. Since just as much time, if not more, is spent on the pool deck than in the pool itself, the proper design and size of the deck becomes important. Some things to take into consideration when designing a pool deck are construction materials (e.g. concrete or wood), finish materials (e.g. tile, stone, pavers), pool equipment (mechanized covers, plumbing covers, etc…), diving boards, slides, incorporating sun and shade, hot tub or spa, grilling area, and fencing.

Pool Deck Substrates – a majority of pool decks utilize concrete as the basic construction material. Concrete is relatively inexpensive, easily poured and makes an ideal substrate for the direct adhesion of tile or stone. In some instances, wood planking decks are constructed for aesthetic value, or for areas where concrete would be difficult to pour. Still other decks have concrete immediately around the pool and sand set concrete or stone pavers are used as the main decking material.

The installation of tile and stone over a concrete pool deck, whether interior or exterior, can be done by using the LATICRETE materials as stated in Section 8 "Pool Deck and Natatorium Tile Installations" and by following industry guidelines for tile installation.

Slope To Drain – a properly constructed pool deck will provide a slope which will evacuate water to a drain or to gutters placed on the ground to take water away from the pool deck. This helps to shed water from the deck and to prevent freeze/thaw conditions from damaging the concrete or pool beam during cold weather months.

Movement Joints – according to the Tile Council of North America Handbook for Ceramic, Glass and Stone Tile EJ171, the guidelines for placement of control joints in an exterior tile or stone installation are every 8' – 12' (2.4 – 3.7 m) in each direction. Interior pool decks should have control joints placed every 20' – 25' (6.1 – 7.6 m) in each direction unless the pool deck, and any subsequent tile or stone installation, is exposed to direct sunlight. If so, then treat the tile or stone application as if it was on an exterior deck and place the control joints every 8' – 12' (2.4 – 3.7 m) in each direction More frequent joint placement may be required depending on materials and environmental conditions.

For exterior decks, the minimum joint width for joints placed in the tile or stone installation is 3/8" (9 mm) for joints spaced 8' (2.4 m) on center and 1/2" (12 mm) for joints spaced 12' (3.7 m) on center. Minimum widths must be increased by 1/16" (1.5 mm) for each 15°F (8.3°C) tile surface temperature change greater than 100°F (38°C) between summer high and winter low[10]. Decks exposed to the sky in northern climates usually require 3/4" (19 mm) wide joints spaced 12' on center.

Cure Time – it is necessary to allow for the proper curing of the tile or stone installation materials (e.g. membrane, thin-set, grout, sealant, etc…) before exposing to traffic or submersion. Please check the data sheets for minimum cure time of each LATICRETE® product used in the installation by visiting www.laticrete.com or by calling LATICRETE Technical Service at 1.800.243.4788,1235 You can also refer to LATICRETE Technical Data Sheet 192 "Installation of Ceramic Tile in Swimming Pools" for more information.

4.7 Safety and Code Considerations

Building Codes – The health and safety of swimming pool users should be the primary concern during the design, construction and enjoyment of the pool. As such, the International Building Code (IBC) and International Residential Code (IRC) address the design and implementation of swimming pool enclosures, safety devices and barrier requirements. The United States Government has also addressed the concerns of properly placed and constructed safety barriers along with entrapment dangers from suction fittings with the passing of H.R. 1721: The Virginia Graeme Baker Pool and Safety Act in December 2007.

Safety Codes – The Virginia Graeme Baker Pool and Safety Act encourages States to improve their pool and spa safety laws to educate the public about pool and spa safety by establishing a grant program administered by the Consumer Product Safety Commission.

While local building codes will mandate any requirements of pool or fountain construction guidelines, the necessity for safety after the pool is finished is tantamount to local, state and government legislators as well as home and property owners. Taking into account the fact that drowning is the fifth leading cause of death in children aged 1 to 14 in the United States, proper implementation of safety devices and barriers is important.

The best way to reduce child drowning in residential pools is for pool owners to construct and maintain barriers that would prevent young children from gaining access to pools. However, there are no substitutes for diligent supervision in both residential and commercial pools. Swimming pool barrier guidelines are designed to prevent a child from getting over, under or through the barrier and gain access to the pool. As outlined in the United States Consumer Product

Safety Commission Publication No. 362 "Safety Barrier Guidelines for Home Pools", some basic guidelines for preventing a child from climbing over a barrier include;

Solid Barrier – no indentations or protrusions should be present, other than normal construction tolerances and masonry joints.

Fence Made Up Of Horizontal and Vertical Members – if the space between the tops of the horizontal members is less than 45" (1,140 mm), the horizontal members should be on the swimming pool side of the fence. The spacing of the vertical members should not exceed 1.75" (44 mm). This size is based on the foot width of a young child and is intended to reduce the potential for a child to gain a foothold. Any decorative cutouts in the fence, the space within the cutouts should not exceed 1.75" (44 mm). If the difference between the tops of the horizontal members is more than 45" (1,140 mm), the horizontal members can be on the side of the fence facing away from the pool. The spacing between vertical members should not exceed 4" (100 mm). This size is based on the head breadth and chest depth of a young child and is intended to prevent a child from passing through an opening. Again, if there are any decorative cutouts in the fence, the space within the cutouts should not exceed 1.75" (44 mm).

Chain Link Fence – the mesh size should not exceed 1.25" (32 mm) square unless slats, fastened at the top or bottom of the fence, are used to reduce mesh openings to no more than 1.75" (44 mm).

Fence Made Up Of Diagonal Members (Lattice) – the maximum opening in the lattice should not exceed 1.75" (44 mm).

Above Ground Pools – above ground pools should have barriers. The pool structure itself serves as a barrier or a barrier is mounted on top of the pool structure. There are two possible ways to prevent young children from climbing up into an above ground pool. The steps or ladder can be designed to be secured, locked or removed to prevent access, or, the steps or ladder can be surrounded by a barrier as previously described.

Some basic guidelines for preventing a child from getting under a barrier include;

Pool Barrier – the maximum clearance at the bottom of the barrier should not exceed 4" (100 mm) above grade, when the measurement is done on the side of the barrier facing away from the pool.

Above Ground Pool with Barrier on Top of Pool – if an above ground pool has a barrier on the top of the pool, the maximum vertical clearance between the top of the pool and the bottom of the barrier should not exceed 4" (100 mm).

Gates – swimming pool barriers should be equipped with a gate or gates which restrict access to the pool. A locking device should be included in the gate design. Gates should open out from the pool and should be self-closing and self-latching. If a gate is properly designed, even if the gate is not completely latched, a young child pushing on the gate in order to enter the pool area will at least close the gate and may actually engage the latch. When the release mechanism of the self-latching device is less than 54" (1,370 mm) from the bottom of the gate, the release mechanism for the gate should be at least 3" (75 mm) below the top of the gate on the side facing the pool. Placing the release mechanism at this height prevents a young child from reaching over the top of a gate and releasing the latch. The gate and barrier should have no opening greater than 0.5" (12 mm) within 18" (455 mm) of the latch release mechanism. This prevents a young child from reaching through the gate and releasing the latch.[11]

Standards – To aid in the proper design, construction, operation, sanitation, and safety of new construction pools and renovation of existing swimming pools and spas, the Association of Pool and Spa Professionals (APSP) has created, or is in the process of creating, a number of American National Standards Institute (ANSI) standards.

Another potential problem in swimming pools and spas is entrapment of pool users (especially young children) at suction fittings. The IBC and IRC include prescriptive safety measures intended to provide the safest possible recirculation system based on current science. These codes require that all pools and spas have dual drains that incorporate American Society of Mechanical Engineers (ASME) A112.19.8 listed suction fittings (drain covers), single 18" x 23" (460 mm x 585 mm) grates or larger, or, single approved channel drains. These systems should also incorporate ASME A112.19.17 listed safety vacuum release systems.

ASME A112.19.8 "Suction Fittings for Use in Swimming Pools, Wading Pools, Spas and Hot Tubs" establishes performance and material requirements for suction fittings, which provide the first line of defense against all entrapment hazards. ASME A112.19.17

"Manufactured Safety Vacuum Release Systems for Residential and Commercial Swimming Pool. Spa, Hot Tub and Wading Pool Suction Systems" establishes performance criteria for devices and systems intended to function as emergency vacuum breakers in case of entrapment.[12]

Some of these standards along with their scope include[13];

- ANSI/NSPI-1 2003 "American National Standard for Public Swimming Pools" – covers public swimming pools to be used for bathing and operated by an owner, licensee, or concessionaire, regardless of whether a fee is charged for use. Public pools covered by this standard include Class A (used for competitive aquatic sports), Class B and C (intended for public or semi-public recreational swimming, and Class F (wading).
- ANSI/NSPI-3 1999 "American National Standard for Permanently Installed Residential Spas" – covers permanently installed residential spas that are used for bathing and are operated by an owner. This standard is meant to cover certain aspects of the design, equipment, operation, installation, new construction, and rehabilitation of spas.
- ANSI/NSPI-4 2007 "American National Standard for Above-ground/On-ground Residential Swimming Pools" – describes certain criteria for the design, manufacturing, testing, care, and use of above-ground/on-ground residential (Type O) non-diving pools and their components.
- ANSI/NSPI-5 2003 "American National Standard for Residential In-ground Swimming Pools" – applies to permanently installed residential in-ground swimming pools intended for noncommercial use as a swimming pool by not more than three owner families and their guests and exceeding 24" (60 cm) in water depth and having a volume over 3,250 gallons (12,300 L). It covers specifications for new construction and rehabilitation for residential in-ground swimming pools and includes design, equipment, operation, and installation.
- ANSI/IAF-8 2005 "Model Barrier Code for Residential Swimming Pools, Spas and Hot Tubs" – states requirements to establish layers of protection for young children against the potential for drowning and near-drowning in residential swimming pools, spa and hot tubs by limiting or delaying their access to the pool area.
- APSP-10 "Standard for Performance Rating and Labeling of Pumps and Pump Motors Used on Swimming Pools, Wading Pools, Spas, Hot Tubs, Whirlpool Baths, and Water Features" – covers performance and labeling criteria for pumps and pump motors used in circulation systems on residential and public swimming pools, wading pools, spas, hot tubs, whirlpool baths, and water features. This standard applies to new and replacement installations.
- International Building Code (IBC) provides basic information for swimming pool construction in Chapter 21 Masonry, Section 2103.5 and 2103.10.

These are just some of the representative standards available for swimming pools and spas. For more pool standards, complete standards or for updated standards please refer to the Association of Pool and Spa Professionals (APSP) website at www.apsp.org. For more information on your local pool and spa codes please visit the International Aquatic Foundation (IAF) website at http://www.internationalaquaticassociation.com

[1] TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC 2019, page 30.

[2] Technical Committee Structural Engineering Work Group (December 1991) Shrinkage and Swelling of Reinforced Concrete Pools Effects On The Bonding Properties of Ceramic Cladding. Postfach, Switzerland: Bundesfachverband Öffentliche Bäder E.V.

[3] TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC 2019, page 432.

[4] Hunsaker, D.J. Pools from the Ground Up. Retrieved 5/8/2008, from http://www.chh20.com?Articles/PoolsfromtheGroundUp.aspx.

[5] Water stop, Retrieved 7/1/2008 from http://www.alibaba.com.

[6] Expansion Joint, Retrieved 7/1/2008 from http://www.alibaba.com.

[7] Water stop materials, Retrieved 4/5/2020 from www.alibaba.com

[8] Tom Harris How Swimming Pools Work, Retrieved 1/15/2008 from http://home.howstuffworks.com/swimming-pool2.htm.

[9] Robledo, Rebecca (February 13, 2006). Windows to the Underworld: Designing and Building with Underwater Windows, Retrieved 7/3/2008 from http://www.allbusiness.com/arts-entertainment-recreation/869164-1.html.

[10] TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC 2019, page 430.

[11] United States Consumer Product Safety Commission. Safety Barriers Guidelines for Home Pools. Washington D.C.: United States Consumer Product Safety Commission.

[12] Duren, Gary S. (2008, September). The Evolution of Pool and Spa Entrapment Prevention. Building Safety Journal, 51–52.

[13] Standards/Codes. https://www.apsp.org/standards-codes

Section 5: Selection of Pool Tile or Finish

5.1 Considerations for Tile Selection

Tile and stone in swimming pools, fountains, spas, and water features is a very appealing way to provide beauty and functionality. There are many types of tile and stone in the world, but not all of them are suitable or functional in a submerged installation. Choosing a tile or stone that is suitable for submerged applications is critical to the long-term performance of the installation.

Generally speaking, tile or stone used in submerged installations must have a low absorption rate, a high coefficient of friction, be freeze/thaw resistant (in cool climates), resistant to moisture expansion, and chemical resistant.

Tile used in swimming pools, fountains, spas, and water features should be vitreous (absorption rate between 0.5% and 3%) or impervious (absorption rate less than 0.5%). Absorption rate of tile is determined by ASTM C373 "Standard Test Method for Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products" and is important for selecting tile or stone for submerged installations, wet areas or any installation that will be subjected to freeze/thaw conditions. Tile for use in submerged installations should also be tested to ASTM C370 "Standard Test Method for Moisture Expansion of Fired Whiteware Products" to determine the extent to which tile will expand when exposed to moisture. Tile or stone with a low absorption rate will be far less susceptible to damage caused by water infiltration and provide a far more durable installation in a demanding environment. The most commonly used tile types for submerged installations are porcelain and glass since they provide the lowest absorption rates. It is also important to check with the distributor or quarry to see if a particular type of stone would be suitable for continual submersion. Ceramic and porcelain tile characteristics are also addressed in the ANSI A137.1 American National Standard Specifications for Ceramic Tile Glass tile characteristics are addressed in ANSI A137.2 American National Standard Specifications for Glass Tile.

Tile with a high coefficient of friction is an important characteristic for tile in continually wet areas, and on pool decks, to help maintain the safety and well being of all who use these areas. Coefficient of friction is commonly determined using ASTM C1028 "Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method." Keep in mind that Americans with Disabilities Act (ADA) requires that floor surfaces be stable, firm, and slip-resistant so choosing the correct tile is required to comply with this important Act. Check with local building codes for minimum coefficient of friction values.

Tile in exterior or continually submerged installations must be freeze/thaw resistant, especially in climates prone to this type of exposure. Water can expand up to 25% of its original volume while freezing, and if this water is located within a solid material (e.g. tile, stone, etc…) then a significant amount of damage can occur to the solid material, especially if there are numerous freeze/thaw cycles. Freeze/thaw resistance is measured using ASTM C1026 "Standard Test Method for Measuring the Resistance of Ceramic Tile to Freeze-Thaw Cycling" and establishes the tiles ability to resist freeze/thaw damage.

Due to the amount of chemicals in a swimming pool, fountain or water feature it is necessary to install tile or stone that is resistant to pool chemicals with tile installation materials that are equally chemical resistant. There are several methods for sanitizing pools (including chlorine, bromine, ozone, and salt water) and the tile should be able to withstand whichever sanitizing type will be used in that particular pool. The chemical resistance of tile is established using ASTM C650 "Standard Test Method for Resistance of Ceramic Tile to Chemical Substances".

Tile should be UV stable, maintain its color when exposed to various chemicals, easily cleanable, and stated for use in submerged installations by the manufacturer. Choosing the wrong tile can lead to significant down time for the pool, tremendous expense removing the old tile, reinstallation of a suitable tile, and other potential issues that can occur when a pool is empty (see Section 4.5 and Section 11 for more information).

Abrasion resistance, more important on a pool deck tile installation, should also be taken into consideration. Testing for abrasion resistance is performed using a test developed by The Porcelain Enamel Institute (PEI). Tile is tested and given a PEI Rating based on a 0 – 5 scale, as shown in Figure 5.1.

PEI 0	Not recommended for floors
PEI 1	Light Residential
PEI 2	Residential
PEI 3	Heavy Residential or Light Commercial
PEI 4	Commercial
PEI 5	Heavy Commercial

Figure 5.1 – Surface Wear Classification[1]

Tile used in residential swimming pool areas should be PEI 3 or higher and commercial swimming pools should have a rating of PEI 4 or 5. Abrasion from chairs, umbrella stands and other hard materials can scratch the surface of tile and cause damage, so choosing a suitable tile is particularly important. Please note that glass tile should never be considered for pool deck applications.

Failure to properly choose and specify a tile for submerged installations can be a costly, time consuming and unnecessary problem. It is essential to choose wisely! Make sure that not only the tile is suitable for this type of installation, but also the way the tile is mounted (mosaics) and the setting materials used to install the tile as well. Mosaic mounting methods will be covered in Section 5.3 while suitable setting materials are covered in Section 7.

5.2 Placement of Tile in Swimming Pool and Pool Deck Installations

Tile can be installed in almost any area within a pool and the color and design may only be limited by the designer's imagination. Choosing where tile or stone will be placed is subject to whatever the finished appearance is to be. Tile can be installed within the entire shell of the pool, just on the bottom, just on the walls, at the waterline, on the coping, and, in competition pools, can be used to designate lanes and depths. Tile is often placed at the waterline because floating oils, dirt and waste can combine to form a scum line around the pool; this is why tile, an easily cleanable surface is placed at the water line around the perimeter of pools.[2]

Figure 5.2 – Tiled lane markers in Water Cube, Beijing, China.

Tile is a very popular finish option for pool decks and choosing a tile or stone for these areas can have a significant visual and safety impact. A pool's functional performance depends largely on the correct use of slip-resistant materials in the various areas (e.g. pool bottom, steps, deck, etc…). It is extremely important to avoid the risk of accidental falls by using slip-resistant tile, even if it means sacrificing some aesthetic values and easy cleaning. However, floor cleaning is an essential factor to ensure that the tile slip-resistant performance is kept intact.

Coefficient of friction (COF) is the measurement of a tile's frictional resistance, closely related to traction and slipperiness. The method for measuring the coefficient of friction (COF) of ceramic tile changed in 2012. Previously, COF was determined per ASTM C1028 from a measurement of the static coefficient of friction (SCOF), which is the frictional resistance one pushes against when starting in motion.3

The new method of testing, ANSI A326.3 is an evaluation using a standardized sensor material prepared according to a specified protocol. As such, it can provide a useful comparison of tile surfaces, but it does not predict the likelihood a person will or will not slip.4

The new method measures the Dynamic Coefficient of Friction (DCOF), which is the frictional resistance of a person already in motion. For both SCOF and DCOF, a slip occurs when pushing off with more force than the surface can resist.5

There are many factors that affect the possibility of a slip occurring on a tile surface including, by way of example, but not in limitation, the following: the material of the shoe sole and the degree of its wear; the presence and nature of surface contaminants; the speed and length of stride at the time of a slip; the physical and mental condition of the individual at the time of the slip; whether the floor is flat or inclined; how the tile surface is used and maintained; the COF of the tile; how the tile is structured; and how drainage takes place if liquids are involved. Because many variables affect the risk of a slip occurring, the COF shall not be the only factor in determining the appropriateness of a tile for a particular application.

Unless otherwise specified, tiles suitable for level interior spaces expected to be walked upon when wet, excluding shower floors, shall have a wet DCOF of 0.42 or greater when tested using SLS solution as per the procedure in ANSI A326.3 Section 8.0. However, tiles with a DCOF of 0.42 or greater are not necessarily suitable for all projects. The specifier shall determine tiles appropriate for specific project conditions, considering by way of example, but not in limitation, type of use, traffic, expected contaminants, expected maintenance, expected wear, and manufacturers' guidelines and recommendations.

It should also be noted that the COF of installed tile can change over time as a result of wear and surface contaminants. In addition to regular cleaning, deep cleaning, and traction-enhancing maintenance may be needed to maintain DCOF values.[6]

For exterior applications, the suitability of the installed tile flooring depends significantly on drainage of the assembly, structure/texture of the tile flooring, expected footwear, intended use, and the variety of contaminants present, in addition to other factors already discussed. Accordingly, a single DCOF limit value for exterior applications is not provided.

For interior ramps and inclines, the suitability of the installed tile flooring depends significantly on the degree of incline, the nature of any non-pedestrian use, the structure/nature of the tile surface, in addition to other factors already discussed. Accordingly, a single DCOF limit value for exterior applications is not provided.7

Germany, Australia, New Zealand, Italy and many other countries have their own standards and test methods for determining both the slip-resistance of tile and acceptable minimum levels to which tile must perform. Whichever test method is employed, the main focus is on providing the best protection for all those who will be using the pool and pool deck.

Another factor which should be taken into consideration for pool deck tile installations is what temperature the finish will be when exposed to direct sunlight. A light colored tile or stone is an ideal choice to absorb less of the heat and maintain a safe and comfortable temperature. Dark colored tile or stone can get extremely hot and create an uncomfortable environment for pool and pool deck users.

5.3 Types of Tile for Submerged Applications

While the types of tile (e.g. impervious, vitreous, some stone, and glass) recommended for use in submerged installations is rather limited, the myriad of colors, sizes, shapes, and designs is very impressive in scope. Tile can range in size from mosaics as small as 0.75" x 0.75" (19 mm x 19 mm) to as large as 5' x 10' (1.5 - 3 m), and stone can come in any size, shape or thickness. Many companies even manufacture pre-fabricated designs in tile which are placed within the finish at the bottom of a pool or fountain and provide a unique and aesthetically pleasing characteristic.

As stated earlier in this section, tile used in submerged installations should have a very low absorption rate (≤3%) which helps to minimize, or even eliminate problems caused by moisture expansion and contraction. Impervious tile and vitreous tile are the most popular choices for swimming pools around the world because they are relatively inexpensive and easy to find. Glass tile, suitable for submerged installations, is very pleasing in appearance but is typically more expensive and requires a higher degree of installation experience and expertise. Stone is also an excellent option but choosing the right stone is important. While many stone types will not experience significant moisture or thermal expansion, some can be affected by pool chemicals and improper mineral balance in the pool water (see Section 11.3 for more information).

The installation of mosaic tiles in swimming pools and fountains has history going back thousands of years. In fact, the first tiled pools and baths incorporated small tesserae to create a variety of designs and mosaic murals. These tiles were installed individually, by hand, could take long periods of time and required installers with artistic ability to create. Fortunately, modern technology incorporates methods and materials to create beautiful installations quickly and easily. Stone, porcelain and glass mosaics are now pre-mounted, using several different methods onto sheets. These mosaics can even be customized to create a likeness of any picture or photograph using specialized computer software or exceptional artistic ability.

Figure 5.3 – Mosaic pool floor found in ruins of Pompeii, Italy.

The tile industry has seen some issues with the mounting of mosaic tile when used in submerged installations. To better understand this point, let's look at the different ways in which tile and stone are mounted onto sheets;

- Paper-face Mounted – paper face mounted tile, as the name suggests, are mosaic tiles that have a sheet of paper adhered to the face of the sheet of tile. This paper keeps the tiles properly separated and allows for the installation of the entire sheet at one time. Once the tile has been installed and has had sufficient time to cure (i.e. when the mortar holds the tile in place but allows for slight adjustments to be made in the tile) the paper is dampened and then is peeled off to reveal the tile finish.

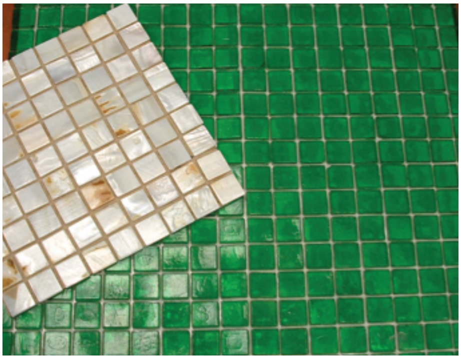


Figure 5.4 – Two examples of paper-face mounted glass mosaic tile.

- Plastic-face mounted – similar to paper face mounting except a clear plastic film is used in place of the paper. A great benefit of using the clear plastic film is that the tile or stone is visible through the plastic, and, if necessary, the plastic could be cut and adjustments made to the tile or stone prior to removing the film. In most cases, the plastic film cannot be removed until the setting mortar has fully cured.

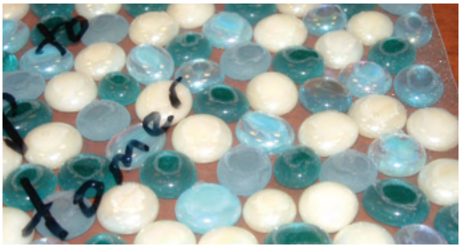


Figure 5.5 – An example of plastic sheet mounted glass mosaic pebbles.

- Rear Dot Mounted – some tile manufacturers use the method of mounting the tiles in sheets using polyvinyl chloride (PVC) dots. While this method eliminates the need to remove the paper face mounting, it carries its own types of concerns. Note the amount of space that the PVC dots cover on the back of each tile in Figure 5.6.

Figure 5.6 – An example of PVC dot mounted tile.

- Rear Mesh Mounted – this method incorporates a fiberglass mesh which is bonded to the back of mosaic sheets to create the sheets. This method also eliminates the need to remove the paper face mounting but, it too, carries its own set of potential problems depending on the type of and the amount of mesh adhesive that is used.

Figure 5.7 – An example of rear mesh mounted glass mosaic tile.

- Rear Paper Mesh Mounted – this method utilizes a paper mounting which is cut into a mesh configuration. While this method does eliminate the need to remove the paper from the front, it is not recommended, for obvious reasons, for use in swimming pools, fountains, spas, water features, or any wet area.

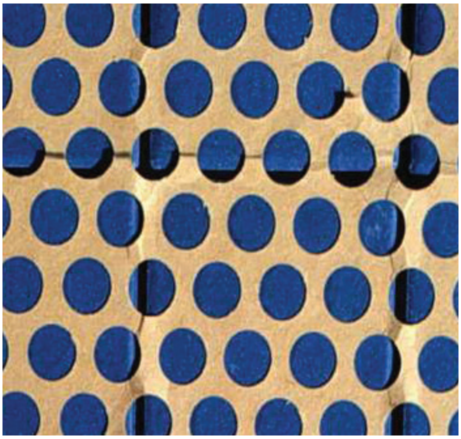


Figure 5.8 – An example of rear paper mesh mounted porcelain mosaic tile.

Installation of tile in swimming pools requires the tile to be fully and solidly bonded to the substrate. Simply put, this means that the tile should have 95 – 100% adhesive coverage not only to the back of the tile but also to the substrate. In submerged installations 95 – 100% coverage is essential to the long term performance of tile or stone. As stated in ANSI A108.5 2.4 Setting ceramic mosaic tile;

"Thoroughly beat all tile or tile assemblies into place with a beating block to obtain maximum contact of bonding mortar on the back of each tile and back mounting material... where contact area shall be 95% when no less than 3 tiles or tile assemblies are removed for inspection".[5]

Since maximum coverage is essential, the preferred tile mounting type for submerged installations would be the paper-face or plastic-face mounted mosaic sheets. Due to the fact that there are no obstacles to full adhesion (e.g. mesh and/or adhesive), 95 - 100% coverage can be achieved. PVC dot mounted mosaic sheets present 2 challenges for proper adhesion to the substrate; the PVC dots take up space on the back of each tile and PVC can be difficult for the tile adhesive to bond to. Keep in mind that the thin-set or epoxy used to bond the tile to the substrate must have 95 – 100% coverage to the tile and the substrate; not the tile, PVC dots, glue and/or mesh, and the substrate. If PVC dot mounted sheets are to be used then choose a type that has an average of less than 5% coverage of the PVC on the back of each sheet.

Another potential problem with PVC dot-mounted mosaic tile is how high the PVC dots are between each tile. If the dots are too high then grout does not have enough surface area to properly bond to the tile, or, there is simply not enough space for the grout to be properly installed. The PVC dots can also inhibit the bond of grout in the joint.

In an effort to reduce costs, some mosaic tile manufacturers haphazardly use inappropriate glues, such as dilute polyvinyl acetate, to mount tile on backing mesh. As stated earlier these glues interfere with contact and bonding between mosaic tiles and the tile adhesive. When immersed in water these glues can soften and then swell as they absorb water, leading to loss of adhesion. This may occur within several weeks to several years but the result is almost always the same.[9] Simply put, the use of back-mounted or dot-mounted sheet mosaic tiles may be precluded from use in submerged or exterior conditions if the sheet backing and/or adhesive adversely affects the development of adequate and permanent adhesion between the mosaic tile body and the bedding mortar.

Tile manufacturers must specify whether their assemblies are suitable for installation in swimming pools, on exteriors, and in other wet areas. Paper back-mounted mosaics are not recommended in wet areas.[10]

It is recommended that glass tiles intended for submerged applications be face-mounted to prevent problems stemming from improper coverage or backing material failure. For back-mounted and edge-mounted products, manufacturers must clearly state for which areas their mounted tiles are suitable.[11]

There are 3 categories of glue to avoid;

- Glues that soften without noticeable swelling as they absorb water. These appear to be clear when dry and white when immersed (similar to PVA wood glues).
- Glues that soften and swell to a gel that eventually forces tile apart and away from the substrate and may fall apart in small pieces rather than stay attached to the mesh.
- Glues that do not change in appearance or feel but gradually lose adhesion to the tile after prolonged immersion in water. Moisture evidently breaks down the adhesion without penetrating far into the film of glue.[12]

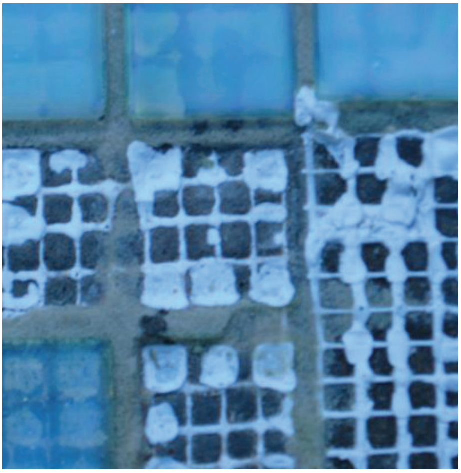


Figure 5.9 – A classic example of an improper adhesive used to mount the mesh for submerged installation. The adhesive has changed color from clear to white and has swelled significantly, forcing delamination.

For mesh backed mosaic tile the fabric mesh and the adhesive used to mount the fabric mesh must be water-resistant and chemical-resistant, should not weaken when exposed to moisture, should be resistant to varying pH levels, resistant to high alkalinity, and should be compatible with the mortar or adhesive used to bond the mosaics. It is the responsibility of the ceramic tile manufacturer to mount the tiles so that the bond requirements of ANSI A137.1, according to ASTM C482 "Standard Test Method for Bond Strength of Ceramic Tile to Portland Cement Paste" are met or exceeded.[13] Beyond that, the architect/designer, tile installer and owner should also make sure that the products being used on the job are acceptable and adequate for the designed purpose. The installation of tile, which is meant for the purpose, using the appropriate setting materials will save time, labor and money and keep the swimming pool or fountain in continual operation for a very, very long time.

5.4 Non-Tiled Pool Finish Types

While tile and stone are beautiful and functional design elements for swimming pools and fountains, there are other finish options.

Plaster – pool plaster is an age old material for finishing swimming pools, fountains and water features. Plastering provides a more watertight seal than the gunite, shot-crete or poured concrete on which the plaster is installed. Pool plasters are often comprised of white portland cement and fine marble dust, known as Marcite or Marbleite, but there are now quartz based plasters that incorporate a fine, pigmented quartz aggregate and provide many color options. Plaster is typically pumped through a high pressure hose to the pool and is then troweled on by trained technicians. While plaster is a very popular finish for swimming pools, often used in conjunction with tile or stone at the water line, plaster must be replaced every so often. See Section 11.3 for more information on the causes of plaster problems. For pools which require waterproofing under the pool plaster, use LATICRETE HYDRO BAN Cementitious Waterproofing. Refer to DS 386.2 for more information.

Figure 5.10 – Typical Marcite plaster installation (notice the spiked shoes).

- Pebble Tec – pebble tec pool finishes are similar to plaster or Marcite, except small river pebbles are mixed with the fine aggregate, white portland cement and pigments. This mix is pumped to the jobsite in a high pressure hose, troweled on by trained personnel and allowed to dry. The pool finish is then acid washed to remove the thin plaster coating which exposes the pebble aggregate and finished surface. For pools which require waterproofing under the pool plaster, use LATICRETE® HYDRO BAN Cementitious Waterproofing. Refer to DS 386.2 for more information.

Paint – one of the most common, and least expensive, pool finish materials is paint. Pool paint is available in a wide variety of colors and can be used to create intricate designs. There are three types of paint which are suitable for use in swimming pools, fountains and water features;

- Epoxy paint – epoxy paint is often used in new pool construction or in pools previously painted with epoxy, and is long lasting and durable. Epoxy coatings are effective against pool chemical attack, UV rays and automatic pool cleaners, and, a good epoxy paint will last approximately 7 – 10 years.
- Chlorinated rubber base paint – rubber base paint is not as durable or expensive as epoxy paint, but is a dependable and easy-to-use coating material. Chlorinated rubber base paint is available in many colors and will last approximately 3 – 5 years.
- Water-based acrylic paint – water-based acrylic paint is inexpensive, applies to almost any surface and cleans with water while still fresh. Available in a wide range of colors acrylic paints will last approximately 2 – 3 years before repainting is necessary.

Vinyl Liner – vinyl liners are custom made sheets of vinyl which are installed between the water and the pool structure. These liners lock into a track located on the bottom of the pool coping immediately under the deck. Vinyl liners provide good resistance to pool chemical maintained at proper levels but may fade or become brittle when harsh chemicals or high concentrations of chemicals are used.[14]

While all of the above mentioned finishes are effective and reliable, none of them have the durability and lasting beauty of tile and stone. Installed properly in a well cared for swimming pool or fountain, tile and stone can (and has) lasted for several millennia!

[1] American National Standard Specifications for Ceramic Tile, ANSI A137.2, Tile Council of North America, SC, pg 22.

[2] Pool Janitor FAQ, Retrieved on 9/17/2008 from www.poolcenter.com.

[3] TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC 2019, page 4.

[4] American National Standard Specifications for Ceramic Tile, ANSI A137.2, Tile Council of North America, SC 2019, pg 18.

[5] TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC 2019, page 4.

[6] American National Standard Specifications for Ceramic Tile, ANSI A137.2, Tile Council of North America, SC 2019, pg 18-19.

[7] American National Standard Specifications for Ceramic Tile, ANSI A137.2, Tile Council of North America, SC 2019, pg 20.

[8] American National Standard Specifications for the Installation of Ceramic Tile Material and Installation Standards, ANSI A108, A118 and A136, Tile Council of North America, NY, 2019, pg 39 - 40.

[9] Vinyl Liners, Retrieved on 9/17/2008 from www.poolcenter.com.

[10] TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC 2019, page 5.

[11] TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC 2019, page 8.

[12] Hartog, Peter, Tiling At The Deep End…Revisited. Retrieved 9/11/08 from www.tiletoday.com.au.

[13] Bulletin 3: Back-Mounted Ceramic Tile. Materials and Methods Standards Association, Houston, TX, 2005.

[14] Vinyl Liners, Retrieved on 9/17/2008 from www.poolcenter.com.

Section 6: Tile Installation Preparation and Equipment

6.1 Installation Equipment, Substrate Preparation and Installation Procedures

The construction equipment, substrate preparation process and installation procedures required for each project and region of the world are unique, and therefore it would not be possible to list all the types and combinations of tools, equipment and procedures involved in the installation of wet area and submerged tile applications. This section will present the most common tools, equipment and installation procedures required for each phase of construction. Tool and equipment requirements are determined by the phase of the installation shown below, and further defined by the type of construction, type of finish material, and the type of adhesive installation.

Installation Procedures, Tools and Equipment for Wet Area and Submerged Installations;

- Substrate and Finish Material Surface Preparation
- Inspection and Evaluation
- Access for Preparation and Installation (Rolling Scaffolds for Vertical Work)
- Mixing of Adhesives
- Installation of Adhesives
- Installation of Finish Material
- Installation of Joint Grout/Sealants

Substrate and Finish Material Surface Preparation – The first step in substrate preparation is the evaluation of the type of substrate and its surface condition. This includes the levelness (plane or flatness deviation), identification of general defects (e.g. structural cracks, shrinkage cracks, laitance, etc…), the presence of curing compounds or surface hardeners, and contamination. Concrete should have a wood float or light steel trowel finish for proper adhesion of thin-sets or membranes. Over finishing a concrete surface can close the pores and may inhibit proper adhesion of thin-sets and membranes.

The ability of a substrate to be wetted by an adhesive is essential to good adhesion and important in determining the performance of the adhesive in bonding to the substrate. This means that not only should the substrate possess a balance between porosity and texture, but also that the surface must be clean of any contamination such as dust, dirt, oil, paint, curing compounds, sealers, and other bond inhibiting substances that could prevent bonding of an adhesive. The levelness tolerance or smoothness of a substrate surface can also play an important role in allowing proper contact and wetting of an adhesive. Typically, the greater the surface area to which the adhesive is in contact, the better the adhesion.

Adhesive Compatibility – Compatibility plays an important role in determining adhesion between the substrate and the tile or membrane being installed. The substrate material must be compatible not only with adhesive attachment, but also with the type of adhesive under consideration. This means that the substrate material must have good cohesive qualities to resist tensile and sheer stress and not have an adverse reaction with the proposed adhesive or membrane. Similarly, the tile being installed must also be compatible with the adhesive. A general consideration in determining compatibility with adhesives is as follows;

The installation of any finish material with an adhesive will only be as good as the setting materials and the substrate to which the finish material will be bonded. The highest strength adhesives and most careful application with the best quality tile will not overcome a weak or dirty substrate.

This section provides information on the identification of common substrate characteristics and defects, and the preventative and corrective actions necessary for proper surface preparation.

6.2 Inspection and Evaluation

Site Visit and Pre-Construction Conference – Prior to commencing ceramic tile work, the tile contractor shall inspect surfaces to receive tile and accessories, and shall notify the architect, general contractor, or other designated authority in writing of any visually obvious defects or conditions that will prevent a satisfactory tile installation. Installation work shall not proceed until satisfactory conditions are provided. Commencing installation of tile work typically means acceptance of substrate and job site conditions.

Job Site Conditions – The following items are examples of potential issues that may need to be addressed prior to commencing the installation:

- Contamination – The surface to which tile or stone installation materials will be bonded must be structurally sound, clean and free of all dirt, dust, oil, grease, paint, concrete sealers, curing compounds, and any other material that can act as a bond inhibitor. Dry, dusty concrete and other surfaces should be swept and then dampened with a sponge and water. Any excess water should be allowed to evaporate or be swept off prior to installation of tile setting materials. See Sections 6.4 and 6.7 for more information.

- Surface and Ambient Temperatures – During the placement of concrete and installation of other types of substrates, extreme cold or hot temperatures may cause numerous surface or internal defects, including shrinkage cracking, a weak surface layer of hardened concrete caused by premature evaporation, or frost damage. Once the concrete is cured, extreme temperatures of both the ambient air and surface of the substrate can also affect the normal properties of tile adhesives.

Elevated ambient air and surface temperatures (>90°F [32°C]) will accelerate the setting of cement, latex cement and epoxy adhesives. Washing and dampening floors and walls will serve to lower surface temperatures for latex cement mortars and epoxy adhesives. Shading the substrate, if exposed to sunlight, is also effective in lowering surface temperatures, but if ambient temperatures exceed 100°F (38°C), it is advisable to defer work with adhesives and membranes to a more suitable time. Humidity may also have an effect on the curing of membranes and portland cement based adhesives and grouts. Higher humidity will work to slow down cure rates while low humidity will accelerate the curing process.

Weather Conditions and Substrate Protection – The optimum conditions for installation of ceramic tile and stone are temperatures between 60° and 80°F (15° and 27°C), with 50% relative humidity. However, these conditions are atypical, so provisions must be made for variations in climate conditions. Protection applies to the substrate, the installation of adhesives and joint grouts, and also the storage and handling of the finish material.

- Hot Temperatures – Protection or corrective action is required if either ambient air or surface temperatures of substrates/finishes go above certain thresholds during installation. Temperature thresholds vary with the types of adhesives and installation accessories, but generally, elevated ambient air (80–100°F [27–38°C]) and surface temperatures will accelerate setting of cement, latex cement, epoxy and silicone adhesives. Washing and dampening floors and walls will not only remove some contaminants, but also serve to lower surface temperatures by evaporative cooling for cement latex mortars and moisture insensitive epoxy adhesives. Shading surfaces that may be in direct sunlight by erecting temporary tents is also effective in lowering surface temperature, but if ambient air and surface temperatures exceed 100°F (38°C), it is advisable to defer work to another time. If work cannot be deferred, it is also possible to cool additives (water, latex, epoxy liquids) in conjunction with the above techniques.

Figure 6.2 – Outdoor pool work done with tenting and heating ducts to regulate temperature.

- Cold Temperatures – Protection or corrective action is required if either ambient air or surface temperatures of substrates go below certain thresholds during installation. Temperature thresholds are different for various types of adhesives. Protection and corrective actions to elevate air and surface temperatures to optimum range typically involve enclosing or tenting of work areas, augmented by temporary heating. If temporary heating is employed, it is very important to vent units to the exterior of enclosures to prevent exposure to toxic fumes, and also to prevent build-up of carbon dioxide, which can cause carbonation of cementitious materials. This condition typically occurs when ambient temperatures during installation are around 40°F (5°C) and only affects exposed surfaces. The length of exposure is a function of time and temperature. Cement hydration stops at 32°F (0°C) surface temperature, when water necessary for hydration freezes, and the cement hydration process is severely retarded starting at 40°F (5°C).

Figure 6.3 – Outdoor pool work done with tenting regulate temperature.

Concentration of carbon dioxide can be elevated when temporary heating units are not properly vented outside of any protective enclosure during cold temperatures. As a general rule, air abd surface temperatures should be maintained above 50°F (10°C) during installation of cement, epoxy, and silicone-based products. Some cement adhesive product formulations may allow installation in temperatures close to 32°F (0°C) and rising, however, at this critical ambient air temperature threshold, it is likely that surface temperatures are below freezing due to thermal lag, and hydration or other chemical reaction may not occur at the adhesive interface.

As a simple rule of thumb; for every 18°F (10°C) above 70°F (21°C) cement based and epoxy based materials cure twice as fast. For every 18°F (10°C) below 70°F (21°C) cement based and epoxy based materials take twice as long to cure.

- Dry and Windy Conditions – These conditions can cause premature evaporation of water necessary for hydration in cementitious materials, and result in loss of strength. Latex additives are formulated to significantly reduce this drying effect by coating cement with a latex film. However, in extreme dry, windy conditions coupled with high temperatures >90°F (32°C), even latex additives do not provide adequate protection. It is recommended to provide temporary protection against rapid evaporation of moisture during hot, dry, windy conditions in the initial 36 hours after installation of cement mortars, screeds, plasters/renders and cement grouts, and to augment by damp curing with periodic daily water misting. Cement based adhesives are only susceptible to premature drying between the spreading of adhesive and the installation of the finish, and requires only temporary protection from dry, high wind speeds during the open or exposed time of the adhesive.
- Wet Conditions – Certain materials used in ceramic tile and stone assemblies can be moisture sensitive. For example, the strength of cementitious adhesives can be reduced from constant exposure to wet or damp substrates. Some materials, such as waterproofing membranes, may not cure properly or may delaminate from a continually wet or damp substrate. A damp substrate may also contribute to the formation of efflorescence. This is a particular concern not only from normal rain exposure during construction, but also in areas of an installation, which may be exposed to rising dampness at ground level, or in areas where leaks from poor design or construction cause continual dampness in the substrate. When specifying liquid latex or a dry redispersible polymer adhesive mortar, verify with the manufacturer that the polymer formulation is not water soluble. However, even formulations that are not soluble when dry are vulnerable to rain during the initial set period (typically 12–24 hours). Therefore, it is essential to provide protection from any significant rain or washing within this period to avoid loss of strength and prevent possible fluid or latex migration staining.

6.3 Moisture Content of Concrete

Materials used in tile and stone installation applications can be affected by moisture during the installation and curing phase. For example, the strength of cementitious adhesives can be reduced from constant exposure to wet or damp substrates. Some materials, such as waterproofing membranes, may not cure properly or may delaminate from a continually wet substrate. A damp substrate may also contribute to the formation of efflorescence. Concrete with a high moisture vapor emission rate (MVER) may also have an impact on a tile or stone installation.

There are generally three tests that are used to determine moisture content in concrete. The three tests are:

1. Calcium Chloride (ASTM F1869 – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloors Using Anhydrous Calcium Chloride).

The Calcium Chloride test involves placing a Petri dish of calcium chloride (covered by a plastic dome adhered to the concrete) on the concrete and allowing the Petri dish to remain in place between 60–72 hours. The calcium chloride absorbs any moisture vapor that transmits through the concrete within the plastic dome. The results of a calcium chloride test measures the amount of moisture absorbed and results are stated in pounds per 1,000 ft^2 (92.9 m^2) in a 24-hour period. Please note that the ASTM F1869 test should only be conducted in interior conditions when the building is completely enclosed and the air conditioning or heating system is turned on, unless otherwise instructed by the test kit manufacturer.

2. Relative Humidity (ASTM F2170 – Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes).

The Relative Humidity test involves placing probes in the concrete and taking readings with a hygrometer. A relative humidity reading of 75% or below is acceptable for most tile applications. Please note that the ASTM F2170 test should only be conducted in interior conditions when the building is completely enclosed and air conditioning or heating system is turned on, unless otherwise instructed by the probe manufacturer.

3. Plastic Sheet Method (ASTM D4263 – Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method).

The Plastic Sheet Method involves taping an 18" x 18" (450 mm x 450 mm) piece of plastic on the concrete and allowing the plastic to remain in place for 18 - 24 hours to determine if any moisture has accumulated under the plastic when it is removed. Please note that the ASTM D4263 test should only be conducted in conditions as stated in the ASTM D4263 document.

Both ASTM F1869 and ASTM F2170 are quantitative tests (stating approximately how much moisture is present) while ASTM D4263 is a qualitative test (stating that moisture is present but not how much), and all are a "snapshot" of moisture vapor emission during the testing period.

Figure 6.4 – ASTM F1869 Calcium Chloride Test Kit and ASTM F2170 Relative Humidity Meter (Photos courtesy of George Donnelly Testing & Inspections at www.moisturetesting.com).

Concrete Curing and Age of Concrete – The age of a concrete substrate is important based on the fact that as concrete cures and loses moisture, it shrinks. A common misconception is that concrete completes shrinking in 28 days. This is not true. Thick sections of concrete may take over 2 years to reach the point of ultimate shrinkage. Under normal conditions, 28 days is the time that it typically takes for concrete to reach its full design strength. At that point, concrete will have maximum tensile strength and can better resist the effects of shrinkage and stress concentration.

Depending upon the curing techniques and exposure to humidity or moisture, there may be very little shrinkage in the first 28 days. Flexible adhesives, certain latex or polymer fortified thin-set mortars (e.g. 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE can accommodate the shrinkage movement and stress that may occur in concrete less than 28 days old. In some cases it may be recommended to wait a minimum of 30–45 days to reduce the probability of concentrated stress on the adhesive interface. Some building regulations or codes may require longer waiting periods of up to 6 months. After this period, resistance to concentrated stress is provided by the tensile strength gain of the concrete, and its ability to shrink as a composite assembly. The effect of the remaining shrinkage is significantly reduced by its distribution over time and accommodated by the use of flexible adhesives.

Cracking – Freshly placed concrete undergoes a temperature rise from the heat generated by cement hydration, resulting in an increase in volume. As the concrete cools to the surrounding temperature, it contracts and is susceptible to what is termed "plastic shrinkage" cracking due to the low tensile strength within the first several hours after the pour.

Concrete also undergoes shrinkage as it dries out, and can crack from build-up of tensile stress. Rapid evaporation of moisture results in shrinkage at an early stage where the concrete does not have adequate tensile strength to resist even contraction. Concrete is most susceptible to drying shrinkage cracking within the first 28 days of placement during which it develops adequate tensile strength to resist a more evenly distributed and less rapid rate of shrinkage. It is for this reason that it is recommended to wait 30–45 days before direct application of adhesive mortars.

Plastic shrinkage occurs before concrete reaches its' initial set, while drying shrinkage occurs after the concrete sets. These types of shrinkage cracks generally do not produce cracks larger than 1/8" (3 mm) in width.

Treating Shrinkage Cracks – There are two different ways to treat shrinkage cracks. The first way is detailed in the LATICRETE Architectural Guidebook – ES-F125 (available at www.laticrete.com/ag) or TCNA Handbook for Ceramic, Glass and Stone Tile Installation – F125. This method only treats the individual crack and not the entire area. This method may suffice for areas that are not completely submerged (such as pool decks or natatorium locker rooms). However, it will not be appropriate for areas that are constantly submerged and require full waterproofing/anti-fracture membrane treatment to create a complete waterproof installation.

The second method of treating the shrinkage crack would be detailed in the LATICRETE Architectural Guidebook – ES-F125A (available at www.laticrete.com/ag) or TCNA Handbook for Ceramic, Glass and Stone Tile Installation – F125A. This method uses the anti-fracture/waterproofing membrane over the entire floor. Following this method will help to protect the finished installation from cracks currently in the concrete substrate and any cracks which may develop over time. This is the preferred method for constant wet area and submerged applications.

Structural Cracks – There is no tile installation practice or method for treating any crack over 1/8" (3 mm) wide or cracks that experience differential vertical movement. These cracks are considered structural in nature and would require determination of the cause of the crack. Once the cause of the structural movement is determined, it must be remedied prior to the installation of the tile system. Repair techniques can vary and a structural engineer should be consulted prior to any remediation or installation of a tile system.

Excessive foundation settlement and movement can be caused by building on expansive clay, compressible or improperly compacted fill soils, or improper maintenance around foundations. Whatever the cause, settlement can destroy the value of a structure and even render it unsafe. In any case, water is the basic culprit in the vast majority of expansive soil problems. Specific components of certain soils tend to swell or shrink with variations in moisture. The extent of this movement varies from soil type to soil type.

When unstable soils are used as a base for a foundation, the tendency for movement is transmitted to the foundation. Since soil movement is rarely uniform, the foundation is subject to a vertical differential movement or upheaval. If all the soil beneath a foundation swells uniformly, there usually is no problem. Problems occur, however, when only part of the slab settles. Then, differential movement causes cracks or other damage. Once again this condition must be corrected before any tile installation can occur.

6.4 Potential Bond Breaking Materials

A tile installation is only as good as its adhesion to the substrate and the tile. An adhesive, in any form, will bond to the first thing it comes in contact with. If that material is dirt, dust, paint, or any other impediment that is lying on a surface, the adhesion to that substrate can be compromised. The importance of a good, clean surface cannot be over emphasized, regardless of the substrate or tile adhesive.

Laitance – Laitance is a surface defect in concrete where a thin layer of weakened portland cement fines have migrated to the surface with excess "bleed" water or air from unconsolidated air pockets. Once the excess water evaporates, it leaves behind a thin layer of what appears to be a hard concrete surface, but in reality is weakened due to the high water to cement ratio at the surface. Laitance has a very low tensile strength, and therefore the adhesion of tile will be limited by the low strength of the laitance.

The removal of laitance by mechanical methods, including the use of chipping hammers or scarifying machines, is recommended. The contaminated concrete surface should be removed until sound, clean concrete is encountered. Measurement of surface tensile strength and the absence of loose material are good indicators of sound concrete.

Abrasive blasting by means of a dry or wet blasting process, or, bead/shot blast methods are also acceptable for the removal of laitance on new and fully cured concrete. Compressed air used in these methods must be oil free. Since wet abrasive blasting reintroduces moisture into the concrete, sufficient drying time must be allowed.

Curing Compounds, Sealers and Form Release Agents – Liquid curing compounds and sealers are topically applied spray-on materials, which are designed to keep moisture in the slab. The constant amount of water kept in the concrete by the curing compounds helps accelerate the curing time and improve the performance of the concrete. Curing compounds and concrete sealers are frequently used in all types of construction, especially in fast track jobs. Unfortunately, all types of curing compounds, concrete sealers and surface hardeners must be completely removed from substrates prior to the installation of tile or any installation accessories, including waterproofing membranes. The preferred methods to remove these curing compounds from the surface would be to bead-blast or shot-blast the horizontal concrete surface, and to high pressure wash vertical concrete surfaces.

There is a very simple and effective test to identify the presence of curing compounds, sealers or other bond breaking conditions. Simply sprinkle a few drops of water onto the substrate and see what happens. If water absorbs into the slab then it is usually suitable for the direct adhesion of tile. On the other hand, if the water beads up on the concrete surface (like water on a freshly waxed car) then there is something present on the concrete surface that can inhibit proper adhesion of the tile adhesive. While the water test is commonly used to determine the presence of bond inhibiting substances, it may not always be accurate.

In addition, to determine if bond inhibiting contamination such as oil or curing compounds are present on concrete, conduct the following test: taking proper safety precautions, mix a 1:1 solution of aqueous hydrochloric (muriatic) acid and water, and place a few drops in various locations. If the solution causes foaming action, then the acid is allowed to react freely with the alkaline concrete, indicating that there is no likely contamination.

If there is little or no reaction, chances are the surface is contaminated with oil or curing compounds. Acids do not affect or remove oily or waxy residue, therefore, mechanical removal may be necessary.

Any surface to receive tile will always be exposed to varying degrees of contamination, especially normal construction dust and debris. Tile is often installed during the last phase of the construction of a building. Imagine all other trades have been in and finished their certain part of the construction, (i.e. sheet rock, plumbing, painting, and many other trades). There is often paint, drywall compound, oil and other materials on the concrete from prior trades that need to be removed. One of the most difficult tasks for any installer is the preparation of the surface before the installation of the tile commences.

However, it is one of the most important steps, if not the most important step, to providing for a successful, long lasting tile installation. Cleaning the surface is mandatory before tile is placed, and sometimes multiple washings will have to take place before tiling. Just sweeping the floor is not good enough!

6.5 Substrate Preparation Equipment and Procedures

Contamination Removal – If contamination removal is required, or if surface damage or defects exist, bulk surface removal may be necessary to prepare the substrate. There are several methods of removal, but it is important to select a method that is appropriate to the substrate material and will not cause damage to the sound material below the surface.

Methods of Removal – There are several methods for removing contamination from a substrate to better prepare for the application of tile and stone installation materials. These include;

- Mechanical Chipping, Scarifying and Grinding – Mechanical chipping, scarifying or grinding methods are recommended only when substrate defects and/or contamination exist in isolated areas and require bulk surface removal greater than 1/4" (6 mm) in depth. Chipping with a pneumatic square tip chisel or grinding with an angle grinder is a common mechanical removal technique.

Figure 6.5 – Saw Tec® Dustless Grinding. This method is ideal for spot preparation and solves localized problems.

- Shot-blasting and bead blasting – This is a surface preparation method, which uses proprietary equipment to pummel the surface of concrete with steel pellets or ceramic beads at high velocity. The pellets of varying size, are circulated in a closed, self-contained chamber, where the pellets and debris are separated. The debris is collected in one container and the pellets are re-circulated for continued use. This is the preferred method of substrate preparation when removal of a thin layer of the concrete surface is required, especially the removal of surface films (e.g. curing compounds or sealers) or paint.

Figure 6.6 – Shot-blasting is ideal for areas outside of pool tanks and water features and for areas where access by the equipment is not an issue.

- Water-Blasting – High pressure water blasting using pressures between 3,000-10,000 psi (21–69 MPa) will remove the top surface layer of concrete and expose aggregate to provide a clean, rough surface. Thorough rinsing of the surface with water after water blasting is necessary to remove any laitance. Water-blasting is only recommended on fully cured concrete because of the high pressure. Proper allowance must be made to allow for the excess water in the slab to dry. This method is commonly used on vertical surfaces and is ideal for preparation of pool tanks, water features and vertical surfaces.

Figure 6.7 – High pressure water wash (water-blasting) may remove the required amount of contaminated concrete.

- Acid Etching – Acid etching or cleaning is never recommended to clean a surface prior to receiving tile. If an acid is not neutralized or cleaned properly after the cleaning takes place, it can continue to weaken the portland cement in the concrete and tile installation materials when in the presence of moisture. Acid must be neutralized with Tri-Sodium Phosphate (TSP) or baking soda mixed with water and then completely rinsed to ensure all the acid is removed from the surface. Again, acid is not recommended for cleaning concrete, since it has an adverse affect on portland cement. A chemical reaction occurs when portland cement and acid are introduced to each other that can destroy the cement matrix. The interaction between the acid and the portland cement exposes the concrete aggregates and weakens the concrete.

Acid can also leave a white powdery substance on the surface which can act as a bond breaker for any tile installation material. To avoid any potential problems it is best to avoid the use of acids as a substrate preparation method.

6.6 Substrate Tolerances

Flatness and Levelness – A flat, plane substrate is an important concern for any tile installation requiring a direct bond adhesive application. According to industry requirements (ANSI A108.01 – 3.2) the following are the requirements for flatness of concrete slabs;

- ANSI A108.01 3.2.1.1 – Where the mortar bed for the tile floors to be bonded to the concrete slabs; "Screed finish concrete slabs that are to receive ceramic tile. Maximum permissible variation in the plane or slope is 1/4" in 10' (6 mm in 3 m) from the required plane when measured with a straight-edge… Properly cure slabs without using liquid curing compounds or other coatings."
- ANSI A108.01 3.2.1.2 – Where tile is to be bonded directly to concrete with one of the thin-set methods; "Steel trowel and fine-broom finish concrete slabs that are to receive ceramic tile. Maximum permissible variation of 1/4" in 10' (6 mm in 3 m) from the required plane. Cure concrete slabs that are to receive tile before tile application. Do not use liquid curing compounds or other coatings that may prevent bonding of the tile setting materials to slabs. Slab shall be dry at time of tile installation. Since any cracking of the concrete slab will be transmitted to the finished surface, take all precautions to prevent cracks in the concrete. Use control joints through the slab and tile finish as specified or where cracks are anticipated."

Large format tile and stone applications may require a tighter tolerance of 1/8" in 10' (3 mm in 3 m) from the required plane. Greater deviations prevent the proper installation of tile into the adhesive, which may result in numerous problems, including loss of bond or excessive lippage.

If levelness tolerance is exceeded, then it may be necessary to employ remedial work, such as re-construction, patching, grinding, or installation of leveling mortars, screeds, or renders (e.g. 3701 Fortified Mortar Bed, Quick Cure Mortar Bed, 3701Lite Mortar, 3701 Lite Mortar R, or 226 Thick Bed Mortar mixed with 3701 Mortar Admix).

If the tolerance is within specifications, then the use of a large, heavy tile mortar (e.g. MULTIMAX™ LITE) and a larger size notch trowel can alleviate some minor defects in the substrate. Please note that while a medium mortar may be used to correct minor substrate defects, it is important to stay within the product manufacturers guidelines for thickness of the setting material.

With most adhesives or cement leveling mortars/renders, such as latex cement mortars or moisture insensitive adhesives, the substrate can be damp during installation; however, it cannot be saturated. The objective is not to saturate the floor, but to make sure all the dust and debris is removed before tiling.

6.7 Final Surface (Residue) Cleaning

Once all corrections to the substrate have been made, the final and most important step of substrate preparation is the final cleaning, not only of the residue from contamination and bulk removal processes described above, but also cleaning of loose particles and dust from airborne contamination.

The final cleaning is considered minimum preparation for all substrates. Final cleaning can be accomplished by pressurized water as mentioned above, but can also be accomplished with standard pressure water and some agitation to eliminate the bond breaking effect of dust films. In some cases, airborne contamination is constant, requiring frequent washing just prior to installation of cement leveling plaster/renders, adhesive mortars, or membranes.

There is no exception from this general rule; and the only variation is the drying time of the substrate prior to the application of the adhesive. Drying time is dependent on the type of adhesive being used. With most adhesives, the substrate can be damp, with no standing water. A surface film of water will inhibit grab and bond of even water insensitive cement and epoxy based adhesives.
The use of a damp sponge just prior to installation of tile is an industry accepted method to ensure that the substrate is cleaned of any dirt and construction dust on the properly prepared substrate.

Monitor the pH level of the substrate prior to laying tile. Do not install tile until the pH has a value less than 10. Properly balance the pool water immediately upon filling.

6.8 Finish Material Preparation

Cleaning of the tile back and substrate surface prevent contamination from inhibiting adhesive bond. While careful consideration is often given to the preparation of the substrate, preparation and cleaning of the finish material bonding surface is an often overlooked specification item or quality control checkpoint. Considerations are dependent on the type of finish material.

Types of Finish Materials

- Ceramic or Porcelain Tile – The bonding surface of the tiles may be contaminated with dirt or dust from normal manufacturing, storage and handling. Porcelain tile may have a coating of a release agent (known by terms such as bauxite, engobe) which prevents fusion of the tile to kiln surfaces during the firing process. The type, amount, and degree of removal of release agent prior to shipping will vary according to manufacturer or production batch. It is recommended to wipe each tile with a clean, damp towel or sponge during or just prior to installation to maximize adhesive bond. Redispersible polymer cement and latex cement adhesive mortars can be applied to a damp, but not dripping wet surfaces.
- Stone – Fabrication dust from cutting, polishing and detailing may leave a dusty residue on the bonding side of the stones. The back of the stone should also be wiped down with a clean damp sponge or cloth and allowed to dry prior to installation for maximum adhesive bond.
- Glass Tile – The preparation of a glass tile prior to installation will vary by glass tile manufacturer. Therefore, it is important to follow the glass tile manufacturer's written installation instructions. In many cases, the glass tiles should be wiped and cleaned of any dust or residue with clean water and then should be wiped dry with a clean cloth prior to installation.

6.9 Adhesive Mixing Equipment and Procedures

Equipment and tools required for mixing of adhesives are primarily dependent on the type of adhesive and construction site conditions such as the size of project.

Types of Adhesives

Latex Cement Based Adhesive Mortars

Manual Mixing

- Bucket, Trowel and Mixing Paddle

Mechanical Mixing

- Low Speed Drill (<300 rpm) and Non-Air Entraining Mixer Blade (Figure 6.6)
- Rotating Blade (Forced Action) Batch Mortar Mixer (Figure 6.7)

NOTE: Rotating drum type concrete mixers are not suitable for mixing adhesive mortars. In mixing cement adhesive mortars, always add the gauging liquid (water or latex additive) to the mixing container or batch mixer first. Begin mixing and add the dry cement based powder gradually until all powder is wet, then continue mixing continuously for approximately one minute or until mortar is wet and plastic (or as directed in mixing instructions). If using site prepared powder mixes of portland cement and sand, add the sand first until it is wet, and then add the cement powder. Take caution to prevent over-mixing by blending only until the mortar is wet and plastic in accordance with the manufacturer's instructions. Over-mixing can entrap air in the wet mortar and result in reduced density (high absorption will reduce freeze thaw stability) and strength.

Epoxy Adhesive

Manual Mixing

- Bucket and Trowel

Mechanical Mixing

- Low Speed Drill (<300 rpm) and Non-Air Entraining Mixer Blade

The mixing instructions for epoxy adhesives vary according to the manufacturer's formulations. The most common epoxy adhesives are three component products, which involve mixing two liquid components (resin and hardener), and a powder component (silica filler). The liquids are mixed together first and fully blended before adding filler powder.

There are several important considerations in mixing epoxies. First, the chemical reaction begins immediately upon mixing the epoxy resin and hardener. Because the "pot" or useful life of the adhesive is relatively short (1 hour) and can be further reduced by ambient temperatures above 70°F (21°C), all preparation for mixing and installation of the epoxy adhesive should be made in advance. Mixing should also be made in quantities that can be installed within the prescribed useful life under installation conditions.

Most epoxy adhesives cure by an exothermic or heat generating chemical reaction beginning with the mixing of the liquid components. The useful life of the epoxy not only begins before adding the filler powder, but the heat generated may accelerate the curing process in many formulations. Removal of the mixed epoxy from the mixing container is one technique used to dissipate heat generation and minimize set acceleration. Liquid components may also be cooled if anticipated ambient or surface temperatures will significantly exceed recommended use temperature range. Conversely, epoxy adhesive cure is retarded by cold temperatures, and the curing process will slow significantly at temperatures below 40°F (5°C); the curing process will continue unaffected if temperatures are raised.

Figure 6.8 – Variety of Mixing Paddles used for Drill Type Mixers.

Mortar Beds

- Aluminum Straight Edges and Screeds
- Concrete/Mortar Bed finishing trowel
- Wheelbarrows
- Square Edges Shovels
- Steel Rakes
- Walking Boards
- Mortar Bed / Tile Shoes
- Mortar Mixer

Figure 6.9 – Rotating Blade Type Mixer.

6.10 Installation Equipment and Procedures

The following are the basic tools and equipment used for the installation of ceramic tile, porcelain tile, glass tile and stone finishes:

Equipment for Application and Bedding of Adhesives and Grout Joints

- Notched Steel Trowel
- Flat Steel Trowel
- Margin Trowel
- Hawk
- Metal Applicator Gun (Silicone Sealant)
- Rubber Mallet
- Wood Beating Block
- Spacer Shims and Wedges
- Grout Float (Cement or Epoxy)

Cutting/Fitting of Finished Materials

- Wet Saw (See Figure 6.10)
- Ceramic Tile Cutter and Accessories

Figure 6.10 – A commercial grade wet saw is ideal for cutting all types of tile and stone in swimming pool, fountain or water feature applications.

Measurement

- Carpenter's Level
- Laser Level
- Straight Edge (4'/1200 mm)

Clean-Up

- Sponges, Towels
- Water Bucket
- Solvents (Epoxy or Silicones)

Personal Protective Equipment (PPE)

- Safety Glasses
- Rubber Gloves
- Dust Mask/Respirator
- Safety Belts and Harness

Functions of a Notched Trowel

- Gauges the Proper Thickness of Adhesive
- Provides Proper Configuration of Adhesive
- Aids in Efficient Application of Adhesive

Notched steel trowel – This is the primary and most fundamentally critical installation tool for the thin-bed or large, heavy tile method of installation. The proper thickness of the adhesive layer is dependent on the type and size of finish, the cladding and substrate bonding surface texture, configuration and tolerance from consistent thickness. A "gauged" or "calibrated finish" is one with a consistent thickness and a specified tolerance for deviation; an "ungauged" cladding is not consistent in thickness. Even gauged large format tile and stone can experience thickness tolerances of up to 1/8" (3 mm). Notched steel trowels are available in several sizes and configurations to control thickness of applied adhesive mortar. The configuration of adhesive application is critical to performance of the tile or stone installation. In addition to controlling final thickness of adhesive, the notched configuration results in "ribbons" or "ribs" of adhesive separated by spaces that control bedding or setting of the finish into the adhesive. The spaces allow the ribs of adhesive to fold into one another to decrease the resistance to pressure required for proper contact, and provide a controlled method of filling all air voids and allowing escape of air parallel to the ribs. This function is critical in assuring full contact and coverage of adhesive, not only to ensure maximum bond strength, but also to eliminate air voids or channels, which can harbor or transport water.

Notch Chart

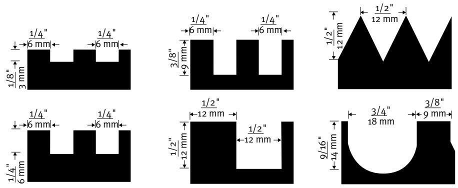


Figure 6.11 – Notched trowel sizes for installation of adhesive mortars.

It is important to maintain the specified notch depth and configuration of notched steel trowels throughout the project. The angle of application can have a significant effect on the height of adhesive ribs, which in turn can affect the height to width ratio necessary for control of thickness and elimination of air voids. Therefore, it is recommended to prohibit the common use of severely worn trowels and to require frequent cleaning and specification of application angle as part of the specification and quality control inspection program. A flat steel trowel is a tool used in applying an initial thin layer of adhesive in positive contact with both the bonding surface of the tile, also known as back-buttering, and the surface of the substrate. The opposite side of a notched trowel typically has a flat edge for this purpose. A rubber mallet and wood beating block, or, for mosaics, a hard rubber grout float, can be used to beat-in the tiles after they are placed to assure full contact with the adhesive, and eliminate any voids in the adhesive layer.

Tile Installation Procedure

The following is an abbreviated step-by-step process for the application of thin-bed and large, heavy tile adhesive mortars. Follow the explicit manufacturer's installation instructions for detailed information. For full installation specifications for thin bed, large, heavy tile mortar, thick bed and membrane instructions – see section 7.

1. Apply a thin skim coat (1/16"/1.5 mm thick) of thin-set, large, heavy tile mortar or epoxy adhesive to the properly prepared dampened substrate with the flat side of the trowel; ensure good contact by scratching the edge of the trowel against the surface.
2. Additional thin-set or epoxy adhesive is then applied with the notched side of the trowel. Comb the mortar on the surface with the notched trowel holding it as close as possible to a 90° angle to the substrate. This will ensure the proper size of notches.

3. The ribs of thin-set, large heavy tile mortar or epoxy adhesive should be troweled in one direction only, and not in a swirl pattern. If additional thickness of adhesive is needed, add to the back of the tile or stone using the same procedure as on the substrate, making sure that the direction of the combed mortar is identical to the one on the substrate, otherwise, you will end up with notches in two directions that disturb each other and consequently will not allow full contact between the mortar and the back of the tile.
4. As a rule, tile sizes larger than 12" x 12" (300 x 300 mm) should be back buttered. Back buttering not only improves the contact between the mortar and the back of the tile, but also helps to ensure complete coverage. Another important consideration for back buttering is that if the tile is not fully bedded by proper beat-in, the ribs of thin-set or epoxy adhesive, which are not flattened, are being sealed by the coat applied to the back of the tile.
5. The tile should be pressed into place, and either twisted and pressed into position, or for tile sizes 12" x 12" (300 x 300 mm) and greater, slide into position with a back and forth motion perpendicular to the direction of the thin-set or epoxy adhesive ribs.
6. The final step is to beat-in with a rubber mallet to ensure thin-set , large, heavy tile mortar or epoxy adhesive contact and make surface level with adjacent tiles.

6.11 Grout and Sealant Materials, Methods and Equipment.

Purpose of Grout or Sealant Joints – The joints or spaces between pieces of tile serves several important purposes. Aesthetically, joints serve as a design element, primarily to lend a pleasing scale with any size tile module. Functionally, joints prevent water infiltration, and compensate for varying dimensional tolerances of the tile or stone. More importantly, though, joints lock the tiles into place and provide protection against various delaminating forces. Depending on the joint material, a joint may also act to dissipate shear stress caused by movement.

Compensate for Tile Thickness Tolerances – The joints between tiles compensate for allowable manufacturing or fabrication tolerances, so that consistent dimensions (from center to center of joints or full panel dimensions) can be maintained. As a result, joints must be wide enough to allow variations in the joint width to accommodate manufacturing or fabrication tolerances in the tile without being evident.

Prevent Water Infiltration – Filled joints between tiles allow most surface water to be shed. This helps prevent infiltration of water, which can lead to saturation of the setting bed and substrate, freezing, strength loss and efflorescence. Depending on the grout or sealant material used, and the quality of installation, no grout or tile will be 100% effective against water penetration, so there may always be a small amount of water infiltration by capillary absorption. Therefore, the use of a waterproofing membrane is strongly recommended in wet area applications.

Dissipate Movement Stress — Probably the most important function of grout or sealant joints is to provide stress resistance and stress relief. The composite locking action with the adhesive layer allows the tile finish to better resist shear and tensile stress. Joints serve to provide stress relief of thermal and moisture movement that could cause delamination or bond failure if the edges of the tiles were butted tightly. Further isolation of movement is handled by separating sections of tile with movement joints (see Section 7.6 – Sealant and Section 10 – Movement Joint Specifications and Details). This ensures that the grout or sealant joint will always fail first by relieving unusual compressive stress from expansion before it can overstress the tile finish or adhesive interface. The dissipation of stress provides an additional safety factor against dangerous delamination or bond failure.

Grout Installation Procedure – The following is an abbreviated step by step process for the installation of grout. Follow the explicit manufacturer installation instructions for detailed information. For full grout installation specifications – see Section 10.

1. Prior to grouting, it is essential to conduct a test panel (preferably as part of the pre-construction quality assurance procedures) to test the grouting installation and clean-up procedures under actual climatic conditions. During this test, you may determine the need to apply a grout release or sealer to the tile prior to grouting in order to aid in clean-up and prevent pigment stain and absorption of cement paste (especially latex cement or epoxy liquids) into the pores of the tile. This test may also determine if additional adjustments are necessary, such as saturation of the finish with water to reduce temperature, lower absorption, and aid in installation and cleaning. Conducting a test panel will also allow for final determination of the grout color in relation to the tile, lighting and other environmental factors to which the finished installation will be exposed.

2. Wait a minimum of 24 hours after installation of tile before grouting.
3. Before commencing with grouting, remove all temporary spacers or wedges; rake any loose excess adhesive mortar from joints. Remove any hardened thin-set or epoxy adhesive which is above half the depth of the tile. Insert temporary filler (rope, foam rod) in movement joints to protect from filling with hard grout material. Wipe the tile surface with a sponge or towel dampened with water to remove dirt and to aid in cleanup.
4. Apply the grout joint material with a rubber grout float, making sure to pack joints full.

Figure 6.13 – Grout joint installation equipment – Grout Float.

5. Remove excess grout by squeegee action with the edge of the rubber grout float diagonal to the joints to prevent pulling of grout from the joints.
6. Allow grout to take an initial set and follow the appropriate cleanup process for the specific grout type used as stated in the manufacturer's written installation instructions.
7. Any remaining weakened grout haze or film should be removed within 24 hours using a damp sponge or towel.

Silicone or Urethane Sealant Joint Fillers

Installation procedures for sealant joint fillers are the same as for movement joints

(see Section 7 – Sealant and Section 10 – Expansion Joint Specification and Details).

6.12 Post Installation Cleaning

Most clean-up should occur during the progress of the installation. Hardened adhesive and grout joint residue may require more aggressive mechanical or chemical removal methods than required while still relatively fresh. Water based cement and latex cement adhesives clean easily with water while fresh, or may require minor scrubbing or careful scraping together with water within the first day. Epoxy and silicone adhesives and joint sealants may require more aggressive scrubbing and solvents if residue is greater than 24 hours old.

6.13 Mechanical Means and Methods

As an alternative to the common traditional means and methods of installation, swimming pool and natatorium applications lend themselves to the use of mechanized means and methods due to the size and uniqueness of the application. In many cases, mechanized equipment can greatly improve productivity and lower labor and installation costs. Generally, the set up and clean up time of the equipment factors into the decision of whether to use the mechanized equipment. The following sections provide an alternative to the traditional means that are typically used in most ceramic tile installations.

Power Screeds – Power screeds are used as an alternative to the conventional wood or aluminum straight-edge methods of leveling and "pulling" of mortar beds. The power screeds run on small electric powered or gas powered engines. The vibration that is caused helps to facilitate the screeding. The power screed sits on aluminum ribbons that set to the desired height. The power screed is pulled over the ribbons to compact and level the mortar faster and more efficiently than manual methods.

Power Grouting – Power grouting is accomplished by using a mechanized grout spreading machine. The grout is spread by using rubber blades mounted on a powered, rotating floor machine. This equipment will spread both latex portland cement based and epoxy grouts in an effective manner. These machines pack the joints and strike the excess grout from the face of the tiles. The rubber blades can be changed when excessive wear is noticed. The mechanized power-grouting machine has interchangeable pads to easily convert to the cleanup process. Traditional methods and equipment will still need to be used in small areas where the use of the mechanized equipment becomes impractical.

Figure 6.14 – Raimondi USA – Power Grouting Machine and Accessories.

Figure 6.15 – Raimondi USA – Power Grouting Machine.

Figure 6.16 – Raimondi USA – Low Speed Power Mixing Tub.

Mortar Mixers and Pumps – Mortar mixers and pumps are used as an alternative to conventional mortar mixers. The pump and mixer apparatus effectively mixes and pumps the mortar through a 3" (75 mm) hose to the desired location. The strength and style of these machines varies greatly depending on the amount of mortar to be mixed, the distance to place the mortar, and the amount of mortar to be placed.

Figure 6.17 – Putzmeister USA Pumps.

Figure 6.18 – Mortar is mixed and pumped to area in a combination mortar mixer/pump combination.

Spraying Waterproofing Membranes – Liquid applied waterproofing membranes are typically applied with heavy nap paint rollers. However, on large natatorium and water feature projects, certain liquid applied waterproofing membranes (e.g. HYDRO BAN® or HYDRO BAN XP) can be effectively sprayed to increase productivity. In addition to the conventional means of applying HYDRO BAN, (see Data Sheet 663.0 and How To Install Data Sheet 663.5) or HYDRO BAN XP (see Data Sheet 36642 and How To Install Data Sheet 663.5) the airless spraying technique can be used as an alternate means of application. The following are the guidelines for this procedure. Most airless spray units can be used to apply the HYDRO BAN or HYDRO BAN XP.

This procedure will refer to the use of Graco's Mark IV Electric Airless Sprayer® and the 5900 HD Gas Powered Airless Sprayer. These sprayers are designed for spraying the contents from a 5 gallon (19 L) pail. Many airless sprayers are similar in design and will accomplish the same purpose.

Mark IV Electric Airless Sprayer

5900 HD Gas Powered Airless Sprayer

Description	Mark IV	5900 HD
Graco Part No.	249636	248699
Max Tip Size	.031 (0.79 mm)	.043 (1.09 mm)
Max GPM (LPM)	0.95 (3.6)	1.6 (6.0)
Max PSI (MPa)	3300 (22.8)	3300 (22.8)

Figure 6.19 – Graco Company airless spray equipment. A good understanding of the equipment, set up, delivery and cleanup procedures are required in order to effectively spray HYDRO BAN® or HYDRO BAN XP.

Airless Spray Tip Characteristics – It is important to remember that the spray tip orifice size, in conjunction with the fan width size, determines the spray characteristics of the tip.

Examples: As the spray tip orifice size increases, while maintaining the same fan width size, the greater the volume of coating will be applied to the same area. Conversely, the larger the fan width size, while maintaining the same orifice size, will result in the same amount of material being applied over a greater surface area.

Figure 6.20 – Graco Company Typical LTX Sprayer Nozzle.

Tip Size: LTX521 – has an orifice of 0.021" (0.5mm) and a fan width of 10" (250 mm) holding the nozzle 12" (300 mm) away from the substrate.

Tip Size: LTX631 – has an orifice of 0.031" (0.8 mm) and a fan width of 12" (300 mm) holding the nozzle 12" (300 mm) from the substrate.

The use of a spray tip with a smaller orifice will result in less product being delivered to the substrate requiring multiple passes to ensure a complete coating with optimum thickness.

Understanding Tip Wear – Choosing the right spray tip is essential for ensuring a quality finish. When beginning a project, choosing the right tip size and fan width will determine how effective the spraying process will be. The correct tip size will have a direct bearing on how much material is dispensed. However, spray tips will wear with normal use. When a tip wears, the orifice size increases and the fan width decreases so delivery time and product consumption will increase. This causes more liquid to hit a smaller area, which wastes waterproofing membrane and slows productivity. It is important to replace a tip when it gets worn to ensure a precise spray pattern, maximum productivity and a quality finish. Therefore, changing the spray tip often will result in greater productivity.

Tip life varies by coating, so if a tip is worn, replace it. Extend tip life by spraying at the lowest pressure that breaks up the coating into a complete spray pattern (atomize). Do not increase the pump pressure; it only wastes waterproofing membrane and causes unnecessary pump component wear.

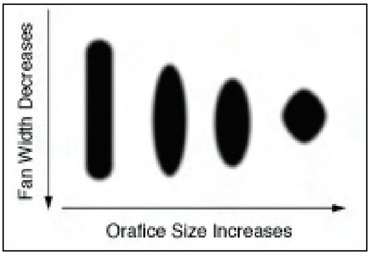


Figure 6.21 – The example demonstrates the spray pattern of new and worn spray tips. As wear occurs, the pattern size decreases and the orifice size increases. As a rule of thumb, it is best to replace the spray tips after spraying 30–45 gallons (114–171 liters) of HYDRO BAN® or HYDRO BAN XP.

Spray Guns – Follow the specific airless sprayer and spray gun manufacturer's written instructions when using their specific equipment. The Graco® Silver Plus Airless Spray Gun is depicted in the following photo. This spray gun can be used for both vertical and horizontal applications. Some Spray Guns will allow filtering in the gun handle. The filters will need to be periodically cleaned and changed to ensure proper liquid flow through the spray gun and tip.

Figure 6.22 – Graco Silver Plus Airless Spray Gun

Application of HYDRO BAN® and HYDRO BAN XP – Follow all surface preparation requirements outlined in HYDRO BAN Data Sheets 663.0 and 663.5 or HYDRO BAN XP Data Sheet 36642. The sprayer should produce a maximum of 3300 psi (22.8 MPa) with a flow rate of 0.95 to 1.6 GPM (3.6 to 6.0 LPM) using a 0.521 or a 0.631 reversible tip. Keep the unit filled with HYDRO BAN or HYDRO BAN XP to ensure continuous application of liquid. The hose length should not exceed 100' (3000 cm) in length and 3/8" (9 mm) in diameter.

Apply a continuous HYDRO BAN® film with an overlapping spray. The wet film has a sage green appearance and dries to a darker olive green color. When the first coat has dried to a uniform olive green color, approximately 45 – 90 minutes at 70°F (21°C), visually inspect the coating for any voids or pinholes.
Fill any defects with additional material and apply the second coat at right angles to the first. The wet film thickness should be checked periodically using a wet film gauge to ensure that the appropriate thickness and coverage is achieved. Each wet coat should be 0.015" – 0.022" (0.4 – 0.6 mm) thick. The combined dried coating should be 0.020" – 0.030" (0.5 – 0.8 mm) thick or 0.029" – 0.043" (0.7 – 0.11 mm) wet. Bounce back and overspray will consume more of the HYDRO BAN or HYDRO BAN XP. To achieve the required film thickness, the coating must be free of pinholes and air bubbles. Do not back roll coating. Allow the HYDRO BAN or HYDRO BAN XP to cure in accord with the instructions in HYDRO BAN Data Sheets 663.0 and 663.5 or HYDRO BAN XP in Data Sheet 36642 prior to the installation of the tile or stone finish.

It is important to note that areas not scheduled to receive the HYDRO BAN or HYDRO BAN XP should be taped off and protected from any potential overspray. Expansion and movement joints should be honored and treated as outlined in product HYDRO BAN Data Sheets 663.0 and 663.5 or HYDRO BAN XP Data Sheet 36642.

NOTES: The operator of the spray equipment must have a working knowledge of the equipment used and be able to adapt to th project conditions as the spraying takes place. As the spray tip wears, adjustments will need to be made. Spray tip selection, pressure adjustments and hose length will have a direct bearing on the results achieved.

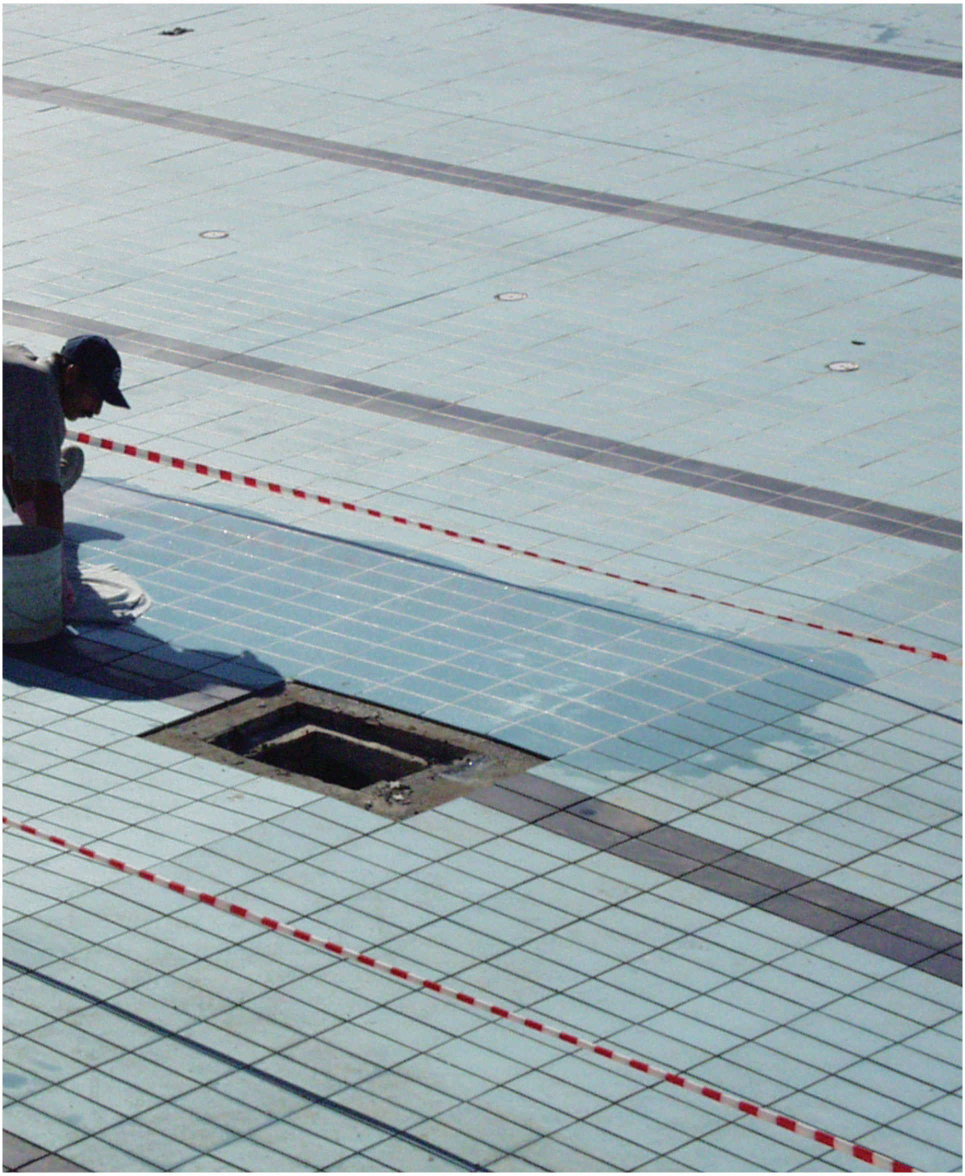
Spray Equipment Setup, Clean Up and Maintenance – Follow the airless sprayer manufacturer's instructions on set up, operation, clean up and maintenance of their equipment. The airless spraying unit should be flushed, clean and free of any contaminants prior to use with HYDRO BAN or HYDRO BAN XP.

Health and Safety – Follow all applicable health and safety requirement when applying HYDRO BAN or HYDRO BAN XP. The use of adequate personal protective equipment (PPE) is recommended. See Safety Data Sheet (SDS) for HYDRO BAN or HYDRO BAN XP for complete information.

Airless spray equipment can be purchased by contacting:

Graco Inc.
Sales/Distribution/Service
P.O. Box 1141
Minneapolis, MN 5540-1441
Tel. 1.800.690.2894
Fax 1.800.334.6955
www.graco.com

Section 7: Pool, Fountain and Spa Tile Installation



7.1 Adhesive and Mortar Performance and Selection Criteria

The performance and use of ceramic tile adhesives are regulated by the country or region according to prominent standards that govern the installation of ceramic tile. Some of these standards are discussed in Section 4. Compliance may either be mandatory or voluntary in the respective countries, depending on whether the standard is incorporated into a building code (see Section 4).

Criteria for Selection of Adhesives and Mortars

- High Adhesive Strength (Tensile and Shear Bond Strength)
- Water Resistant
- Flexible (Differential Movement)
- Permanent
- Fire and Temperature Resistant
- Non-Toxic and User Friendly
- Good Working Properties (Open Time, Pot Life, Sag Resistance)

High Adhesive Strength (Tensile and Shear Bond Strength) – Shear stress occurs when a force is applied parallel to the face of the material. The greater the resistance to shear stress, the higher the shear strength result.

Tensile stress occurs when a force is applied to pull a material to the point where it loses bond with the surface to which it is applied. The greater the resistance to tensile stress, the higher the tensile strength result.

Tile and stone installations can experience both shear and tensile forces. It is important to note that shear bond testing is limited to laboratory testing. On the other hand tensile bond testing can be performed in both laboratory conditions and in the field. Therefore, both tests are applicable and suitable to measure a material's bond strength.

Water Resistance – For proper exterior and interior wet area performance, and in demanding submerged applications, an adhesive must not be soluble in water after it is fully cured. The adhesive should also develop water insensitivity within 24 – 48 hours so as not to require an unreasonable degree of protection against deterioration when exposed to water.

Flexible (Differential Movement) – Adhesives must have a low modulus of elasticity, or flexibility, to withstand differential movement between the finish material and the underlying substrate/ structure. Differential movement can be caused by uneven or sudden temperature changes, moisture expansion or shrinkage of the finish material, substrate or structure, or, live loads such as filling and draining the tiled vessel with water.

Permanence – This criteria may seem obvious, but even if all other performance criteria are met, beware that some adhesive mortars can become soluble in submerged applications and may deteriorate over time. In addition, some epoxies can become brittle with age, and some urethanes can undergo a phenomena known as "reversion," where the adhesive may soften and revert back to its original viscous state. Certain polymeric modification of cement mortars work only to enhance the workability and curing process to improve the physical characteristics of cement, but do not contribute any significant lasting improvement to the physical characteristics of the cement adhesive mortar.

Fire and Temperature Resistance – When cured, adhesives must meet building code requirements and standard engineering practices by not contributing any fuel or smoke in the event of a fire. In addition, the adhesive must maintain its strength and physical properties during and after exposure to high temperatures of a fire, or from absorption of heat under normal service.

Non-Toxic and User Friendly – The adhesive should be non-hazardous during storage, installation, and disposal. This includes other materials which may be necessary for preparation or final cleaning. The adhesive should be non-toxic, non-flammable, low odor, easy to use, and environmentally (VOC) compliant. It is always best to verify low VOC compliance by obtaining third party certification of the installation materials (e.g. GREENGUARD). For example, LATICRETE International, Inc. manufactures a variety of setting materials for submerged applications (and otherwise) which are UL GREENGUARD Gold Indoor Air Quality Certified. For more information, please visit www.laticrete.com/green.

Good Working Properties – The adhesive should have good working properties to ensure a cost effective and problem-free installation. This means that the adhesives must be easy to handle, mix, and apply without having to take extraordinary precautionary measures. Good initial adhesive grab to substrate and the finish material, long pot life, long open time (tacky, wet surface after spreading), vertical sag resistance (both the adhesive alone and with tile), and temperature insensitivity are all recommended working properties.

Bedding of Tiles – Solidly bedding the tile is one of the most important steps to achieving a permanent and trouble free installation. Back-buttering the tiles and ensuring complete coverage without air pockets or voids is a key process to meeting this end. The Project Architect can specify this procedure in the installation specification to ensure that this essential step is part of the construction process. Inspectors and applicators should periodically remove a tile to verify the coverage that is being attained. United States ANSI A108 Standards require a minimum 95% coverage in wet areas. Ensuring that no voids exist will prevent water penetration into the adhesive mortar layer and into the pore structure of the tile or stone (see Section 6 for more information on the application of adhesives and how to achieve the correct coverage).

7.2 Green Design Considerations

3.7 Green Design Considerations – With the awareness of "green" building and environmental impact awareness, building construction continues to go through changes.

The use of low Volatile Organic Compounds (VOC) materials, products manufactured with recycled content, products that help expand the Life Cycle Analysis (LCA) of a structure, and help maintain a healthy environment for building occupants have become the norm throughout the world.

Environmental Impact and Energy Efficiency
Today, we use the equivalent of 1.5 Earths to meet the resource needs of everyday life and absorb the resulting wastes. This measure of our planet's carrying capacity means that it takes Earth 18 months to re-generate what is used in only 12 months. If current trends continue, estimates suggest, by the year 2030 we will need the equivalent of two planets. Turning resources into waste faster than they can be regenerated puts the planet into ecological overshoot, a clearly unsustainable condition that we all must address.

The forces driving this situation are numerous. Human population has increased exponentially in the past 60 years, from about 2.5 billion in 1950 to more than 7 billion today. Our linear use of resources, treating output as waste, is responsible for the toxins that are accumulating in the atmosphere, in water, and on the ground. This pattern of extraction, use and disposal has hastened depletion of finite supplies of nonrenewable energy, water and materials used in accelerating the pace of our greatest problem – climate change. Buildings account for a significant portion of greenhouse gas emissions: in the U.S., buildings are associated with 38% of all emissions of carbon dioxide, and globally, the figure is nearly one third."25

LEED (Leadership in Energy and Environmental Design)
The United States and various other countries around the world have adopted the USGBC LEED Program, using the LEED Reference Guide for Green Building Design and Construction, as a basis for their green building. The USGBC has also developed the LEED Schools Reference Guide for educational facilities constructed in areas where the LEED program is utilized.

The LEED Green Building Systems are voluntary, consensus-based, and market driven. Based on existing and proven technology, they evaluate environmental performance from a whole-building perspective over a building's life cycle, providing a definitive standard for what constitutes a green building in design, construction and operations.

LEED is a framework for identifying, implementing and measuring green building and neighborhood design, construction, operation and maintenance. LEED is a voluntary, market-driven, consensus-based tool that serves as a guideline and assessment mechanism. LEED rating systems address commercial, institutional and residential buildings and neighborhood development.26

Each rating system is organized into six environmental categories: Location and Transportation (LT), Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), and Indoor Environmental Quality (EQ). Additional categories, Innovation (IN) and Regional Priority (RP), can be used to address sustainable building expertise based on regional considerations and recognizing innovations which are not found in the current version of LEED and which are not covered under the six environmental categories.

Sustainability
The United States and various other countries around the world have adopted the USGBC LEED Program, using the LEED Reference Guide for Green Building Design and Construction, as a basis for their green building. The USGBC has also developed the LEED Schools Reference Guide for educational facilities constructed in areas where the LEED program is utilized.

In most cases, steam room facilities are designed and constructed to last as long as possible. To achieve the maximum number of years of problem-free use, a steam room must be constructed with first rate building components and installation assemblies. Service life and product durability should be factored into the selection of steam room/steam shower components. In addition, easily maintainable and long lasting finish materials (e.g. porcelain tile) should be considered and specified for these projects. Steam room/steam shower maintenance has a direct impact on environmental sustainability. In other words, safe and easy to maintain finish materials in these demanding applications equate to lower maintenance costs and longer life cycles with minimal impact on the environment and the economy. Ceramic tile and stone finishes, along with a low maintenance, high performance epoxy grout, and 100% silicone sealant are a natural fit for these applications. The use of these tile and stone finish materials allow for minimal levels of maintenance while providing high quality and durable performance.

Greater emphasis will continue to be placed on the benefits that green and sustainable materials and methods provide not only for steam room construction, but for all types of buildings and building environments. To this end, the need exists to implement best practices for the construction of sustainable buildings and environments. Green construction materials and methods speak a great deal about the core goals of the designer, owner and maintenance personnel. For instance, how smart is it to construct a hot tub or swimming pool as part of a gym or health facility in which building materials with high volatile organic compound (VOC) levels are used during construction and/or during routine maintenance. The use of high VOC materials, which may off-gas over time, can cause the people who use the facility to become sick. Occupants who utilize facilities inside buildings constructed with high VOCmaterials can have short term and possibly even long-term effects on their health.

Sustainable building products are no longer just an added benefit to product selection and use. In many regions of the world, green building codes and other green building practices are mandated for projects that receive federal, state or regional government funding. For example, in the United States federally funded construction or renovation projects must comply with green building standards and achieve a designated green rating under the USGBC LEED program. Therefore, the selection and use of building products that comply with these standards is mandatory. Fortunately, ceramic tile/stone and the installation materials typically fit in very nicely with these requirements. In fact, the National Green Building Standard ICC 700, sets forth the requirements for green construction and sustainability for various projects. In addition, requirements and standards for the interior environment and other key areas are also set forth. Many finishes and their installation components can off gas volatile organiccompounds. The use of low VOC content and emission products should be specified for all installations of tile or stone for steam rooms and steam showers. LATICRETE provides UL GreenGuard Gold certified products, which requires ultra-low VOC emissions, and that are tested in accordance with California Department of Public Health (CDPH) v1.2 in an Office and Classroom Environment. For a complete list of UL GreenGuard Gold certified products, please go to https://laticrete.com/en/innovation-and-impact/green-leed/greenguard-certified-products.

Environmentally Friendly Products

In today's construction marketplace, the phrase "environmentally friendly product" is thrown around on such a frequent basis, that the term 'green washing' was coined some years ago. Environmentally friendly products are materials that do not harm the space that humans occupy, and, do not have any adverse impact on the ecology or environment during their harvesting, manufacturing, installation, curing/drying, and time in service. In making the determination for whether a product is environmentally friendly or not; the following questions should be asked:

- Does the material break down over time?
- What is the life of the product?
- Will it off-gas, what will it off-gas and for how long?
- How often does the material need to be replaced?

For example, there are some materials in the plastics family, which just do not break down easily. They can stay in landfills for hundreds of years. There are several types of flooring products that fall into this category (e.g. vinyl composition tile, linoleum, rubber flooring). In addition, when these types of flooring materials are installed with a urethane type adhesive; they can be potentially dangerous to the environment for many years after they are discarded. A great feature of ceramic tile and stone is that they are mainly composed of basic materials, which are found in the earth. There is not much that needs to be done with slabs of marble, limestone, slate, sandstone, granite or quartz; except to maybe alter its finish. That is easily accomplished by polishing the surface to a glimmering mirror like finish, or, just a bit to a softer honed finish.

As far as ceramic tile, the ingredients that go into it are mainly clay and shale that are then pressed or extruded into shape and then fired at high temperatures to achieve a very dense and durable finish. Manufacturers of ceramic tile have become so effective in their production processes, that the cost of ceramic and porcelain tiles is actually coming down, as opposed to the cost of other types of flooring and wall finishes where the costs continue to increase. Therefore, vinyl flooring, carpet and similar finishes that were considered inexpensive alternatives to ceramic tile and stone are actually at an even greater disadvantage. When a design professional was looking for an inexpensive alternative, they accepted the drawbacks of off gassing and short life cycles associated with these other types of finishes (e.g. vinyl composition tile, linoleum, carpet, rubber, paint, wall covering). They no longer have to compromise since ceramic and porcelain tiles are durable, dense, sustainable, long-lasting (60 years or more), and easy to maintain.

Ceramic tile and stone are also considered environmentally clean. If for any reason tile or stone is removed (and this is usually only because it looks dated), it can be buried in a landfill and will not harm the ecology or the environment. Unlike the adhesive mortars that are used to install resilient and wood floors or carpeting; tile and stone adhesives are typically portland cement based and do not pose any danger to the environment. The vast majority of cement based and epoxy based adhesives are inert once they harden and do not off-gas or emit any volatile organic compounds (VOC). LATICRETE offers a wide-range of products that are UL GreenGuard certified for ultra-low VOC emissions, so you can trust that these products will not off-gas and have a negative impact on the occupants of a building or on the environment.

Volatile Organic Compounds (VOC)

Volatile organic compounds are carbon compounds, which participate in atmospheric photochemical reactions that vaporize at normal room temperatures. These compounds are considered as harmful to building occupants when excessive levels are reached. This is what may cause a person to develop reactions to materials in a building. It is the off-gassing of the volatile organic compounds that creates respiratory or allergic reactions. Some of the ingredients in building materials, which are considered as VOC are formaldehyde, styrene, ozone, total aldehydes, and 4-phenylcyclohexene compounds. These ingredients exist in over 2,000 chemicals (Ahuja, 2004, p. 2).

The LEED Reference Guide for Green Building Design and Construction states that tile adhesives should have a maximum VOC content of 65 g/L (8.7 oz./gallon) less water, per South Coast Air Quality Management District (SCAQMD) Rule 1168. LEED Reference Guide for Green Building Design and Construction v4.1 Credit "Low Emitting Materials" also requires manufacturers to state compliance with the general emissions evaluation, as measured using CDPH v1.2, including the exposure scenario, the amount of wet-applied product (applied in mass surface area), the range of total volatile organic compounds (TVOC), and follow the guidelines in CDPH Standard Method v1.2, Section 8, to help attain the "Low Emitting Materials" credit. The ranges of TVOC are 0.5 mg/m3 or less, between 0.5 and 5 mg/m3, or 5 mg/m3 or more.

LATICRETE Contributions to LEED Certification

Third party green building materials certification organizations (e.g. UL Environment) help specifiers and designers to choose products that comply with the latest green building standards and codes. Many of the products manufactured by LATICRETE International, Inc. are independently certified by UL Environment as low VOC compliant. UL GREENGUARD Gold certificates for many LATICRETE products are available on the LATICRETE web site at www.laticrete.com/green or at www.greenguard.org. LATICRETE also has the LATICRETE LEED Project Certification Assistant to help tile contractors, distributors, architects, and specifiers easily obtain all of the information required for LEED certification in regards to LATICRETE products.

As stated earlier in this section, LATICRETE has taken the necessary steps to contribute to the Green Movement by not only manufacturing low VOC products, but to have them independently certified by UL Environment as such. LATICRETE manufactures UL GREENGUARD Gold certified products in the underlayment, membrane, thin-set, large, heavy tile mortar, grout, and epoxy adhesive categories which means that any job requiring low VOC compliance can be accomplished with a complete, warranted LATICRETE system.

UL Environment is an industry independent, third-party certification organization that qualifies products for low chemical emissions. UL GREENGUARD Gold certification programs use defined product standards, test methodologies, product sample collection and handling procedures, program application processes and on-going verification procedures. UL GREENGUARD standards, methods and procedures are available at www.greenguard.org. Please note that any LATICRETE product which has attained a UL GreenGuard Gold certificate meets the CDPH v1.2 test criteria in both the Office and Classroom scenarios. The following swimming pool, spa and fountain suitable products are UL GREENGUARD Gold certified for low VOC; HYDRO BAN®, HYDRO BAN XP, HYDRO BAN Quick Cure, 9235 Waterproofing Membrane, HYDRO BAN Cementitious Waterproofing, 3701 Fortified Mortar Bed, Quick Cure Mortar Bed, 3701 Lite Mortar, 3701 Lite Mortar R, 257 Titanium™, 254 Platinum, MULTIMAX™ LITE, LATAPOXY® 300 Adhesive, LATAPOXY BIOOGREEN™ 300 Adhesive, PERMACOLOR® Grout; PERMACOLOR Select, PERMACOLOR Select NS, and SPECTRALOCK® PRO Premium Grout†. LATASIL™, while not UL GREENGUARD Gold certified, meets the LEED EQ Credit 4 requirements for low VOC content and low VOC emissions, and, has been independently tested for VOC emissions per CDPH v1.2 and meets the <0.5 mg/m3 level in both the Office and Classroom scenarios. Please click these links to access this test report and certificate. LATASIL9118 Primer also meets the LEED EQ Credit 4 requirements for low VOC content for architectural, porous sealant primers.

7.3 Methods of Installation

There are several methods generally used in the installation of tile in pools and water features.

Application Methods

- Thin-Bed Method
- Large, Heavy Tile Mortar Method
- Thick Bed (Bonded Type Wet-Wet Method, Bonded Type Cured Thick Bed)

NOTE: Refer to Section 8 for unbonded, wire reinforced cured thick bed method and unbonded, wire reinforced wet-set method for natatorium pool decks and other non-submerged areas.

Thin Bed Method – This method, also referred to as the adhesive method, is defined as an application of a layer of adhesive, ranging from a minimum of 1/8" (3 mm) to a maximum of approximately 3/8" (9 mm) thick that is in full contact with no less than 95% of the bonding surface of the tile or stone and substrate. The substrate must be prepared to proper flatness, level and plumb in advance; adhesives are not intended for leveling or correcting level and plumb deviations. The adhesive can range from a pure or neat portland cement paste, to latex cement and epoxy adhesives. The thickness of the adhesive layer is dependent on the type and size of the tile, substrate bonding surface texture, and configuration of the tile (flat or ribbed back). A "gauged" tile is one with a consistent thickness and a specified tolerance for deviation; an ungauged finish material type is not consistent in thickness and typically requires thick bed or large, heavy tile mortar methods of installation. Generally, most, redispersible powder polymer and latex cement mortars are suitable for use with the thin-bed or large, heavy tile mortar methods, but not all of these mortars are suitable for submerged installations. Follow the adhesive manufacturer's guidelines for limitations on thickness, which varies based on formulation and for suitability in submerged installations. Refer to Section 9 – Specifications and Section 10 – Detail Drawings for ES-P601D for more information.

Large and Heavy Tile Method – Generally, thicknesses over 3/8" (9 mm) are not recommended for standard thin-bed or adhesive types of cement mortar mixes. Thickness over 3/8" (9 mm) typically require either a special formulation of powder containing a higher proportion of coarse sand, or modification of a site mix with the addition of extra coarse sand. These products are also known as large and heavy tile mortars. Large and heavy tile mortars are typically used when the adhesive thickness ranges from 1/8" (3 mm) up to 3/4" (19 mm). An example of this type of mortar is MULTIMAX™ Lite (ideal for use in submerged applications).

Figure 7.1 – Trowel applied large, heavy tile mortar with a 3/4" (19 mm) loop notch trowel.

Thick Bed Method – Also known as the "wet-set" or "float and back-butter" method of installation, this method encompasses several different techniques. The most common thick bed technique is the "float and back butter" method. This method starts with the floating or screeding of the substrate with cement leveling mortar. The mortar bed can either be of the unbonded type (for pool decks) or the bonded type (pool decks or submerged).

Mortar beds and wall renders are very commonly used in pool and water feature applications. Mortar beds allow for the creation of proper pitch/falls to drains, slopes in pools and decks and the creation of coves and transitions as pool floors slope and the depth changes.

Bonded Type (Floors) – In the bonded type for floors, a slurry bond coat consisting of 254 Platinum, 257 TITANIUM™. or MULTIMAX™ LITE is applied to the concrete substrate. While the slurry bond coat remains wet and workable, the mortar bed (e.g. 3701 Fortified Mortar Bed or 3701 Lite Mortar) is placed, compacted and then screeded, leveled, and pitched as required. The above mentioned mortar bed and slurry bond coat products are ideal for use in submerged applications. Unbonded mortar bed types require wire reinforcing which can be subject to corrosion in submerged applications and are therefore, unsuitable for use in this type of application.

Bonded Type (Wall Renders) – Wall renders do not require the use of slurry bond coat beneath them as the mortar is mixed to a more plastic mix containing a liquid to mortar powder ratio. This consistency allows the cement paste to wet out the concrete/masonry substrate in a sufficient manner to achieve proper bond. Wall renders are generally applied in several lifts with each lift never exceeding 1/2" (12 mm) in thickness. The first lift is the scratch coat. This layer is applied to the wall and is scratched up with a small metal comb like tool or trowel that roughens up the layer in order that the subsequent layer will achieve better mechanical bond. The scratch coat is allowed to harden and then the subsequent "brown" coats are applied in the same 1/2" (12 mm) maximum lifts. If additional lifts are required, the previous brown coat should be scratched up before it hardens.

3701 Fortified Mortar Bed, Quick Cure Mortar Bed, 3701 Lite Mortar and 3701 Lite Mortar R are pre-packaged thick bed and rendering mortars which comply with industry standards and will hold up to the rigors of submerged applications. The use of pre-packaged mortars eliminates inconsistencies in job site powder proportioning and raw material quality. Refer to Section 9 – Specifications and Section 10 – Detail Drawings for ES-P601 for more information.

These products are also components of the LATICRETE System Warranties and apply to submerged installations Please visit www.laticrete.com for more information on LATICRETE warranties or call LATICRETE Technical Services at 1.800.243.4788 x1235.

Figure 7.2 – Latex fortified render is being applied to wall surface. Notice the lath strips that are set into the mortar. The lath strips are leveled and plumbed to establish the correct wall render depth. Once the render achieves a sufficient cure, the lath strips are carefully removed and the cavities are filled with mortar.

Templates – Swimming pools and water features may include intricate shapes, coves, goosenecks and other special attributes that can only be achieved by careful placement of bonded mortar beds and wall renders. Wood form templates are created and used to screed and shape the mortar to conform to these unique shapes. Traditional pools generally used formed tile gutters/skimmers/drains/ladders as part of the design and functionality.

Tile mechanics will often spend many hours fabricating these templates to create these intricate flowing shapes. This is a critical step in establishing the correct depths and elevations of the finish tile. In many cases, the shaped tile gutters and gooseneck dictates the finished elevations of the balance of the pool tile assembly including the pool deck.

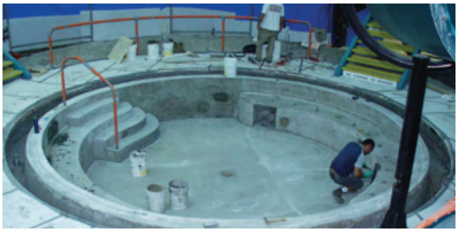


Figure 7.3 – Tile mechanics float and shape pool utilizing templates, floats and screeds to achieve the desired form and height of the renders and mortar beds.

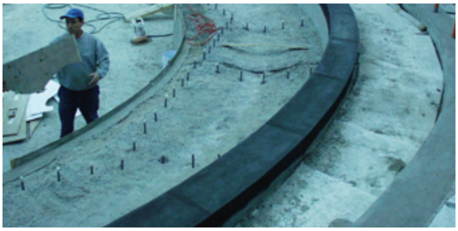


Figure 7.4 – Mechanic is using a wooden template to shape and screed the swale in the water feature tank.

Gutters and Special Forms – Modern pools generally use stainless steel gutters in lieu of the formed tile gutters. The stainless steel gutters also help to set the depth of the wall renders and the finish tile height. These elevations have a direct bearing on the floor heights and the radius of the coves that tie the walls into the floors.

Figure 7.5 – Stainless Steel Pool Gutter Assembly. Tile or Stone is brought up to the gutter assembly in the tank and on the deck (Photo courtesy of Barrier Lining, Inc.)

Figure 7.6 – Uniquely shaped pool/deck rim which required careful forming of the render in order to place the finished tile.

7.4 Waterproofing

Importance – Waterproofing protection is one of the most practical steps to ensure the longevity of any tile installation. It not only protects the spaces below and adjacent to the tile installation, it also protects the setting bed, reinforcing wire or metal lath (if used), concrete base and concrete reinforcing from potential damage and corrosion. Since damage to components can occur, it is no surprise that the majority of construction liability claims involve water damage that has resulted from the lack of, or an improperly installed, waterproofing membrane. The pressure of completing projects in a timely manner, often leads to tile installations being rushed and not installed correctly. The advanced technology that goes into waterproofing and anti-fracture membranes allows the end user to take advantage of quicker curing times, allowing quicker time to flood testing and ultimately allows the tile installation to move forward in a timely fashion. Various types of waterproofing and anti-fracture membranes are available and include; troweled applied, liquid applied and sheet good types.

The traditional asphaltic/bitumen based roofing type waterproofing membranes are omitted from this manual. However, it is important to note that if they were to be specified and used in a swimming pool or water feature, a topping concrete slab would need to be placed over this type of membrane. Direct bonding of tile or stone to these membrane types is not possible.

The most important factor in all types of waterproofing membranes is to closely follow the membrane manufacturer's installation recommendations. This will significantly reduce the possibility of job site problems and potential failures. Adhering to industry standards is also paramount to the success of the tile installation. Consideration should be given to membranes that carry plumbing and building code approval as well as being environmentally friendly (e.g. HYDRO BAN®, HYDRO BAN XP or HYDRO BAN Cementitious Waterproofing Membrane).

Many crack isolation and waterproofing membranes can be applied over concrete, mortar beds, exterior glue plywood (interior only) and cement backer board. Some waterproofing membranes serve as both waterproofing and anti-fracture membranes (e.g. HYDRO BAN or HYDRO BAN XP).

The installation of waterproofing is covered under ANSI A108.13, Installation of Load Bearing, Bonded, Waterproof Membranes for Thin-set Ceramic Tile and Dimension Stone, and crack isolation is covered under ANSI A108.17, Installation of Crack Isolation Membranes. The product standards for waterproofing can be found under ANSI A118.10 and the product standards for crack isolation membranes can be found under ANSI A118.12. Selection of membranes must take into account the conditions of a submerged application including exposure to pool water chemicals. Direct bond waterproofing membranes protect underlying leveling mortars and the concrete shell from saturation and prevent problems caused by moisture penetration such as moisture expansion, chemical attack (e.g. chloride ion deterioration of reinforcing steel), and efflorescence. LATICRETE products in this category include HYDRO BAN, HYDRO BAN XP or HYDRO BAN Cementitious Waterproofing Membrane.

External "Sandwich" Type Roofing Membrane – In suspended, exterior roof swimming pool and water feature applications over occupied space, primary roofing membranes can be specified to be installed in between two concrete pours that serve as the platform or substructure of the water feature. These external type roofing membranes are also typically used when external or negative hydrostatic pressure is present to protect ceramic tile from delamination when pools are emptied. A concrete topping slab is required in order to protect the membrane from damage and to provide a suitable substrate to receive subsequent work. These types of primary roofing membranes can be bituminous asphaltic, neoprene, PVC or other durable bladder type material. Ceramic tile and stone cannot be bonded directly to these types of membranes.

Sheet membranes – Sheet membranes are typically made from chlorinated polyethylene, polyvinyl chloride, or other materials. Sheet membranes are made in a variety of lengths and widths to accommodate many different types of installations, with product performance that can vary depending on the manufacturer and product type. Generally, these sheet membranes have polyester or fiberglass mesh or scrim bonded to both sides of membrane sheet which allows the membrane to be bonded to the substrate, and tile or stone to bond directly to the sheet membrane. Check with the sheet membrane manufacturer for suitability in submerged installations.

Typically, a latex portland cement mortar (meeting ANSI A118.4) is used to bond the membrane to the substrate and to bond tile to the membrane. If time is a limiting factor, some membrane manufacturers allow the use of a rapid-setting thin-set to adhere the membrane to the substrate, which in turn allows the installation of tile to take place immediately without the loss of bond from the membrane to adhesive.

It is very important to consider the moisture vapor emission rate (MVER) and the alkalinity of the concrete slab prior to the installation of the products. A high MVER rate and/or high alkalinity can create adhesion problems and can even be destructive to the membrane and the overall installation. The sheet membrane manufacturer can provide information on the MVER and alkalinity limits of their products.

Sheet type membranes are pressed into contact with the substrate in an effort to eliminate air bubbles and voids between the membrane and substrate. Generally, this can be done using a 75– or 100 (34 – 45kg) pound sheet vinyl roller. It is important to note that the substrate or setting bed surface must meet the same substrate smoothness criteria required for direct bond tile applications. Basically, if the surface is not smooth and flat enough for tile, then it is not smooth and flat enough for a membrane.

Precautions and concerns with sheet type membranes are as follows:

1. Trapping air below the membrane can cause air pockets to form and radically diminish the compressive strength of the membrane.
2. Overlapping and sealing the seams. The seams may require treatment with a suitable sealant or solvent. This process can be very involved and requires careful attention to detail and safety concerns.
3. Membrane thickness increases in the folds of inside and outside corners, seams and other transition areas. Additional flashing or skim coating treatment may be necessary to minimize the effects that this can have on the finish tile appearance.
4. High alkalinity and moisture can attack and adversely affect some sheet type membrane and the adhesive used to adhere the membrane to the substrate.
5. High MVER – generally in excess of 5 lbs/1000 ft^2/24 hours (283 mg/s m^2) can have a negative impact on the adhesion of sheet type membranes (follow membrane manufacturer's guidelines for MVER).

Peel and Stick Membranes – Peel and stick membranes are very similar to sheet type membranes in performance. The major difference between the two styles is that the peel and stick type does not rely on a separately applied thin-set or adhesive to bond it to the substrate. These membranes are generally asphalt based with a reinforcing fabric on the tile bonding side of the membrane and a removable Kraft paper type backing which exposes a tacky surface once it is peeled away. The installation of peel and stick membranes begins with priming the substrate with the appropriate primer for the application. Some primers are latex based types and others can be epoxy based materials.

Once the primer is in place, the removable film is peeled from the back side of the membrane and rolled onto the primed substrate.

Check with the peel and stick membrane manufacturer for suitability in exterior or wet area installations.

Precautions and concerns with peel and stick type membranes are as follows:

1. Careful consideration must be taken where the seams overlap. Spreading the tile mortar over the seam can be tricky and care should be taken to avoid humps where the tile lays over seams.
2. These types of membranes have a tendency to soften when exposed to sunlight. Windows that face the sun and let more sunlight in could pose problems for peel and stick membranes.
3. Cleaning regimens also play a factor in whether peel and stick membranes should be used or not. Solvents typically have an adverse effect on this type of membrane. Consult the manufacturer for specific applications.
4. Use of these membrane types should be limited to pool decks and other intermittent wet areas. These membranes should not be used in submerged applications.

Trowel Applied Membranes – Trowel applied membranes come in various forms, including latex fortified cement based types, epoxy resin types and urethane types. Some of the trowel applied membranes include a reinforcing fabric used in corners, coves, and to tie into plumbing fixtures (including drains). After the typical pre-treatments are made to cracks and transition areas, the main application normally consists of keying the membrane into the substrate with the flat side of the trowel. This is immediately followed by combing the material in a singular direction, and then finally another pass with the flat side of trowel to smooth the surface. A few key elements are the notches in the trowel which act as a gauging device for the membrane. Most membranes require a certain thickness of product to ensure complete waterproofing coverage. As with all waterproofing membranes, the products should be applied at the continuous required mil thickness to ensure waterproofing integrity. The use of a wet film gauge is recommended to assure acceptable uniform thickness.

Check with the trowel applied membrane manufacturer for suitability in submerged installations.

Latex Cement Based Membranes – This membrane type is generally comprised of a liquid latex polymer that is mixed into a portland cement based powder. These products are generally very economical in cost and in ease of application. However, the physical characteristics of these types of products generally restrict their use in demanding submerged applications.

Check with the latex cement based membrane manufacturer for suitability in submerged installations.

Epoxy Based Membranes – Epoxy membranes are normally 3-component systems consisting of an epoxy hardener, epoxy resins, and a filler powder. These products are generally very chemical resistant and suitable for submerged applications. Some other advantages to this category type of waterproofing are as follows:

- Flood Testing Can Be Performed in 24 Hours at 70° F (21°C)
- Adheres to Metal, Such as Stainless Steel, as well as Metal Plumbing Fixtures
- Flexible and Able to Adhere to Most Substrates
- Can Be Used as a Flashing Membrane to Tie Into Other Types of Membranes or Surfaces When Required (e.g. Pipe Penetrations, etc…)

An example of this category type of waterproofing membrane is LATAPOXY® Waterproof Flashing Mortar.

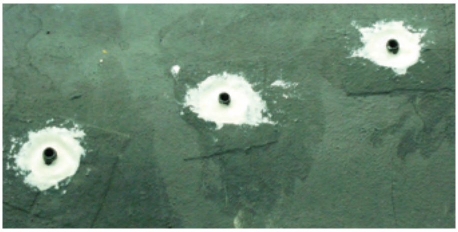


Figure 7.7 – Epoxy waterproofing membrane is applied at the pipe penetrations over the cured liquid applied waterproofing membrane to ensure a complete seal at the penetrations.

Liquid Applied Membranes – This category type offers an ideal solution to the demanding requirements of submerged tile and stone applications. In addition, to holding up under normal conditions in these applications, liquid applied waterproofing membrane types are the easiest to install and provide many features and benefits. These features and benefits include:

- Providing Both Waterproofing and Anti-Fracture Protection
- Meet ANSI A118.10 Standards for Waterproofing

- Meet ANSI A118.12 Standards for Crack Isolation
- Plumbing Code Approved (IAPMO and ICC)
- Green Building Approved for Low VOC Content (GREENGUARD® Certified)
- Thin – Load Bearing
- Shock Resistant
- Fully Compatible With the Entire Range of Ceramic Tile or Stone Installation Materials Which are Recommended for Submerged Installations
- Fully Formable to Fit Into Tight Areas
- Can Be Shaped to Follow Any Substrate Contour
- Flood Testing Can Vary According to the Membrane Type and Generally Ranges From 2 Hours to 7 Days at 70° F (21° C)
- Some Liquid Applied Waterproofing Membranes (e.g. HYDRO BAN® or HYDRO BAN XP) May Be Spray Applied with a Commercial, Airless Sprayer

Figure 7.8 – Liquid applied membrane applied to concrete substrate.

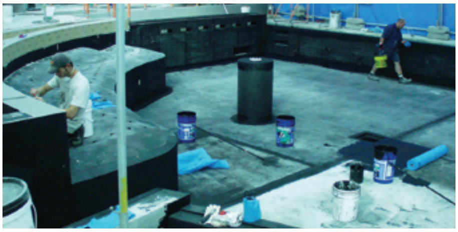


Figure 7.9 – Full scale view of liquid applied waterproofing membrane on a large scale pool project.

Examples of this category type are HYDRO BAN® and HYDRO BAN XP. HYDRO BAN and HYDRO BAN XP are thin, load bearing waterproofing membranes do not require the use of reinforcing fabric in most situations, completely compatible with latex thin-set mortars.

Detailing Of Penetrations/Railings/Steps – Detailing of penetrations through the waterproofing membrane and tile or stone finish is one of the most critical areas of a submerged application. Generally, a suitable flexible sealant designed for these applications is a key component to treating penetrations. Railings, ladders, drains, gutters, filter inlets and outlets, lights, and receiver hooks are among the list of items that could potentially penetrate the waterproofing membrane in a submerged application. Silicones (e.g. LATASIL™) and urethane type sealants offer solid performance in these applications. In many cases, manufacturers of these products will also offer primers that aid the sealant's ability to remain adhered in these applications (e.g. 9118 Primer). Each penetration through the waterproofing membrane and finish is unique. Therefore, consult with the tile and stone installation materials manufacturer for their suggestions on compatible penetration treatments. See Section 10 for details ES-WP-300 for information on the treatment of pipe penetrations and ES-WP301 and WP-302 for information on the treatment of drain assemblies.

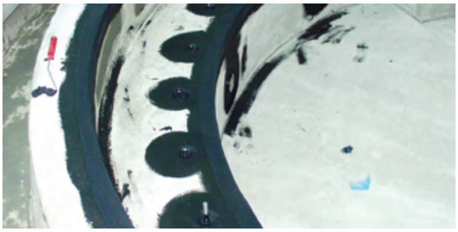


Figure 7.10 – Detail treatment of the pipe penetrations in this pool application. Liquid applied waterproofing membrane is double applied at the penetrations to ensure adequate reinforcement and protection. This pool is now ready for the full waterproofing treatment.

Flood Testing – Flood testing criterion can also vary according to the type of water feature application. Generally, a flood test is conducted after the waterproofing membrane and penetrations through the membrane are treated and all installed components reach full cure.

Although there are no known flood testing standards for pools and water features, ASTM D5957 "Standard Guide for Flood Testing Horizontal Waterproofing Installations" can serve as a basic guide for flood testing submerged applications. Generally, flood tests are conducted for a period of 24 – 72 hours and must be continuously monitored during the flood test period. Please note that accumulation of rain water, or water from any other outside source, may render the results of the flood test inaccurate.

Most latex fortified portland cement based installation systems (mortar bed, thin set mortar and grout, flexible sealant) require a minimum 14 day cure at 70°F (21°C) after the final grouting period prior to the initiation of the flood test. If an epoxy grout is used, the minimum cure can be reduced to a 10 day cure at 70° F (21°C) after the final grouting period.

As a rule of thumb, water is placed into the water feature at a rate of 1" (25 mm) per hour. Flood tests are generally conducted for 24 – 72 hours. All piping and drains will need to be plugged and isolated to eliminate the potential for the plumbing as a cause of water loss. If any measurable water loss is observed, the following process will be required:

- The Water Feature Will Need to be Drained at the Same Rate Used to Fill the Tank (2' [600 mm] per 24 Hours)
- Allow the Water Feature to Dry
- Inspect For Leaks
- Repair the Leaks
- Allow the Installed Products to Reach Full Cure
- Repeat Flood Test Procedure Until Successful

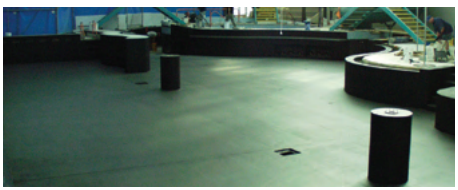


Figure 7.11 – Waterproofed pool tank is curing and awaiting a flood test. Curing term of waterproofing membranes can vary by manufacturer. Consult with waterproofing manufacturer for detailed information on cure rates and flood testing processes.

For more information on flood testing procedures, please refer to TDS 169 "Flood Testing Procedures" available at www.laticrete.com.

Figure 7.12 – Pool tank is filled with water during the flood test stage. Upon successful flood testing, the pool will be drained, dried and ready to be tiled (as a side note, notice the tenting that is protecting the water feature from the elements during the installation and curing process).

7.5 Tile Setting Mortars

Types of Adhesives

- Redispersible Polymer Fortified Cement Mortar (Mixed With Water)
- Liquid Latex Fortified Cement Mortar (Latex in Lieu of Water)
- Modified Emulsion Epoxy Adhesives (Cement, Water, Epoxy Resins)
- Epoxy Resin Adhesives (100% Epoxy)

Redispersible Polymer Fortified Cement Mortar – This type of cement based adhesive mortar is available only as a manufactured proprietary product. There are a wide variety of these types of adhesive mortar products on the market. These materials typically are mixed with potable water; however, many redispersible polymer mortars can be mixed with liquid latex additive to improve performance (see latex fortified cement mortar). For example, 317 Mortar can be mixed with either water for good performance or with 3701 Mortar Admix for improved performance. In fact, for submerged applications, 317 Mortar must be mixed with 3701 Mortar Admix. These adhesive mortars differ mainly by the type and quantity of polymeric content. In addition, premium high strength redispersible polymer fortified thin bed mortars are available and suitable for use in submerged applications. For example, 257 Titanium is ideal for these areas. Performance characteristics of 257 Titanium comply with both ANSI 118.4 and 118.11 standards. Please visit www.laticrete.com for more information on each LATICRETE product including mixing instructions.

Types of Redispersible (Polymeric) Powders

- Modified Cellulose
- Polyvinyl Acetate Powder (PVA)
- Ethylene Vinyl Acetate Copolymer Powder (EVA)
- Polyacrylate Powder

Many of the redispersible powder cement mortars available on the market are not recommended for submerged applications for a variety of reasons. Some of the polymers used, such as PVA, are water soluble and can re-emulsify after prolonged contact with moisture, causing polymer migration and resulting in staining, loss of flexibility and strength. Most products that conform to ANSI 118.1 adhesive standards contain only water retentive additives such as cellulose, which provide water retention for prolonged open time and improvement of working properties, but ultimately provides minimal improvement of strength or flexibility when compared to traditional cement mortar.

EVA modified mortars that conform to ANSI A118.4 standards may require special formulation and vary in quantity of the polymeric powder in order to have the characteristics and physical properties required for an industrial application. Some products which employ EVA polymers do not have good resistance to prolonged moisture exposure and are not recommended for submerged applications. While dry redispersible polymer fortified adhesives are economical and easy to use, it is recommended to verify suitability for use in submerged applications with the manufacturer, and to request or conduct independent testing to verify the manufacturer's specified performance.

Liquid Latex Fortified Cement Mortar – There are a wide variety of proprietary liquid additives that can be used with both generic cement (and sand), or with proprietary cement mortar powders, including the previous category of redispersible polymer fortified mortars, to prepare an adhesive for submerged tile installations. As with redispersible polymer products, the liquid additives differ mainly by the type and quantity of polymeric content. Therefore suitability and performance characteristics for water feature applications must be verified.

Types of Liquid Additives

- Vinyl Acetate Dispersions
- Acrylic Dispersions
- Styrene-Butadiene Rubber

Liquid polymer modified cement mortars are also a good choice for submerged applications. However, as with redispersible polymer powder mortars, not all liquid additives mixed with cement based powders are suitable. Both, the type and quantity of latex, as well as other proprietary chemicals, will determine if a liquid additive is suitable for these applications. A common and highly generalized misconception is that either acrylic polymers or styrene butadiene rubber are superior to one another. This is not true. Both polymers can be formulated to have high adhesive strength, and be equally flexible. Superior performance is achieved through the formulation of these two materials. It is recommended to verify the suitability of a latex additive for pool applications, and conduct or request independent testing to verify the manufacturer's specified performance.

Figure 7.13 – Installation of mosaic tile with liquid latex fortified portland cement thin-set mortar.

Figure 7.14 – Installation of glazed porcelain tile with liquid latex fortified portland cement thin-set mortar over a liquid applied waterproofing membrane.

Epoxy Resin Adhesives – This type of adhesive is typically a three component system, consisting of epoxy resin and hardener liquids, and some filler type material, such as silica sand. Epoxy adhesives which conform to ANSI A118.3 contain 100% solids epoxy. LATAPOXY® 300 Adhesive is a high strength, 100% solids epoxy that works well for submerged applications. These adhesive mortar types are required for use when tiling directly to steel or fiberglass pool tanks. Refer to Section 9 – Specifications and Section 10 – Detail Drawings for ES-P603 and ES-P604 for more information.

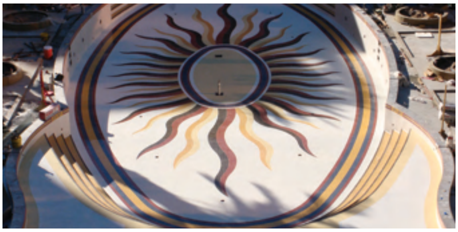


Figure 7.15 – Mosaic tiled stainless steel pool tank. Only an epoxy adhesive can be used to install tile directly to steel tanks. (Photo courtesy of Bradford Products, LLC).

In addition, while the grouting materials will take the brunt of any potential chemical attack, some chemicals and strong cleaners can work their way through the tile and even attack the tile or stone adhesive over an extended period of time. Therefore, it is important to consider this potential problem exists. The use of LATAPOXY 300

Adhesive can ensure the long term performance of an installed water vessel that may be exposed to chemical attack.

The primary disadvantages are that epoxy adhesives can be significantly more expensive, and the working qualities in cold or warm temperatures can limit production and further escalate costs. Sag resistance and temperature resistance are secondary limitations, depending on the requirements for the installation. Epoxy adhesives can bond to virtually any suitable substrate which is structurally sound, so they are often recommended as a supplementary adhesive to more economical cement based systems when the tile or pavers must be adhered to unusual substrates such as steel or fiberglass pool tanks.

7.6 Grout

Importance – As is the case in any tile or stone installation, the grout is the most visible and most scrutinized part of the installation system. In submerged applications, the performance of the grout is critical to the long term durability of the installation system. Therefore, the selection and use of the appropriate grout is a key design element. Grout in submerged applications can be exposed to chemicals, pH imbalance, varying water mineral and metal content levels, moisture expansion and other factors that could affect the integrity of traditional cement based grouts. In addition, for grout exposed above the water line, consideration for UV resistance must also be made. Therefore, it is important to specify a grout that can withstand all of the potential issues that can develop (e.g. SPECTRALOCK® PRO Premium Grout and PERMACOLOR® Select). In many commercial and public water features, pH pool water imbalance can lead to degradation of cement grouts. In addition, calcium extraction of the portland cement component of traditional cement based grouts can occur when prolonged mineral imbalance occurs (see Section 11 for further information). Epoxy grouting products are resistant and immune to these issues. Epoxy grouts are also more resistant to harsh cleaners and chemicals that may be used to clean and maintain institutional and therapeutic pools which are emptied, cleaned on a frequent basis and then filled again.

Latex Cement Grout – Similar to the same adhesive mortar category, latex-fortified grout is a combination of either a proprietary pre-mixed sand-cement (and pigment) powder, or site mixed cement-sand grout powder with a ratio of approximately 1:2 by volume for joint widths to 1/2" (12 mm), gauged with a liquid latex or acrylic polymer additive. As with polymer modified grouts, the liquid latex or acrylic additive must be formulated for wet areas. An example of this product type is PERMACOLOR® Select Grout†. Cement based products also have limited chemical resistance and are generally only used where no exposure to chemical attack occurs. If a cement based grout is selected for a water feature, careful detail to the maintenance regimen is a must. At times the extra cost associated with additional maintenance of a cement-based grouted water feature can be offset with the selection and use of an epoxy grout that will greatly reduce the maintenance required.

Epoxy Grout – ANSI A118.3 compliant grouts are chemical resistant, water cleanable grouting epoxies. These grouts are epoxy compositions; essentially a 100% solids system that are supplied in two or more parts to be mixed immediately before use as a joint filling grout for ceramic tile, and that is partially emulsified by water, after mixing, in order to expedite cleaning from tile surfaces during application before the epoxy hardens. SPECTRALOCK® PRO Premium Grout† complies with ANSI A118.3. These types of grouts are the ideal choice for water feature applications. Epoxy grouts offer both lower water absorption rates and improved chemical resistance when compared to traditional cement based grouts, and epoxy grouts are immune to the typical attack that traditional cement based grouts can face.

7.7 Sealant

Importance – Sealants are typically used as a joint filler material only in movement joints, changes in plane, between dissimilar materials in an application (such as steel gutters and the tile installation), and where a high degree of adhesion and resistance to differential movement and tensile or compressive stress is required. Movement joints are intended for relief of significant stress build-up that may be transmitted over a larger area, and sealants must have the characteristics to resist much greater elongation or compression than more rigid materials like cement. These materials also adhere to dissimilar materials such as steel gutters, metal window frames, penetrations, and drain covers to not only maintain a water barrier where a more rigid material may fail, but also to accommodate the significantly different thermal movement characteristics of some dissimilar materials such as aluminum and steel.

Movement joints that are in the field of the installation must allow for the anticipated movement, while maintaining a waterproof barrier. In these cases, any joints that exceed 1/8" are filled with a polymer modified thin-set mortar before being covered the waterproofing membrane (e.g. HYDRO BAN®, HYDRO BAN XP or HYDRO BAN Cementitious Waterproofing Membrane) to enable the joint to move freely while the waterproofing membrane continues to function (see figures 7.16, 7.17, 7.18 and 7.19). A liberal amount of waterproofing liquid is applied on both sides of the expansion joint (at least 4" to 6" [100 mm to 150 mm]) and into the joint opening. While the liquid is wet and tacky, the waterproofing reinforcing fabric is folded and placed into the movement joint opening and folded over onto the side of the concrete or mortar bed. Immediately, saturate the waterproofing reinforcing fabric with additional waterproofing membrane liquid. The fabric treatment must have enough "slack" to go down deep enough into the expansion joint to accommodate the anticipated joint movement.

After several hours, another coat of waterproofing liquid is applied to this treatment to ensure a complete seal. Next, the full waterproofing membrane treatment with fabric is placed over the pre-treated expansion joint areas following the same looping profile. Therefore, the expansion joints have a "double treatment of looped fabric". These joints must be honored and must come up through to tile or stone finish and treated with backer rod and a suitable flexible sealant. (See Sections 4 and 10 for more information on the use of flexible sealants in expansion joints).

Always check with the manufacturer of the sealant and primer for acceptability in submerged applications.

Backup Strip (Backer Rod) – The use of the rounded backup strip in movement joints is necessary to regulate the depth of the sealant for proper width/depth ratio and to prevent three sided adhesion. Typical sealant joint depth is half the width of the joint. The backer rod should be set into the joint to achieve this ratio. Sealants perform optimally when adhesion occurs only at the joint flanks (two-sided bond). The backer rod also helps to transmit the tooling force of the sealant to achieve bond to the tile edges. Polyethylene bond breaker tape can be used for thin bed applications where backer rod cannot be utilized. The polyethylene bond breaker tape also helps to prevent three-sided bond.

Typical back up strip materials are flexible and compressible and fall into one of the following categories:

- Closed Cell Foam Polyethylene
  (Best For Submerged and Wet Area Applications)
- Butyl Rubber
- Open Cell Polyurethane
- Closed Cell Polyurethane

Silicone – Single component, mildew resistant 100% silicone sealants are suitable for use in submerged water feature applications. An example of this type of sealant is LATICRETE LATASIL™.

These sealants usually fall into the following category:
ASTM C90 which designates sealants according to Type, Grade, Class and Use

– Type S – Single component
– Grade NS – Non Sag
– Class 25 – Sealant can withstand an increase and decrease of +/- 25% of joint width
– Uses M and G – Sealant will remain adhered to mortar (M) and glass (G)

Silicone sealants can also be supplied with a primer that will improve the adhesion of the sealant to the joint flanks. An example of this type of primer is 9118 Primer. The two most common ways to specify sealants are:

1. List the manufacturer and brand name(s) of the acceptable products.
2. Specify the characteristics by description and / or by reference to standards.

Urethane or Polyurethane – Urethane based sealants that do not employ the use of solvent based primers are also suitable for use in submerged applications provided that they fall into the same ASTM C90 categories as listed under silicone sealants.

Acrylic – Typically, acrylic sealants are used for interior non-wet areas. Therefore, the physical properties of acrylic sealants/caulks preclude their use in water features and submerged applications.

Figure 7.16 – Waterproofing liquid is applied onto the sides and into the expansion joints.

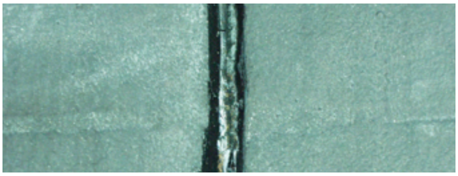


Figure 7.17 – Waterproofing reinforcing fabric is then folded and placed into the movement joint and folded onto the concrete/mortar bed. Additional waterproofing liquid is applied over the treatment. A third coat of liquid is then applied to seal off the entire treatment.

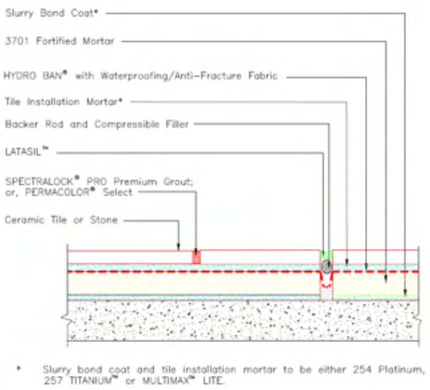


Figure 7.18 – Profile view detail depicting the waterproofing membrane looped into the movement joint.

Figure 7.19 – View of completed swimming pool. Note the movement joint at the changes of plane on the floor of the pool and the other field movement joints on the walls and floors.

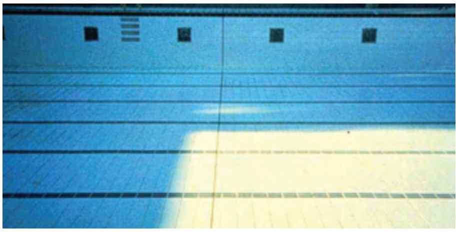


Figure 7.20 – View of completed swimming pool. Note the movement joint running continuously through the width of the swimming pool both at the walls and floors. A properly placed water stop in the concrete shell is a critical design element to ensure system functionality.

7.8 Post Installation

Cure Times – Typically the following cure times should be observed after the final grouting period in swimming pools and water features: Observe a minimum cure time of 14 days at 70°F (21°C) for latex fortified portland cement grout installations to prevent latex migration, and 10 days at 70°F (21°C) for epoxy grouts to reach maximum chemical resistance prior to filling the water feature. Cure time can be significantly increased or decreased due to temperature and humidity.

Inspection – A swimming pool or water feature should be inspected prior to filling and then again prior to use for any non-conformities. Final grouting and sealant touch-ups should be performed during this phase. Critical areas include the sealant treatment at all penetrations and drains. The sealant should be in place and cured prior to filling the water feature to prevent any water intrusion behind the tiled system. Cleaning should also take place prior to filling the water feature to prevent any dirt, cleaners and 'dirty' water from entering the filtration system.

Before filling of the pool, and its subsequent provisional acceptance at substantial completion, the tile installation shall be visually inspected and sounded in the presence of the Architects and/or the Owner's representative to verify adhesion of the tile to its substrate as well as its over-all compliance with the specific requirements.

Any and all tile work found to be loose, improperly adhered, out of plane, misaligned or otherwise non-conforming shall be removed and replaced.

Protection of Waterproofing Membranes – Waterproofing membranes must be allowed to fully cure at the required temperatures as stated by the manufacturer. The membranes must be protected from UV exposure beyond the stated time period and from the elements (including rain, wind and direct sunlight). Tenting and shading the work areas for the installation and cure periods is critical to ensuring the long-term performance of the installation system.

Protection of Completed Tile and Grout Installation – The completed tile and grout installation must also be protected from construction traffic, debris from other trades and the elements until all the installation components reach their full cure. In many cases, latex fortified portland cement mortars and grouts require a minimum 14 day cure at 70°F (21°C) after the final grouting period. Epoxy adhesives and grouts require a minimum 10 day cure at 70°F (21°C) after the final grouting period. If the completed installation is exposed to the elements, it should be tented and shaded during this time frame to ensure a proper cure.

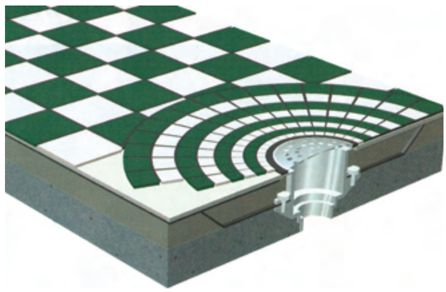
7.9 Typical Renders and Details for Swimming Pool and Water Features

Surface Preparation – 3701 Fortified Mortar Bed

3701 Fortified Mortar Bed is a polymer fortified blend of carefully selected polymers, portland cement and graded aggregates. 3701 Fortified Mortar Bed does not require the use of latex admix. 3701 Fortified Mortar Bed is designed to mix with water only and provides exceptional working properties and exceptional performance characteristics.

Waterproofing Membrane – HYDRO BAN®, HYDRO BAN XP or HYDRO BAN Cementitous Waterproofing

HYDRO BAN and HYDRO BAN XP are thin, flexible, load-bearing, liquid-applied waterproofing membranes that do not require the use of fabric in most situations. HYDRO BAN Cementitious Waterproofing Membrane is a one component, polymer fortified, cement based waterproofing material that mixes with water. This product can be used on walls and floors in wet areas; swimming pools, water features and fountains, balconies and terraces over unoccupied space. HYDRO BAN Cementitious Waterproofing Membrane also handles negative & positive hydrostatic pressure up to 2 Bars (29 PSI) when applied at 40 mil (1mm) thick and allows flood testing within 2 hours. Passes ANSI A118.10 Waterproofing and ANSI A118.12 Crack Isolation (with mesh/fabric up to 1/8" (3mm)). HYDRO BAN, HYDRO BAN XP and HYDRO BAN Cementious Waterproofing help minimize efflorescence and deterioration of underlying assembly components by eliminating damaging water infiltration. Both membranes are applied with a paint roller or brush, are non-flammable and have no significant odor. Consult LATICRETE Product data sheets for full installation instructions. Consult the LATICRETE website at www.laticrete.com for latest information.



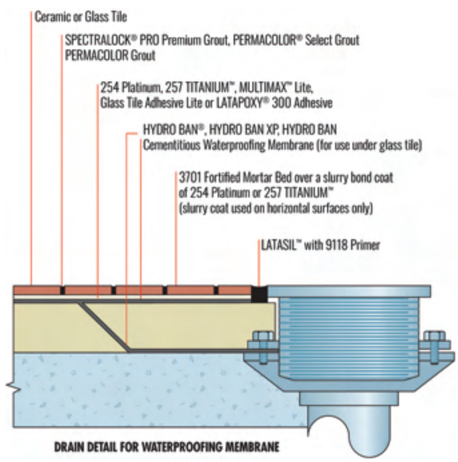


Figure 7.21 – Thick Bed Floor / Waterproofing System with drain detailing.

Stain Resistant Grout – SPECTRALOCK® PRO Premium Grout is a chemical and stain-resistant grout for ceramic tile and stone. SPECTRALOCK PRO Premium Grout is ideally suited to eliminate deterioration caused by pool water chemicals and poor water chemistry maintenance. SPECTRALOCK PRO Premium Grout provides for easy clean ability and low maintenance while maintaining extremely long lasting performance.

Latex Fortified Grout – PERMACOLOR Select is an ideal choice for submerged installations where[†] proper pool[^] water chemistry is maintained continually. PERMACOLOR Select by UV light and rain, and provides a hard, durable grout joint.

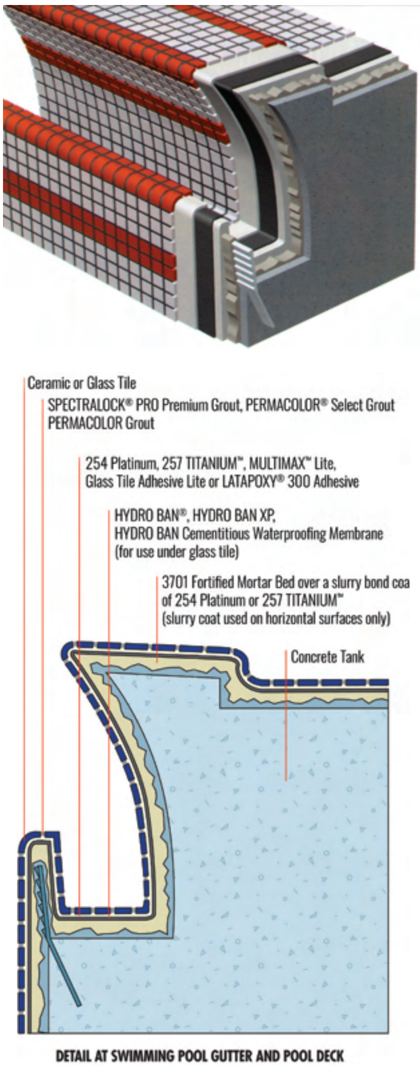


Figure 7.22 – Tiled pool gooseneck gutter assembly with adhesive mortars.

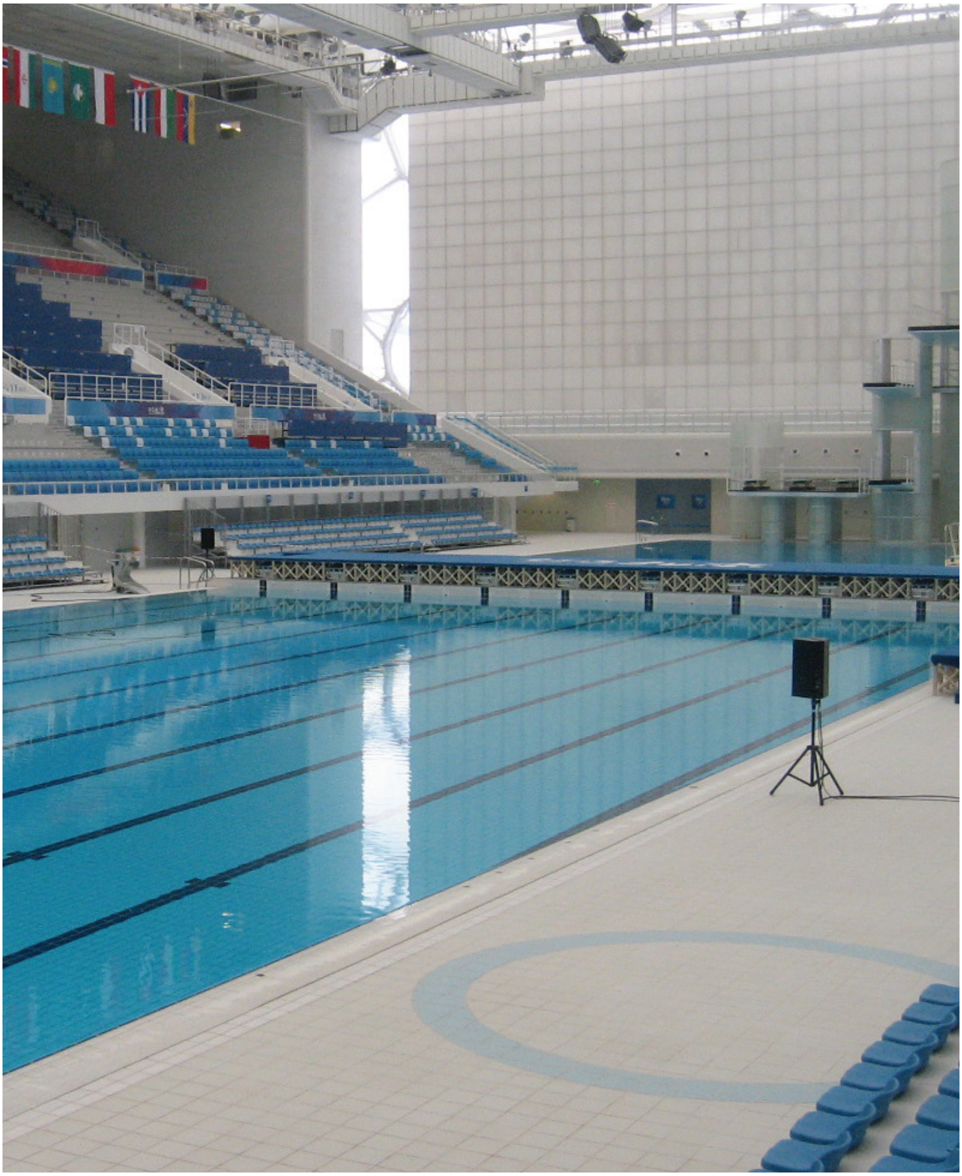
7.10 Warranty

Laticrete International, Inc. offers[†] the most comprehensive[^] systems warranty in the tile and stone installation industry. Please refer to the LATICRETE 25 Year System Warranty (DS 025.0) in Section 12.1 for more information. Please visit www.laticrete.com for the most recent copies of these documents.

† United States Patent No.: 6881768 (and other Patents).

^ United States Patent No.: 6784229 B2 (and other Patents).

Section 8: Pool Deck and Natatorium Tile Installation



8.1 Tile Installation Materials Performance and Selection Criteria

The information contained in Section 7 is applicable to the leveling mortars, floating mortars, adhesive mortars, waterproofing/anti-fracture membranes, grouting materials and sealant performance and selection criteria required for pool decks. Please refer to Section 7 for this information. Some natatoriums may include spas or steam rooms. For detailed information on how to design and install tile in these applications, refer to the Tiled Steam Room and Steam Shower Technical Design Manual published by LATICRETE International, Inc. and is available at www.laticrete.com

8.2 Methods of Installation

The same methods of installation outlined in Section 7 apply to pool deck tile installations as well. Tile and stone can be installed by utilizing the thin bed, large, heavy tile mortar and thick bed methods on pool decks. It is important to note that unbonded wire-reinforced thick bed mortars can be used on pool decks. May be suitable for exterior applications in areas not subject to freeze/thaw cycling when appropriate precautions are taken, including expansion joint placement, proper slope, waterproofing, and material selection.[1] Unbonded thick bed mortar bed assemblies cannot be used within the water feature tank itself. Refer to Section 7 for in depth information on the following application method types:

- Thin Bed Method
- Large, Heavy Tile Mortar Method
- Thick Bed (Bonded methods)

Unbonded Type (Pool Decks and other Non-Submerged Applications) – Unbonded floor mortar beds can be used on pool decks and other areas around water features that are not subject to continuous underwater submersion.

In the unbonded mortar bed type, a cleavage membrane is placed over the substrate. The cleavage membrane can take the form of 15 lb builders felt, 6 mil thick polyethylene sheeting or a waterproofing membrane. Half of the 3701 Fortified Mortar Bed or other LATICRETE® mortar bed product is then placed. Next, a welded wire mesh complying with ANSI A108.02 3.7 is placed as close to the middle of the mortar bed as possible. This will allow the mortar bed to achieve maximum tensile strength resistance. The rest of the mortar bed is then placed over the wire. At this point, the mortar bed is compacted, screeded, leveled, and pitched as required.

Figure 8.1 – Example of a non-bonded, wire reinforced mortar bed. Wire mesh is placed in the middle of the mortar bed and lapped together to ensure continuity.

Once the mortar bed is properly installed, it can either be allowed to cure, or the tiles/pavers can be installed (wet set) into the fresh mortar bed.

If a waterproofing or anti-fracture membrane is required, the mortar bed should be allowed to harden for at least 48 hours at 70°F (21°C)or until sufficiently dry. Refer to the specific membrane data sheet for more information on acceptable moisture levels. If the unbonded mortar bed is being installed in an exterior application, the mortar bed must be protected from rain and moisture, allowing the mortar bed to dry sufficiently prior to the application of a waterproofing and/or anti-fracture membrane. Cooler temperatures require longer cure time prior to installation of the waterproofing or anti-fracture membrane. Protection from wind and direct sunlight is also good practice that will lead to help promote curing of the mortar bed. Consult product data sheet for specific guidelines.

If the option to bond the tiles to the fresh mortar bed is desired, a slurry bond coat is required. A trowel applied slurry bond coat consisting of 254 Platinum, 257 TITANIUM™ or MULTIMAX™ LITE is preferred over the conventional dusting with dry portland cement and wetting with water method. The preferred method provides complete contact with the bonding slurry and reduces the chances of hollow and drummy sounding areas.

Figure 8.2 – Tile mechanic screeding an unbonded mortar bed.

The tile is then placed into the wet slurry bond coat and tapped into place and leveled with adjacent tile.

Once the tiles are installed, they should be allowed to cure for a minimum of 24 hours at 70°F (21°C) prior to grouting. The use of a high performance epoxy based grout (e.g. SPECTRALOCK® PRO Premium Grout†) is recommended for interior pool and natatorium decks.

LATICRETE Plaza and Deck System is recommended for installations of tile or stone on exterior pool decks located over occupied space. The Plaza and Deck System incorporates LATICRETE Drain Mat placed over a primary roofing type membrane (not a LATICRETE product) on a properly pre-pitched surface. A mortar bed consisting of 3701 Fortified Mortar Bed, Quick Cure Mortar Bed, 3701 Lite Mortar, 3701 Lite Mortar R, or 226 Thick Bed Mortar gauged with 3701 Mortar Admix (minimum 2" [50mm] thick) reinforced with an ANSI A108.02 3.7 compliant wire mesh, is placed onto the LATICRETE Drain Mat and allowed to dry. The installation must be protected from exposure to water at this point to allow the installation of the waterproofing membrane onto the mortar bed. The mortar bed must be allowed to dry sufficiently prior to installation of the waterproofing membrane (e.g. HYDRO BAN®, HYDRO BAN XP, HYDRO BAN Quick Cure or 9235 Waterproofing Membrane). Once the mortar bed is dry the installation of the waterproofing membrane can commence. Once the membrane is cured, tile or stone can be installed using 254 Platinum, 257 TITANIUM™ or MULTIMAX™ LITE and grouted using PERMACOLOR® Select.

8.3 Waterproofing/Anti-Fracture Membranes

Many anti-fracture and waterproofing membranes can be applied over concrete, mortar beds, and cement backer board. Some waterproofing membranes serve as both waterproofing and anti-fracture membranes (e.g. HYDRO BAN®, HYDRO BAN XP and HYDRO BAN Quick Cure or 9235 Waterproofing Membrane) and are ideal for use on decks, locker rooms, showers, steam rooms and other areas commonly found in natatoriums or recreational water facilities.

The installation of waterproofing is covered under ANSI A108.13, Installation of Load Bearing, Bonded, Waterproof Membranes for Thin-set Ceramic Tile and Dimension Stone, and crack isolation is covered under ANSI A108.17, Installation of Crack Isolation Membranes. The product standards for waterproofing can be found under ANSI A118.10 and the product standards for crack isolation membranes can be found under ANSI A118.12.

Membranes that are used on areas outside of the pool tank should also meet the same performance criteria outlined in Section 7 for submerged applications. Pool decks and other natatorium areas will be subjected to many if not all of the same conditions that the submerged areas are exposed to. In many cases, the waterproofing/anti-fracture membrane can be carried from within the water feature tank out onto the deck areas and then carried up the walls that surround the decks to create a totally waterproof application. Since the membranes must accommodate various transitions, thin load bearing liquid applied types are excellent choices for these applications (e.g. HYDRO BAN®, HYDRO BAN XP, HYDRO BAN Quick Cure or 9235 Waterproofing Membrane).

8.4 Tile Setting Mortars

Pool decks are exposed to unique factors not typically found in the submerged areas. The adhesive mortars must also be able to deal with potentially greater expansive forces than are typically found within the submerged areas. Therefore, the adhesive mortars and grouting materials must be able to withstand these demands in addition to providing all of the performance properties of the materials used in the submerged areas.

Redispersible Polymer Fortified Cement Mortar and Liquid Latex Fortified Cement Mortar – The use of high performance redispersible polymer fortified cement mortar and liquid latex fortified cement mortar designed for use in submerged applications and freeze thaw applications are the tile adhesive mortars of choice for these applications.

254 Platinum, 257 TITANIUM™ or MULTIMAX™ LITE are the ideal choices for these applications. These products are formulated to have high adhesive strength while providing the flexibility, freeze/thaw resistance and other characteristics required of adhesive mortars used for ceramic tile and stone installations in natatoriums, and exterior and interior pool deck applications.

Epoxy Resin Adhesives – LATAPOXY® 300 Adhesive is also an ideal product for deck areas. LATAPOXY 300 Adhesive can not only withstand chemical attack, but can also provide the desired level of adhesion and strength to tiles and stones that cannot be installed with polymer fortified mortars. Examples of these finish types can include moisture sensitive stone, resin backed tile and stone, and resin agglomerate stone types to mention a few. The tile or stone finish type should be suitable for the area of use.

8.5 Grout

Importance – As is the case in any tile or stones installation, the grout is the most visible and most scrutinized part of the installation system. The grout in pool deck and natatorium areas is subject to many of the same elements and factors that are found in submerged applications. In addition, the grout must also be able to remain colorfast and maintain its performance integrity when subjected to ultra violet rays and the thermal forces found in external applications (e.g. freeze/thaw and thermal shock resistance).

Epoxy Grout – SPECTRALOCK® PRO Premium Grout† is the ideal choice for interior pool decks, natatorium areas, showers, steam rooms, and bathrooms. These grouts offer both lower water absorption rates and improved chemical resistance when compared to traditional cement based grouts. Epoxy grouts are immune to the typical attack that traditional cement based grouts can face. Therefore, the life cycle cost for these materials is much lower than traditional latex cement based grouts which may require periodic re-grouting due to erosion caused by pH and mineral imbalances, and different forms of chemical attack.

Polymer Fortified Cement Grout – PERMACOLOR™ Select is an excellent product that is found in this family type. It is important to note that cement based grout products have limited chemical resistance and are generally only used where no exposure to chemical attack occurs. If a cement based grout is selected for a pool deck or other areas found in natatoriums, careful detail to the maintenance regimen is a must. At times, the extra cost associated with additional maintenance of a cement based grout used in a water feature can be offset with the selection and use of an epoxy grout that will greatly reduce the maintenance required.

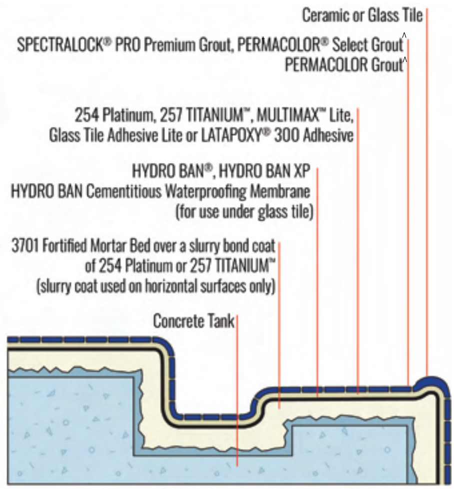
8.6 Sealants

Sealants used on pool decks and in natatorium areas are subjected to a host of movement related issues. Refer to Section 7 for more information. In addition, to the exposure outlined in section 7, sealants on pool decks must also be able to withstand movement associated with thermal stresses (e.g. freeze/thaw and thermal shock). Sealants must also hold up to ultra violet exposure while maintaining flexibility and retaining its performance properties. LATASIL™ along with LATASIL 9118 Primer (if required) is an ideal choice for these applications. A suitable backer rod or bond breaker tape should be used along with the sealant.

Section 7 contains much more information on how to install the sealant in conjunction with the waterproofing/anti-fracture membrane and the finish materials.

8.7 Typical Renders and Details for Swimming Pool and Natatorium Deck Applications

Adhesive Mortar – 254 Platinum, 257 TITANIUM™ or MULTIMAX™ LITE provides unsurpassed strength, with each exceeding ANSI A118.15 requirements. The performance of 254 Platinum, 257 TITANIUM™ or MULTIMAX™ LITE is backed by the LATICRETE 25 Year System Warranty, so there is no need to worry about tile or stone failure, even in the most demanding projects. 254 Platinum, 257 TITANIUM™ or MULTIMAX™ LITE are ideal for interior, exterior and submerged applications on all suitable substrates. In addition, 254 Platinum, 257 TITANIUM™ or MULTIMAX™ LITE provide easy workability and exceptional bond strength when installing difficult to bond porcelain or glass tile.



SWIMMING POOL ROLL OUT RIM INTERIOR AND EXTERIOR

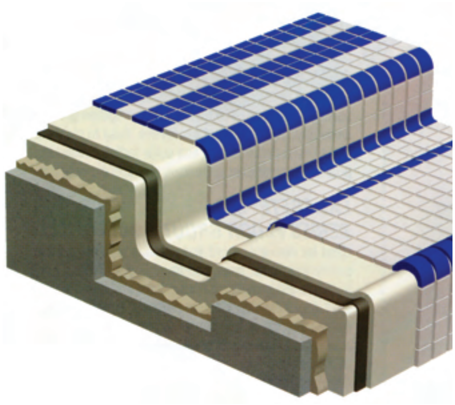


Figure 8.3 – Thick Bed Floor / Waterproofing System with drain detailing.

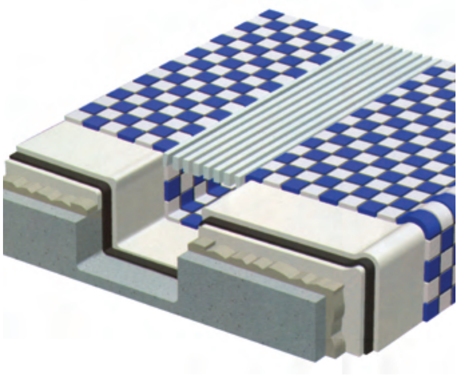
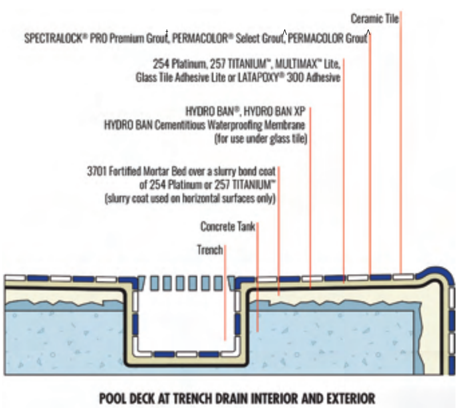


Figure 8.4 – Tiled pool deck trench drain and pool tank transition.

Epoxy Thin-Bed System

For areas where the substrate is properly pitched, tile, stone or brick are economically installed using LATAPOXY® 300 Adhesive and grouted with LATICRETE® SPECTRALOCK® PRO Premium Grout† or PERMACOLOR® Select. To prevent damage caused by water infiltration use HYDRO BAN®, HYDRO BAN XP, HYDRO BAN Quick Cure or 9235 Waterproofing Membrane.



[1] TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2022, page 68.

† United States Patent No.: 6881768 (and other Patents).

^ United States Patent No.: 6784229 B2 (and other Patents).

Section 9: Specifications for Swimming Pools, Fountains and Spa Installations

PART 1 – GENERAL

NOTE TO SPECIFIER: This specification applies to installations of traditional thickness ceramic and porcelain tiles on interior, and exterior, floor and walls. For all installations of large, thin porcelain tiles, refer to 'LATICRETE Guide Specification – Large, Thin Porcelain Tiles.'

9.1 Summary

A. Scope of work - Provide ceramic tile, tile installation materials and accessories as indicated on drawings, as specified herein, and as needed for complete and proper installation.

B. Related Documents - provisions within General and Supplementary General Conditions of the Contract, Division 1 - General Requirements, and the Drawings apply to this Section.

9.2 SECTION INCLUDES

NOTE TO SPECIFIER: Edit for applicable products.

A. Ceramic wall tile and trim units (glazed)

B. Ceramic floor tile/mosaics and trim units (glazed or unglazed)

C. Ceramic tile pavers and trim units (glazed or unglazed)

D. Quarry tile pavers and trim units (glazed or unglazed)

E. Porcelain tile

F. Glass tile (including mosaics)

G. Special purpose tile

H. Decorative thin wall tile

I. Installation Products; adhesives, mortars, grouts and sealants

J. Waterproofing membranes for Ceramic tile work

K. Anti-fracture membranes for Ceramic tile work

L. Uncoupling Membranes for Ceramic tile work

M. Sound control underlayments

N. Thresholds, trim, cementitious backer units and other accessories specified herein.

9.3 Products Furnished But Not Installed Under This Section

NOTE TO SPECIFIER: Edit for applicable products.

9.4 Products Installed But Not Furnished Under This Section

NOTE TO SPECIFIER: Edit for applicable products.

9.5 Environmental Performance Requirements

A. Environmental Performance Criteria: The following criteria are required for products included in this section.

Refer to Division 1 for additional requirements:

1. Products manufactured regionally within a 100 mile radius of the Project site;
2. Adhesive products must meet or exceed the VOC limits of South Coast Air Quality Management District Rule (SCAQMD) #1168 and Bay Area Air Quality Management District (BAAQMD) Reg. 8, Rule 51.

9.6 Related Sections

NOTE TO SPECIFIER: Above are examples of typical broad scope and narrow scope sections related to ceramic tile installation. Edit for applicable related sections.

A. Section 03 30 00 Cast-in-Place Concrete

B. Section 03 39 00 Concrete Curing

C. Section 03 41 00 Precast Structural Concrete

D. Section 03 53 00 Concrete Topping

E. Section 04 20 00 Unit Masonry (CMU wall substrates)

F. Section 04 43 00 Stone Masonry

G. Section 06 10 00 Rough Carpentry (plywood sub-floors)

H. Section 07 13 00 Sheet Waterproofing

I. Section 07 14 00 Fluid Applied Waterproofing

J. Section 07 50 00 Membrane Roofing

K. Section 07 92 00 Joint Sealants

L. Section 09 28 00 Backing Boards and Underlayments

M. Section 09 29 00 Gypsum Board

N. Section 10 28 00 Toilet, Bath, and Laundry Accessories

9.7 Allowances

NOTE TO SPECIFIER: Edit for detail of applicable ALLOWANCES; coordinate with Section 01 21 00 Allowances. Allowances in the form of unit pricing are sometimes used when the scope of the tile work at time of bid is undetermined.

9.8 Alternates

NOTE TO SPECIFIER: Edit for applicable ALTERNATES. Alternates may be used to evaluate varying levels of performance of setting systems or to assist in the selection of the tile by economy.

9.9 Reference Standards

NOTE TO SPECIFIER: Edit for applicable reference standards.

A. American Iron and Steel Institute (AISI) Specification for the Design of Cold-Formed Steel Structural Members

B. American National Standards Institute (ANSI) A137.1 American National Standard Specifications For Ceramic Tile

C. American National Standards Institute (ANSI) A137.2 American National Standard Specifications For Glass Tile

D. American National Standards Institute (ANSI) A108.01 - A108.17 American National Standard Specifications For The Installation Of Ceramic Tile

E. American National Standards Institute (ANSI) A118.1 - A118.15 American National Standard Specifications For The Installation Of Ceramic Tile

F. American National Standards Institute (ANSI) A136.1 American National Standard Specifications For The Installation Of Ceramic Tile

G. American Plywood Association (APA) Y510T Plywood Design Specifications

H. American Society For Testing And Materials (ASTM) A82 Standard Specification for Steel Wire, Plain, for Concrete Reinforcement

I. American Society For Testing And Materials (ASTM) A185 Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement

J. American Society For Testing And Materials (ASTM) C33 Standard Specification for Concrete Aggregate

K. American Society For Testing And Materials (ASTM) C36 Standard Specification for Gypsum Wallboard

L. American Society For Testing And Materials (ASTM) C109 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)

M. American Society For Testing And Materials (ASTM) C144 Standard Specification for Aggregate for Masonry Mortar

N. American Society For Testing And Materials (ASTM) C150 Standard Specification for Portland Cement

O. American Society For Testing And Materials (ASTM) C171 Standard Specification for Sheet Materials for Curing Concrete

P. American Society For Testing And Materials (ASTM) C241 Standard Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic

Q. American Society For Testing And Materials (ASTM) C267 Standard Test Method for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacings

R. American Society For Testing And Materials (ASTM) C482 Standard Test Method for Bond Strength of Ceramic Tile to Portland Cement

S. American Society For Testing And Materials (ASTM) C503 Standard Specification for Marble Dimension Stone (Exterior)

T. American Society For Testing And Materials (ASTM) C531 Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes

U. American Society For Testing And Materials (ASTM) C627 Standard Test Method for Evaluating Ceramic Floor Tile Installation Systems Using the Robinson-Type Floor Tester

V. American Society For Testing And Materials (ASTM) C794 Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants

W. American Society For Testing And Materials (ASTM) C847 Standard Specification for Metal Lath

X. American Society For Testing And Materials (ASTM) C905 Standard Test Method for Apparent Density of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings

Y. American Society For Testing And Materials (ASTM) C920 Standard Specification for Elastomeric Joint Sealants

Z. American Society For Testing And Materials (ASTM) C955 Standard Specification for Load Bearing (Transverse and Axial) Steel Studs, Runners (Tracks), and Bracing or Bridging for Screw Application of Gypsum Board and Metal Plaster Bases

AA. American Society For Testing And Materials (ASTM) D226 Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing And Waterproofing

BB. American Society For Testing And Materials (ASTM) D227 Standard Specification for Coal-Tar Saturated Organic Felt Used in Roofing and Waterproofing

CC. American Society For Testing And Materials (ASTM) D751 Standard Test Method for Coated Fabrics

DD. American Society For Testing And Materials (ASTM) D751 Standard Test Method for Rubber Property - Durometer Hardness

EE. American Society For Testing And Materials (ASTM) D1248 Standard Test Method for Staining of Porous Substances by Joint Sealants

FF. American Society For Testing And Materials (ASTM) D2240 Standard Test Method for Coated Fabrics

GG. American Society For Testing And Materials (ASTM) D4263 Standard Test Method for Indicating Moisture in Concrete by The Plastic Sheet Method

HH. American Society For Testing And Materials (ASTM) D4397 Standard Specification for Polyethylene Sheeting for Construction, Industrial and Agricultural Applications

II. American Society For Testing And Materials (ASTM) D4716 Standard Test Method for Determining the (In Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geo-synthetic Using a Constant Head

JJ. American Society For Testing And Materials (ASTM) E84 Standard Test Method for Surface Burning Characteristics of Building Materials

KK. American Society For Testing And Materials (ASTM) E90 Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions

LL. American Society For Testing And Materials (ASTM) E96 Standard Test Methods for Water Vapor Transmission of Materials

MM. American Society For Testing And Materials (ASTM) E413 Standard Classification for Rating Sound Insulation

NN. American Society For Testing And Materials (ASTM) E492 Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine

OO. American Society For Testing And Materials (ASTM) E989 Standard Classification for Determination of Impact Insulation Class (IIC)

PP. American Society For Testing And Materials (ASTM) E1155 Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness

QQ. American Society For Testing and Materials (ASTM) F1869 Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

RR. American Society For Testing and Materials (ASTM) 2170 Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs using in situ Probes

SS. American Society For Testing and Materials (ASTM) 2420 Standard Test Method for Determining Relative Humidity on the Surface of Concrete Floors Slabs using Relative Humidity Probe Measurement and Insulated Hood

TT. American Society of Mechanical Engineers (ASME) - ASME A112.6.3 Floor and Trench Drains

UU. Canadian Sheet Steel Building Institute (CSSBI) Lightweight Steel Framing Binder {Publication 52M}

VV. Federal Housing Administration (FHA) Bulletin No. 750 Impact Noise Control in Multifamily Dwellings

WW. Housing and Urban Development (HUD) TS 28 A Guide to Airborne, Impact and Structure-borne Noise-Control in Multifamily Dwellings

XX. International Organization for Standardization (ISO) 13007 Standards for Grouts and Adhesives

YY. Materials And Methods Standards Association (MMSA) Bulletins 1-16

ZZ. Metal Lath/Steel Framing Association (ML/SFA) 540 Lightweight Steel Framing Systems Manual

AAA. Steel Stud Manufacturers Association (SSMA) Product Technical Information and ICBO Evaluation Service, Inc. Report ER-4943P

BBB. Terrazzo, Tile And Marble Association Of Canada (TTMAC) Specification Guide 09300 Tile Installation Manual

CCC. Tile Council Of North America (TCNA) Handbook For Ceramic, Glass, and Stone Tile Installation

9.10 System Description

NOTE TO SPECIFIER: The below systems are example descriptions; edit for additional applicable systems.

A. Ceramic floor tile installed over concrete floor slabs using latex portland cement mortar and latex portland cement grout.

B. Quarry tile and base installed using latex portland cement mortar and industrial epoxy grout.

9.11 Submittals

NOTE TO SPECIFIER: Edit for applicable requirements.

A. Submittal Requirements: Submit the following "Required LEED Criteria" certification items as listed below. Refer to Division 1 for additional requirements:

1. A completed LEED Environmental Building Materials Certification Form. Information to be supplied generally includes:

   a. Manufacturing plant locations for tile installation products.

   b. LEED Credits as listed in Part 1.4B "LEED Credit Submittals"

   c. Recycled content; pre-consumer or post-consumer; or; Project specific information gathered using the LATICRETE LEED Project Certification Assistant available at www.laticrete.com/green.

2. UL GREENGUARD Certification Program For Chemical Emissions For Building Materials, Finishes And Furnishings, UL 2818 or UL GREENGUARD Gold certificates provided by the tile installation materials manufacturer on UL GREENGUARD letterhead stating "This product has been UL GREENGUARD Gold Product Certified For Low Chemical Emissions by the UL Environment under the UL GREENGUARD Certification Program For Chemical Emissions For Building Materials, Finishes And Furnishings" for each tile installation product used to verify Low VOC product information.

3. Contractor's certification of LEED Compliance: Submit Contractor's certification verifying the installation of specified LEED Compliant products.

4. Product Cut Sheets for all materials that meet the LEED performance criteria. Submit Product Cut Sheets with Contractor or Sub-contractor's stamp, as confirmation that submitted products were installed on Project.

5. GHS format Safety Data Sheets for all applicable products.

B. LEED Credit Submittals for the following;

1.LEED Reference Guide for Green Building Design and Construction, LEED v4 MR Credit Building Product Disclosure and Optimization – Material Ingredients: Manufacturer's product data for tile installation materials, including Health Product Declaration (HPD) on HPD Collaborative letterhead.

2.LEED Reference Guide for Green Building Design and Construction, LEED v4 MR Credit Building Product Disclosure and Optimization – Sourcing of Raw Materials Option 2 (Recycled Content): Manufacturer's product data for tile installation materials.

3.LEED Reference Guide for Green Building Design and Construction, LEED v4 MR Credit: Building Product Disclosure and Optimization – Sourcing of Raw Materials Option 2 (Regional Materials): Product data indicating location of material manufacturer for regionally manufactured Materials (within 100 miles of project site).

4.LEED Reference Guide for Green Building Design and Construction, LEED v4 Edition MR Credit Construction and Demolition Waste Management: Path 1 (Divert 50% and Three Material Streams) Manufacturer's packaging showing recycle symbol for appropriate disposition in construction waste management.

5.LEED Reference Guide for Green Building Design and Construction, LEED v4 Edition MR Credit Construction and Demolition Waste Management: Path 1 (Divert 75% and Four Material Streams) Manufacturer's packaging showing recycle symbol for appropriate disposition in construction waste management.

6.LEED Reference Guide for Green Building Design and Construction, LEED v4 EQ Credit Low-Emitting Materials: Manufacturer's product data for tile installation materials, including UL GREENGUARD Gold Certificate on UL GREENGUARD letterhead stating product VOC emissions.

7. LEED Schools Reference Guide (Educational Projects Only), 2007 Edition Credit EQ 9 (Enhanced Acoustical Performance): Impact noise reduction test reports and product data on sound control product(s).

8. LEED Schools Reference Guide (Educational Projects Only), 2007 Edition Credit EQ 10 (Mold Prevention): Manufacturer's packaging and/or data showing anti-microbial protection in product(s)

C. Submit shop drawings and manufacturers' product data under provisions of Section (01 30 00) (01 34 00)

D. Submit samples of each type/style/finish/size/color of ceramic tile, mosaic, paver, trim unit or threshold under provisions of Section (01 30 00) (01 34 00)

E. Submit manufacturers' installation instructions under provisions of Section (01 30 00) (01 34 00)

F. Submit manufacturer's certification under provisions of Section (01 45 00) that the materials supplied conform to ANSI A137.1 for ceramic tile or ANSI A137.2 for glass tile.

G. Submit proof of warranty.

H. Submit Health Product Declarations (HPD) for each tile installation material.

I. Submit sample of installation system demonstrating compatibility/ functional relationships between adhesives, mortars, grouts and other components under provision of Section (01 30 00) (01 34 00). Submit proof from ceramic tile manufacturer or supplier verifying suitability of ceramic tile for specific application and use; including dimensional stability, water absorption, freeze/ thaw resistance (if applicable), resistance to thermal cycling, and other characteristics that the may project may require. These characteristics must be reviewed and approved by the project design professional(s).

J. Submit list from manufacturer of installation system/adhesive/ mortar/grout identifying a minimum of three (3) similar projects, each with a minimum of ten (10) years service.

K. For alternate materials, at least thirty (30) days before bid date submit independent laboratory test results confirming compliance with specifications listed in Part 2 - Products.

9.12 Quality Assurance

NOTE TO SPECIFIER:

1. It is strongly recommended to use installers who have demonstrated their commitment to their craft and taken the time to stay current with the latest materials and methods. Requiring references and a portfolio along with a bid or estimate is a good way to ensure the installer has successfully completed work of similar size, scope, and complexity.

2. Pools, exterior facades, mortar beds, shower pans, steam showers, etc. require different skills. Matching installer ability to the project at hand requires close evaluation of their experience, training, state licensing (where applicable), and certifications/ credentials (where applicable). The Ceramic Tile Education Foundation (CTEF) provides a Contractor Questionnaire that can be used to aid in evaluating and comparing contractors (www.tilecareer.com).

3. Various programs administered by associations, non-profit educational organizations, unions, and private companies serve the tile industry by providing education, hands-on training, and evaluation of the skills and competency of installers and contractors. It is important to distinguish between the many programs available:

- **Hands-on training**
- **Evaluation/certification of installation skills**
- **On-line training**
- **On-line knowledge evaluation (without a hands-on component)**

As with all programs, the rigor and credibility of the program must also be considered.

The following non-profit programs are well established and recognized by the Tile Council of North America's (TCNA) Handbook Committee (listed alphabetically):

Ceramic Tile Education Foundation (CTEF) Certified Tile Installer Program: CTEF tests hands-on installation skills and knowledge. Installers must achieve the minimum required score on both tests to earn the "CTEF Certified Installer" designation. Contractors that employ CTEF Certified Installers are listed in the CTEF Contractor Directory, found in this Handbook and on the CTEF website. See www.tilecareer.org for more information.

International Masonry Institute (IMI) Contractor College Program: IMI conducts professional and technical courses for union masonry and tile contractors, which lead to certification in installation and project supervision. See www.imiweb.org for more information.

Journeyman Tile Layer Apprenticeship Programs: Installers recognized by the U.S. Department of Labor (DOL) as Journeyman Tile Layers are required to fulfill and document several years of training and on-the-job experience as apprentices to become Journeymen. The majority of these setters earn their Journeyman status through union-affiliated training programs, although some non-union tile contractors administer their own DOL-recognized apprenticeship programs and employ journeyman tile layers. Contractors that employ union Journeyman Tile Setters can be found through the union locals that list their signatory contractors, primarily the Bricklayer and Allied Craftworkers (BAC) and the United Brotherhood of Carpenters (UBC). See www.bacweb.org and www.carpenters.org for more information.

National Tile Contractors Association (NTCA) Five Star Contractor Program: NTCA is a tile contractors association, with membership open to all tile contractors. Their Five Star program is a peer review program to recognize NTCA members who have demonstrated a track record of providing successful installations. Earning the Five Star designation requires recommendations from customers, suppliers, and peers as well as participation in continuing education, training, and safety programs. See www.tile-assn.com for more information.

Tile Contractors' Association of America (TCAA) Trowel of Excellence Program: TCAA is a contractors association for BAC signatory contractors. Its Trowel of Excellence program is a peer review program to recognize TCAA members who have demonstrated a track record of providing successful installations. Earning the Trowel of Excellence designation requires letters of reference, submittal of a detailed project description and photos, employee participation in educational programming, and proof of financial responsibility. See www.tcaainc.org for more information.

A. Tile Manufacturer (single source responsibility): Company specializing in ceramic tile, thin brick, masonry veneer, mosaics, pavers, trim units and/or thresholds with three (3) years minimum experience. Obtain tile from a single source with resources to provide products of consistent quality in appearance and physical properties.

B. Installation System Manufacturer (single source responsibility): Company specializing in adhesives, mortars, grouts and other installation materials with ten (10) years minimum experience and ISO 9001 certification. Obtain installation materials from single source manufacturer to insure consistent quality and full compatibility.

C. Submit laboratory confirmation of adhesives, mortars, grouts and other installation materials:

1. Identify proper usage of specified materials using positive analytical method.

2. Identify compatibility of specified materials using positive analytical method.

3. Identify proper color matching of specified materials using a positive analytical method.

D. Installer qualifications: company specializing in installation of ceramic tile, thin brick, masonry veneer, mosaics, pavers, trim units and/or thresholds with five (5) years documented experience with installations of similar scope, materials and design.

9.13 Mock-Ups

Provide mock-up of each type/style/finish/size/color of ceramic tile, thin brick, masonry veneer, mosaics, pavers, trim units and/or thresholds along with respective installation adhesives, mortars, grouts and other installation materials, under provisions of Section(s) (01 43 00) (01 43 39).

9.14 Pre-Installation Conference

Pre-installation conference: At least three weeks prior to commencing the work attend a meeting at the jobsite to discuss conformance with requirements of specification and job site conditions. Representatives of owner, architect, general contractor, tile subcontractor, Tile Manufacturer, Installation System Manufacturer and any other parties who are involved in the scope of this installation must attend the meeting.

9.15 Delivery, Storage and Handling

A. Acceptance at Site: deliver and store packaged materials in original containers with seals unbroken and labels, including grade seal, intact until time of use, in accordance with manufacturer's instructions.

B. Store ceramic tile, stone, and installation system materials in a dry location; handle in a manner to prevent chipping, breakage, and contamination.

C. Protect latex additives, organic adhesives, epoxy adhesives and sealants from freezing or overheating in accordance with manufacturer's instructions; store at room temperature when possible.

D. Store portland cement mortars and grouts in a dry location.

9.16 Project/Site Conditions

A. Provide ventilation and protection of environment as recommended by manufacturer.

B. Prevent carbon dioxide damage to ceramic tile, thin brick, masonry veneer, mosaics, pavers, trim units and/or thresholds as well as adhesives, mortars, grouts and other installation materials, by venting temporary heaters to the exterior.

C. Maintain ambient temperatures not less than 50°F (10°C) or more than 100°F (38°C) during installation and for a minimum of seven (7) days after completion. Setting of portland cement is retarded by low temperatures. Protect work for extended period of time and from damage by other trades. Installation with latex portland cement mortars requires substrate, ambient and material temperatures at least 37°F (3°C). There should be no ice in slab. Freezing after installation will not damage latex portland cement mortars. Protect portland cement based mortars and grouts from direct sunlight, radiant heat, forced ventilation (heat & cold) and drafts until cured to prevent premature evaporation of moisture. Epoxy mortars and grouts require surface temperatures between 60°F (16°C) and 90°F (32°C) at time of installation. It is the General Contractor's responsibility to maintain temperature control.

9.17 Sequencing and Scheduling

NOTES FOR SPECIFIER: Edit for project specific sequence and scheduling

A. Coordinate installation of tile work with related work.

B. Proceed with tile work only after curbs, vents, drains, piping, and other projections through substrate have been installed and when substrate construction and framing of openings have been completed.

9.18 Warranty

NOTES FOR SPECIFIER: Select one of the following LATICRETE system warranties

A. The Contractor warrants the work of this Section to be in accordance with the Contract Documents and free from faults and defects in materials and workmanship for a period as determined by local or project requirements. The manufacturer of adhesives, mortars, grouts and other installation materials shall provide a written twenty-five (25) year warranty, which covers materials and labor - reference LATICRETE Warranty Data Sheet 025.0 for complete details and requirements.

B. For exterior facades over steel or wood framing, the manufacturer of adhesives, mortars, grouts and other installation materials shall provide a written fifteen (15) year warranty, which covers materials and labor - reference LATICRETE Warranty Data Sheet 230.15 for complete details and requirements.

9.19 Maintenance

Submit maintenance data under provisions of Section(s) (01 74 13) (01 74 16) (01 74 23). Include cleaning methods, cleaning solutions recommended, stain removal methods, as well as polishes and waxes recommended.

9.20 Extra Materials Stock

Upon completion of the work of this Section, deliver to the Owner 2% minimum additional tile and trim shape of each type, color, pattern and size used in the Work, as well as extra stock of adhesives, mortars, grouts and other installation materials for the Owner's use in replacement and maintenance. Extra stock is to be from same production run or batch as original tile and installation materials.

Part 2 – Products

9.21 Tile Manufacturers

NOTE TO SPECIFIER: Provide list of acceptable tile manufacturers.

Subject to compliance with paragraphs 1.12 and performance requirements, provide products by one of the following manufacturers:

9.22 Wall Tile Materials

NOTE TO SPECIFIER: Edit for each tile type.

A. Ceramic Tile:

B. Grade:

C. Size:

D. Edge:

E. Finish:

F. Color:

G. Special shapes:

H. Location:

9.23 Floor Tile Materials

NOTE TO SPECIFIER: Edit for each tile type.

A. Ceramic Tile

B. Grade:

C. Size:

D. Edge

E. Finish:

F. Color

G. Special shapes

H. Location:

9.24 Installation Materials Manufacturer

A. LATICRETE International, Inc.,
1 LATICRETE Park North,
Bethany, CT 06524-3423 USA
Phone 800.243.4788, +1.203.393.0010 technicalservices@laticrete.com, www.laticrete.com; www.laticrete.com/green

NOTE TO SPECIFIER: The following 'Accessories' are separated into two (2) categories; 'Ceramic Tile' accessories and 'Exterior Adhered Veneer' accessories. Edit as applicable – delete all that do not apply.

9.25 Installation Accessories — Ceramic Tile

NOTE TO SPECIFIER: Edit applicable tile installation accessories. Refer to the LATICRETE membrane product data sheet and the physical test data contained therein for information to be used by the Project Design Professional to determine suitability, placement, building code conformance and over-all construct appropriateness of a given installation assembly.

A. Waterproofing and Crack Isolation Membrane to be thin, cold applied, single component liquid and load bearing and UL GREENGUARD Gold certified. Reinforcing fabric to be non-woven rot-proof specifically intended for waterproofing membrane. Waterproofing Membrane to be non-toxic, non-flammable, and non-hazardous during storage, mixing, application and when cured. It shall be certified by IAPMO and ICC approved as a shower pan liner and shall also meet the following physical requirements:

1.Hydrostatic Test (ASTM D4068): Pass

2.Elongation @ break (ASTM D751): 20-30%

3.System Crack Resistance (ANSI A118.12): Pass (High)

4.7 day Tensile Strength (ANSI A118.10): 265 psi (1.8 MPa)

5. 7 day Shear Bond Strength (ANSI A118.10) 200 psi (1.4 MPa)

6. 28 Day Shear Bond Strength (ANSI A118.4): 214 psi (1.48 – 2.4 MPa)

7. Service Rating (TCNA/ASTM C627): Extra Heavy

8. VOC Content: 2.39 g/L

9. Total VOC Emissions: ≤0.22 mg/m^3

(Basis of Design: HYDRO BAN XP®)**

B. Epoxy Waterproofing Membrane to be 3 component epoxy, trowel applied specifically designed to be used under Ceramic tile, stone or brick and requires only 24 hours prior to flood testing:

1. Breaking Strength (ANSI A118.10): 450-530 psi (3.1-3.6 MPa)

2. Waterproofness (ANSI A118.10): No Water penetration

3. 7 day Shear Bond Strength (ANSI A118.10): 110-150 psi (0.8-1.0 MPa)

4. 28 Day Shear Bond Strength (ANSI A118.10): 90-120 psi (0.6–0.8 MPa)

5. 12 Week Shear Bond Strength (ANSI A118.10): 110-130 psi (0.8-0.9 MPa)

6. Total VOC Content:<3.4 g/L

(Basis of Design: LATAPOXY® Waterproof Flashing Mortar)

C. A one component, polymer fortified, cement based waterproofing that mixes with water that passes ANSI A118.10, and, ANSI A118.12 when used with LATICRETE waterproofing/Anti-Fracture Fabric and can withstand 2 Bars (29 psi) of negative hydrostatic pressure.

1. 7 Day Hydrostatic Test (ANSI A118.10): Pass

2. 7 Day Breaking Strength (ANSI A118.10): 450 - 500 psi (3.1 – 3.45 MPa)

3. 7 Day Water Immersion (ANSI A118.10): 120 - 150 psi (0.83 – 1.03 MPa)

4. 7 Day Shear Bond Strength (ANSI A118.10): 320 – 400 psi (2.21 – 2.76 MPa)

5. 28 Day Shear Strength (ANSI A118.10): 370 – 450 psi (2.55 – 3.10 MPa)

6. System Crack Resistance Test (ANSI A118.12 5.4): Pass-High (with fabric)

7. Water Vapor Transmission (ASTM E96 Procedure B: 1.6 – 1.7 grains/hr • ft (1.1 – 1.2 g/hr • ft)

8. Water Vapor Permeance (ASTM E96 Procedure B): 3.9 – 4 perms (225 – 235 ng/Pa • s • m^2)

9. System Performance (ASTM C627 – TCNA Rating): Cycles 1 – 14 “Extra Heavy”

10. Tensile Strength for Elongation: 25%

11. Installed Thickness (Dried): 40 mil (1.02mm)

(Basis of Design: HYDRO BAN® Cementitious Waterproofing)

D. Low Profile Linear Floor Drain to be comprised of heavy duty 304 stainless steel, specially designed for bonded waterproofing installations, allow for large format tile use in showers with single slope to drain, available with standard, vertical waste line and horizontal side outlet, and with flow rate of ≥ eight (8) gallons per minute (30 liters per minute).

(Basis of Design: HYDRO BAN Linear Drain)

E. Low Profile Bonding Flange Floor Drain to be comprised of heavy duty 304 stainless steel, specially designed for bonded waterproofing installations, allow for elimination of pre-slope layer and primary shower pan liner, per TCNA B422, and with flow rate of ≥ eight (8) gallons per minute (30 liters per minute).

(Basis of Design: HYDRO BAN Bonding Flange Drain)

F. Floor Sealer: Colorless, stain- and slip-resistant sealer, not affecting color and physical properties of ceramic tile and stone surfaces as recommended by sealer manufacturer for application indicated.

(Basis of Design: STONETECH® BulletProof® Sealer)

G. Wire Reinforcing: 2" x 2" (50 x 50 mm) x 16 ASW gauge or 0.0625" (1.6mm) diameter galvanized steel welded wire mesh complying with ANSI A108.02 3.7, ASTM A185 and ASTM A82.

H. Cleavage membrane: 15 pound asphalt saturated, non-perforated roofing felt complying with ASTM D226, 15 pound coal tar saturated, non-perforated roofing felt complying with ASTM D227 or 4.0 mils (0.1 mm) thick polyethylene plastic film complying with ASTM D4397.

I. Cementitious backer board units: size and thickness as specified, complying with ANSI A118.9.

H. Thresholds: Provide marble saddles complying with ASTM C241 for abrasion resistance and ASTM C503 for exterior use, in color, size, shape and thickness as indicated on drawings.

9.26 Performance Specification – Tile Installation Materials

NOTE TO SPECIFIER: Edit applicable tile installation accessories. Refer to the LATICRETE membrane product data sheet and the physical test data contained therein for information to be used by the Project Design Professional to determine suitability, placement, building code conformance and over-all construct appropriateness of a given installation assembly.

A. Epoxy Waterproofing Membrane/Flashing Mortar to be 3 component epoxy, trowel applied specifically designed to be used under masonry veneer, stone or thin brick and requires only 24 hours prior to flood testing:

1. Breaking Strength (ANSI A118.10): 450-530 psi (3.1-3.6 MPa)
2. Waterproofness (ANSI A118.10): No Water penetration
3. 7 day Shear Bond Strength (ANSI A118.10): 110-150 psi (0.8-1 MPa)
4. 28 Day Shear Bond Strength (ANSI A118.10): 90-120 psi (0.6–0.83 MPa)
5. 12 Week Shear Bond Strength (ANSI A118.10): 110-130 psi (0.8-0.9 MPa)
6. Total VOC Content: <3.36 g/L

(Basis of Design: LATAPOXY® Waterproof Flashing Mortar)

B. Sealer (Exterior Masonry Veneers): water-based formula specifically designed for topical application on porous stones in exterior applications:

(Basis of Design: STONETECH® Heavy Duty Exterior Sealer for non-submerged areas)

C. Galvanized, diamond metal lath: flat expanded type, weighing not less than 3.2 lb. per yd2 (1.4 kg/m2). Metal lath shall comply with ASTM C847.

D. Cleavage membrane: 15 pound asphalt saturated, non-perforated roofing felt complying with ASTM D226, 15 pound coal tar saturated, non-perforated roofing felt complying with ASTM D227 or 4.0 mils (0.1 mm) thick polyethylene plastic film complying with ASTM D4397.

E. Cementitious backer board units: size and thickness as specified, complying with ANSI A118.9 .

9.27 Installation Materials – Ceramic Tile

NOTE TO SPECIFIER: Edit applicable tile installation materials.

A. Moisture Vapor Reduction to be epoxy based and UL GREENGUARD Gold certified as well as meet the following physical requirements:

1. Shear Bond to Concrete (ANSI A118.12-5.1.5): >285 psi (2.0 MPa)
2. Alkalinity Resistance (ASTM C267): Pass
3. Permeability (ASTM F1869): 9.7 lb/1,000ft2/24 hours down to 0.2 lb/1,000 ft2/24hours (248 µg/s•m^2 down to 11 µg/s•m^2)
4. VOC Content: 9.4 g/L
5. Total VOC Emissions: ≤0.22 mg/m^3

(Basis of Design: NXT® Vapor Reduction Coating and VAPOR BAN™ Primer ER)**

B. Latex Portland Cement Mortar for thick beds, screeds, leveling beds and scratch/plaster coats to be weather, frost, shock resistant, UL GREENGUARD Gold certified, and meet the following physical requirements:

1. Compressive Strength (ANSI A118.4 Modified): >4,000 psi (27.6 MPa)
2. Water Absorption (ANSI A118.6): ≤ 5%
3. Flexural Strength (ANSI A118.7 3.5): 1,100 – 1,200 psi (7.5 – 8.3 MPa)
4. Service Rating (TCA/ASTM C627): Extra Heavy
5. Shrinkage (ASTM C157 - 7 Day Cure): 0.05%
6. VOC Content: 0.00 g/L
7. Total VOC Emissions: ≤0.22 mg/m^3

(Basis of Design: 3701 Fortified Mortar)**

C. Epoxy Adhesive to be chemical resistant 100% solids epoxy with high temperature resistance, UL GREENGUARD Gold certified, conform to ISO R2, and meet the following minimum physical requirements.

1. Compressive Strength (ANSI A118.3): >5000 psi (34.4 MPa)
2. Shear Bond Strength (ANSI A118.3): >1250 psi (8.6 MPa)
3. Thermal Shock Resistance (ANSI A118.3): >600 psi (4.1 MPa)
4. Tensile Strength (ANSI A118.3): >1400 psi (9.6 MPa)
5. Shrinkage (ANSI A118.3): 0 – 0.1%
6. VOC Content: 0.80 g/L
7. Total VOC Emissions:≤0.22 mg/m^3

8. ISO 13007 Classification: R2

9. Cured Epoxy Adhesive to be chemically and stain resistant to ketchup, mustard, tea, coffee, milk, soda, beer, wine, bleach (5% solution), ammonia, juices, vegetable oil, detergents, brine, sugar, cosmetics and blood, as well as chemically resistant to dilute food acids, dilute alkalis, gasoline, turpentine and mineral spirits.

(Basis of Design: LATAPOXY® 300 Adhesive)**

D. Modified Dry-Set Cement Thin Bed Mortar for thin set and slurry bond coats to be weather, frost, shock resistant, non-flammable, UL GREENGUARD Gold certified, conform to ISO C2TES1P1, and meet the following physical requirements.

1. Bond strength (ANSI A118.4): >450 psi (3.1 MPa)
2. Smoke & Flame Contribution (ASTM E84 Modified): 0
3. VOC Content: 0.00 g/L
4. Total VOC Emissions: ≤0.22 mg/m^3

(Basis of Design: 254 Adhesive)**

E. Improved Modified Dry-Set Cement Thin Bed Mortar for thin set and slurry bond coats to be weather, frost, shock resistant, non-flammable, UL GREENGUARD Gold certified, meet ANSI A118.15 requirements, conform to ISO C2TES1P1,and meet the following physical requirements.

1. 28 Day Porcelain Tile Shear Strength (ANSI A118.15): >475-575 psi (3.3-4.0 MPa)
2. 28 Day Dry Cure / 20 Cycle Freeze-Thaw Porcelain Tile Shear Strength (ANSI A118.15): ≥ 250 psi (1.7 MPa)
3. 7 Day Cure / 7 Day Water Immersion (ANSI A118.15): > 280 psi (1.9 MPa)
4. Extended Open Time (ANSI A118.15): > 100 psi (0.7 MPa)
5. Smoke & Flame Contribution (ASTM E84 Modified): 0
6. VOC Content: 0.00 g/L
7. Total VOC Emissions: ≤0.22 mg/m^3

(Basis of Design: 257 TITANIUM™)**

F. Rapid-Setting Modified Dry-Set Cement Thin Bed Mortar to be weather, frost, shock resistant, non-flammable, conform to C2FTS2 adhesive, and meet the following physical requirements.

1. 28 Day Porcelain Tile Shear Strength (ANSI A118.4): >400 psi (2.8MPa)
2. 7 Day Cure / 7 Day Water Immersion (ANSI A118.4): >200 psi (1.4 MPa)
3. Shear Bond / Quarry Tile to Plywood (ANSI A118.11): >190 psi (1.3 MPa)
4. Open Time (ANSI A118.4): ≥ 30 minutes
5. VOC Content: 0 g/L

(Basis of Design: 254R Platinum Rapid)

G. Modified Dry-Set Cement Thin Bed Glass Tile Adhesive to be weather, frost, shock resistant, non-flammable, UL GREENGUARD Gold certified, conform to ISO C2TS1, and meet the following physical requirements.

1. Bond strength (ANSI A118.4 5.2.4): >370 psi (2.55 MPa)
2. Bond strength (ANSI A118.4 5.2.3): 199 psi (1.37 MPa)
3. VOC Content: 0.00 g/L
4. Total VOC Emissions: ≤0.22 mg/m^3

(Basis of Design: Glass Tile Adhesive Lite)**

H. Modified Dry-Set Cement Medium Bed Mortar to be weather, frost, shock resistant, non-flammable, UL GREENGUARD Gold certified, conform to ISO C2T, and meet the following physical requirements.

1. 28 Day Tensile Strength (ISO 13007-4.4 4.2): 215 - 275 psi (1.5 – 1.9 MPa)
2. 28 Day bond strength (ANSI A118.15 7.2.5): 500 - 600 psi (3.5 – 4.1 MPa)
3. 7 Day Water Immersion Shear (ANSI A118.15 7.2.4): 350 – 450 psi (2.4 – 3.1 MPa)
4. Freeze/Thaw Tensile Strength (ISO 13007-4.4 4.5: 145 – 215 psi (1.0 – 1.5 MPa)
5. Sag Resistance (ANSI A118.4 6.0): 0 mm
6. ISO Classification (ISO 13007): C2TES1P1
7. VOC Content: 0.00 g/L|
8. Total VOC Emissions: ≤0.22 mg/m^3

(Basis of Design: Multimax™ Lite)**

I. Epoxy Grout (Commercial/Residential) shall be non-toxic, non-flammable, non-hazardous during storage, mixing, application and when cured, UL GREENGUARD Gold certified, and shall meet the following physical requirements.

1. Compressive Strength (ANSI A118.3): 3,800 psi (26.2 MPa)

2. Shear Bond Strength (ANSI A118.3): 1,100 psi (7.6 MPa)

3. Tensile Strength (ANSI A118.3): 1,100 psi (7.6 MPa)

4. Thermal Shock (ANSI A118.3): >800 psi (5.5 MPa)

5. Water Absorption (ANSI A118.3): <0.05%

6. Vertical Joint Sag (ANSI A118.3): Pass

7. VOC Content: 0.031 g/L

8. Total VOC Emissions: ≤0.22 mg/m3

9. Cured Epoxy Grout to be chemically and stain resistant to ketchup, mustard, tea, coffee, milk, soda, beer, wine, bleach (5% solution), ammonia, juices, vegetable oil, brine, sugar, cosmetics, and blood, as well as chemically resistant to dilute acids and dilute alkalis.

(Basis of Design: SPECTRALOCK® PRO Premium Grout)**

J. Latex Portland Cement Grout to be weather, frost and shock resistant, conform to ISO 13007 requirements for CG2WAF, UL GREENGUARD Gold certified, as well as meet the following physical requirements.

1. Compressive Strength (ANSI A118.7): 3,500 psi (24.1 MPa)

2. Tensile Strength (ANSI A118.7): 510 psi (3.5 MPa)

3. Flexural Strength (ANSI A118.7): 1,250 psi (8.6 MPa)

4. Water Absorption (ANSI A118.7): < 5%

5. Linear Shrinkage (ANSI A118.7): < 0.5 %

6. Smoke & Flame Contribution (ASTM E84 Modified): 0

7. VOC Content: 0.00 g/L

8. Total VOC Emissions: ≤0.22 mg/m^3

(Basis of Design: PERMACOLOR® Select)**

K. Expansion and Control Joint Sealant to be a one component, neutral cure, exterior grade silicone sealant and meet the following requirements.

1. Tensile Strength (ASTM C794): 280 psi (1.9 MPa)

2. Hardness (ASTM D751; Shore A): 25 (colored sealant) / 15 (clear sealant)

3. Weather Resistance (QUV Weather-ometer): 10,000 hours (no change)

4. VOC Emissions: ≤0.5 mg/m^3

5. VOC Content: 35 g/L (translucent) and 42 g/L (sanded)

(Basis of Design: LATASIL™ and LATASIL 9118 Primer)

L. Roof Decks (and other exterior paving applications over occupied/storage spaces) shall consist of a Primary Roofing/Waterproofing Membrane, as specified in Section 0700 (q.v.), and a lightweight, frost/weather resistant installation system for tile, pavers, brick and ceramic tile that provides integral subsurface drainage and meets the following physical requirements.

1. Compressive Strength (ASTM C109 Modified): 3,000 psi (20.7 MPa)

2. Hydraulic Transmissivity (ASTM D4716): 1.6 gal./minute (6.1 L/minute)

3. Service Rating (ASTM C627): Extra Heavy

(Basis of Design: Plaza and Deck System)

**UL GREENGUARD Certified For Low Chemical Emissions (ULCOM/GG 2818) and UL GREENGUARD Gold Certified For Low Chemical Emissions (ULCOM/GG UL 2818).

9.27 Images and Drawings for Download

Pool, Tub, Fountain, & Water Feature Specifications

Method P601 – Concrete Pool Shell with Thick Bed Mortar

Method P601B – Concrete Pool Shell with Roll Out Rim

Method P601C – Concrete Pool Deck with Trench Drain

Method P601D – Concrete Pool Shell Direct Bond

Method P602 – Concrete Pool Shell with Cementitious Waterproofing

Method P603 – Steel Pool Shell with Thick Bed Mortar

Method P604 – Steel Pool Shell Direct Bond

Method P605 – Fiberglass Pool Shell Direct Bond

Method B417A – Concrete Tubs, Fountains & Water Features Method

Method B417B – Wood Form Tubs, Fountains & Water Features Method

Exterior Pool Deck Specifications

Method F101 – Concrete Slab with Bonded Mortar Bed

Method F102 – Concrete Slab Direct Bond

Method F103 – Plaza & Deck System Over Occupied Space

Interior Pool Deck

Method F112 – Concrete Slab with Bonded Mortar Bed and Waterproofing Membrane

Method F121 – Concrete Slab with Unbonded Mortar Bed and Waterproofing Membrane

Method F122 – Concrete Slab Direct Bond with Waterproofing Membrane

PDF

P601 Concrete Pool Shell with Mortar Bed and Waterproofing (P601)

P601A Concrete Pool Shell – Gutter (P601A)

P601B Concrete Pool Shell – Roll Out Rim (P601B)

P601C Concrete Deck – Trench Drain (P601C)

P601C HBLD Concrete Deck – HYDRO BAN Linear Drain (P601C HBLD)

P601D Concrete Pool Shell – Direct Bond Tile with Waterproofing (P601D)

P602 Concrete Pool Shell with Cementitious Waterproofing & Tile (P602)

P602A Concrete Pool Shell with Waterline Tile & Pool Plaster (P602A)

P602B Concrete Pool Shell with Glass Tile at Waterline (P602B)

P603 Steel Pool Shell with Thick Bed Mortar (P603)

P604 Steel Pool Shell – Direct Bond Tile (P604)

P605 Fiberglass Pool Shell – Direct Bond Tile (P605)

B417A Concrete Tubs, Fountains & Water Features (B417A)

B417B Wood Formed Tubs, Fountains & Water Features (B417B)

B417C Concrete Tubs, Fountains & Water Features with Curb (B417C)

B417D Wood Formed Tubs, Fountains & Water Features with Curb (B417D)

B417E Wood Floor with Wood Framed Curb and Curb Overlay (B417E)

F101B Exterior Concrete Pool Deck – Bonded Thick Bed with Waterproofing Membrane (F101B)

F102B Concrete Pool Deck – Direct Bond Tile with Waterproofing Membrane (F102B)

F103B Exterior Pool Deck Over Occupied Space – LATICRETE Plaza and Deck System (103B)

F112B Interior Concrete Pool Deck – Bonded Thick Bed with Waterproofing Membrane (F112B)

F121 Interior Concrete Pool Deck – Unbonded Thick Bed with Waterproofing Membrane (F121)

F122 Interior Concrete Pool Deck - Direct Bond Tile with Waterproofing Membrane (F122)

WP301 Waterproofing Connection to Clamping Ring Drain (WP301)

WP302 Pool Waterproofing Connection to Clamping Ring Drain (Detail) (WP302 Pool)

WP305 Interior Pool Deck - Connection to HYDRO BAN Bonding Flange Drain (WP305)

WP306 Pool Deck Connection to HYDRO BAN Linear Drain (WP306 Pool Deck)

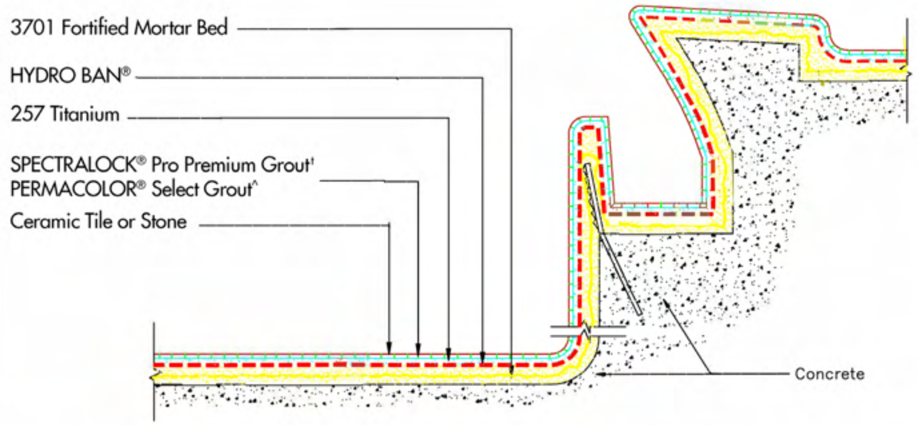
WP307 HYDRO BAN to HYDRO BAN Cementitious Waterproofing Transition (WP307)

Section 10: Swimming Pools, Fountains and Spas Detail Drawings

Section 10: Swimming Pools, Fountains and Spas Detail Drawings

The following section includes typical details for use in specifying and installing ceramic tile and stone installations in swimming pools, fountains, spas, and water features. Details are subject to change without notice. For the most current revision of these details and the corresponding specifications please visit **www.laticrete.com/ag**.

10.1 CONCRETE – SWIMMING POOL TANK P601



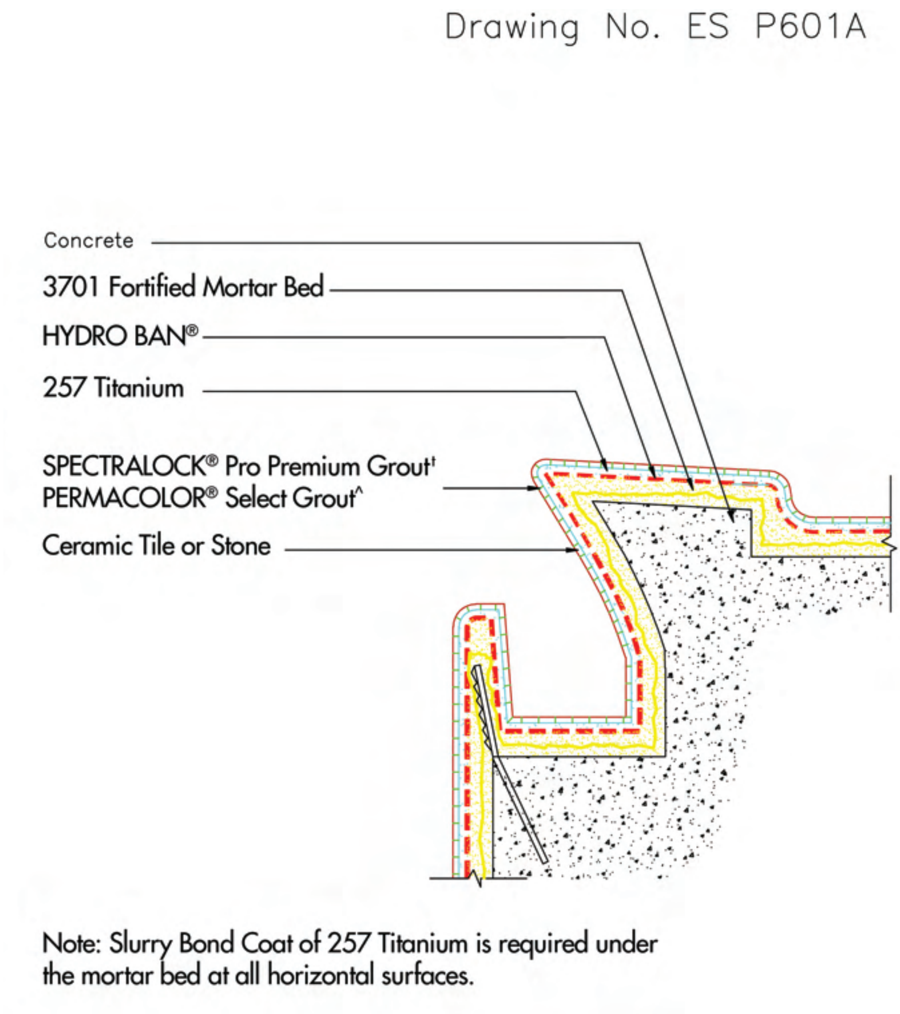
Note: Slurry Bond Coat of 257 Titanium is required under the mortar bed at all horizontal surfaces.

† United States Patent No.: 6881768 (and other Patents).

^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

10.2 CONCRETE – SWIMMING POOL GUTTER P601A

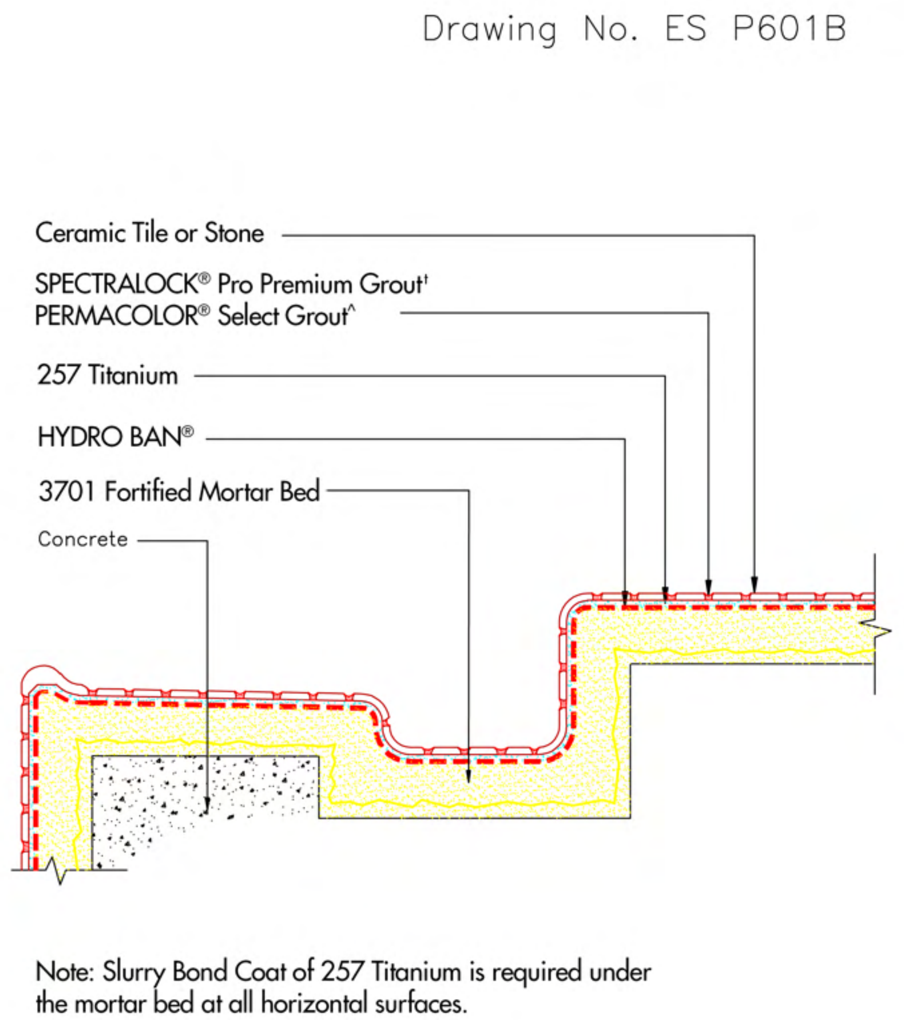


† United States Patent No.: 6881768 (and other Patents).
^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

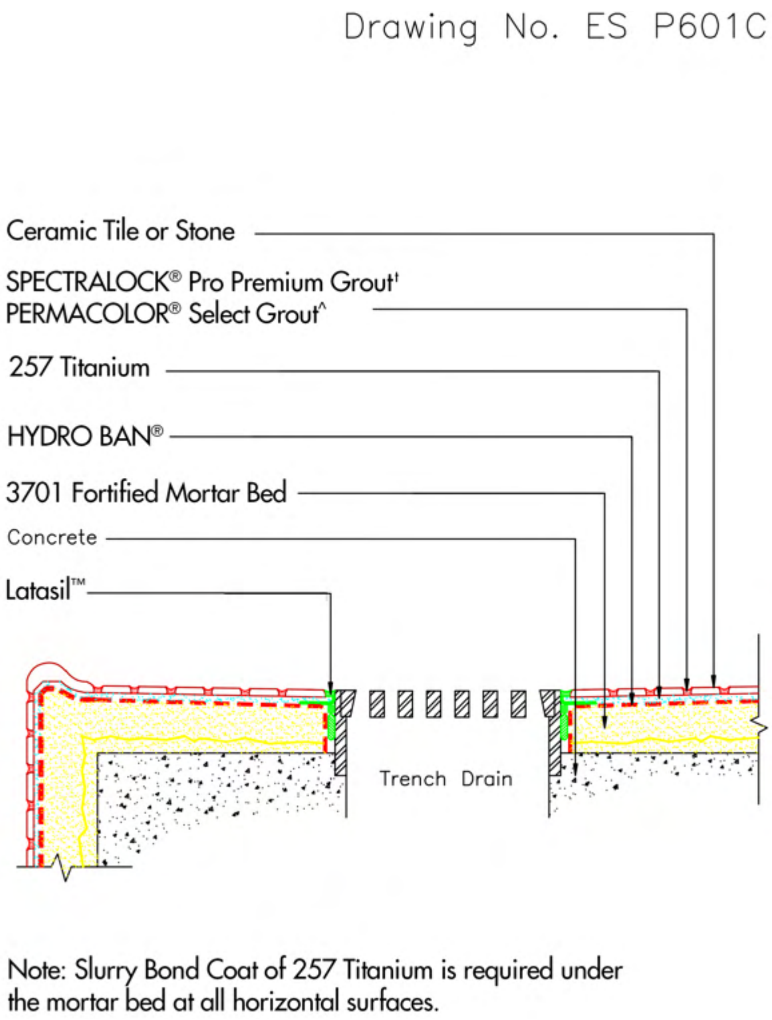
10.3 CONCRETE – SWIMMING POOL ROL OUT RIM P601B



† United States Patent No.: 6881768 (and other Patents).
^ United States Patent No.: 6784229 B2 (and other Patents).
* United States Invention Patent No.: 6881768 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

10.4 CONCRETE – SWIMMING POOL DECK/TRENCH DRAIN P601C



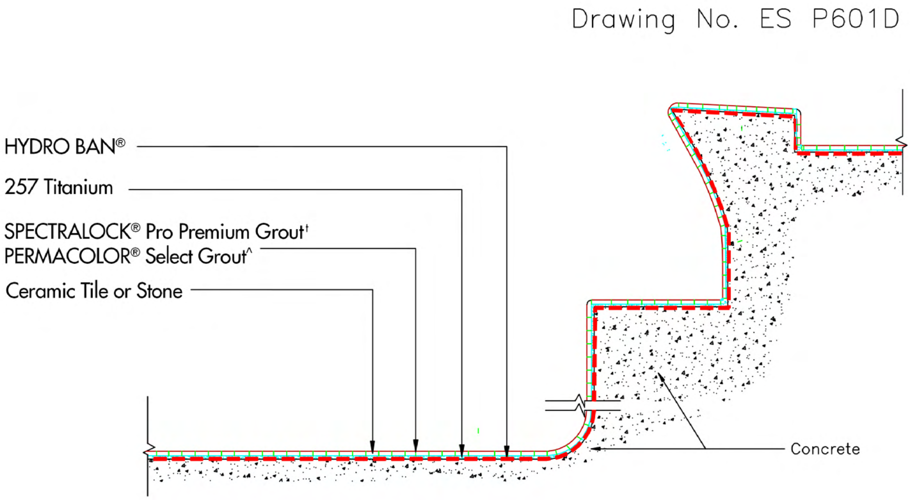
† United States Patent No.: 6881768 (and other Patents).
^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.5 CONCRETE – SWIMMING POOL DIRECT BOND P601D



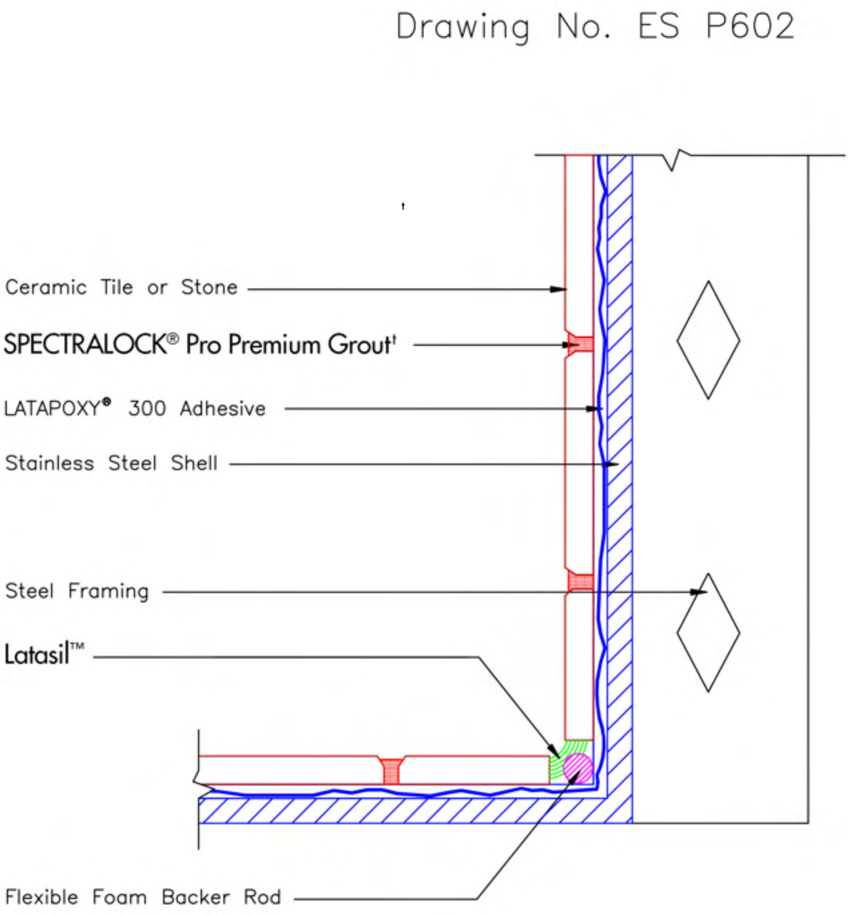
† United States Patent No.: 6881768 (and other Patents).
^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.6 STAINLESS STEEL – POOL/SPA THIN-BED P602



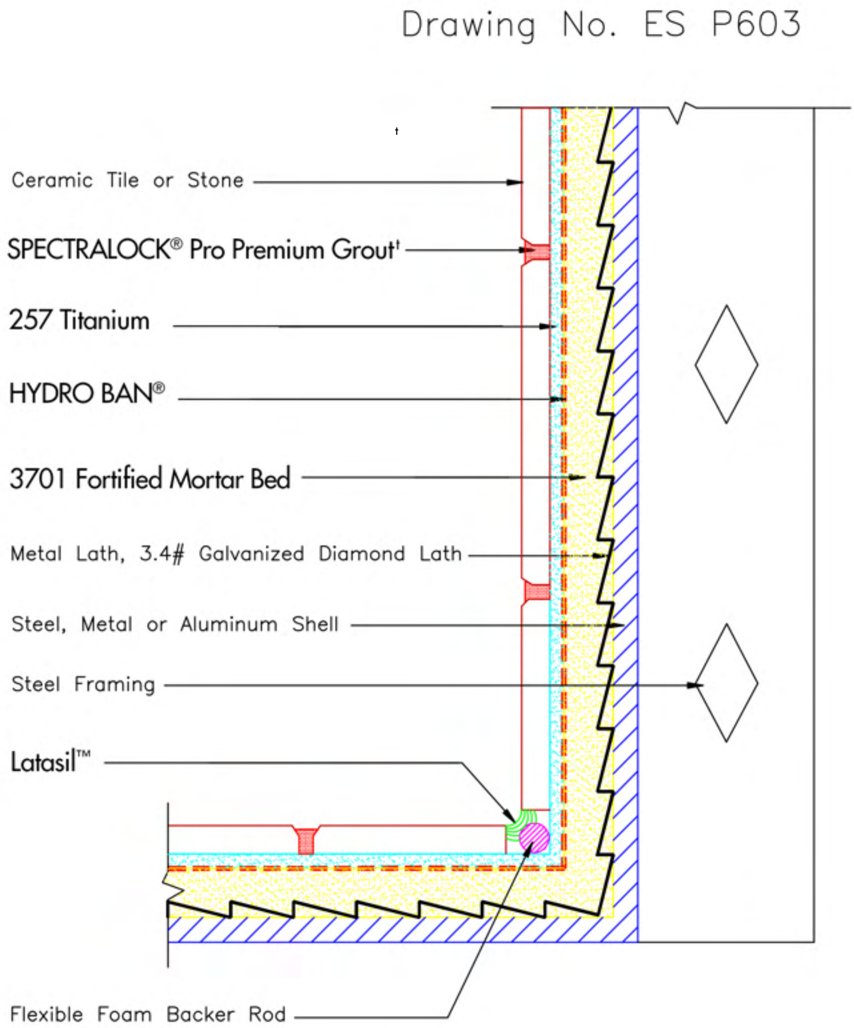
† United States Patent No.: 6881768 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.7 STAINLESS STEEL – POOL/SPA THICK BED P603

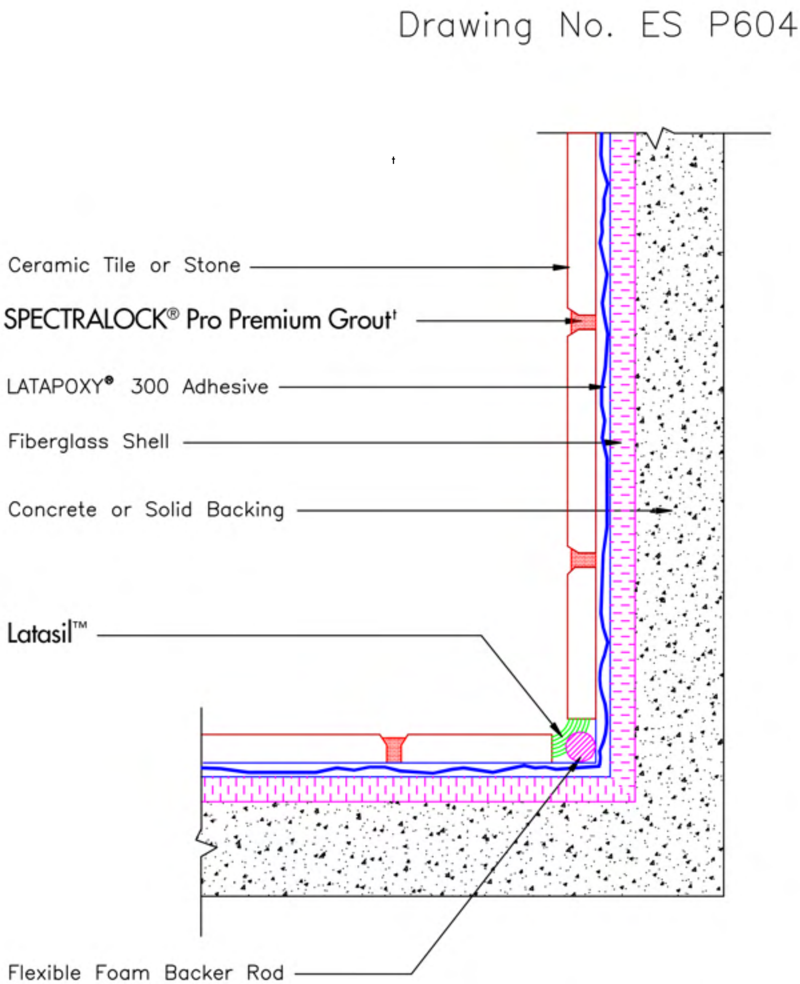


† United States Patent No.: 6881768 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.8 FIBERGLASS – POOL/SPA THIN BED P604



† United States Patent No.: 6881768 (and other Patents).

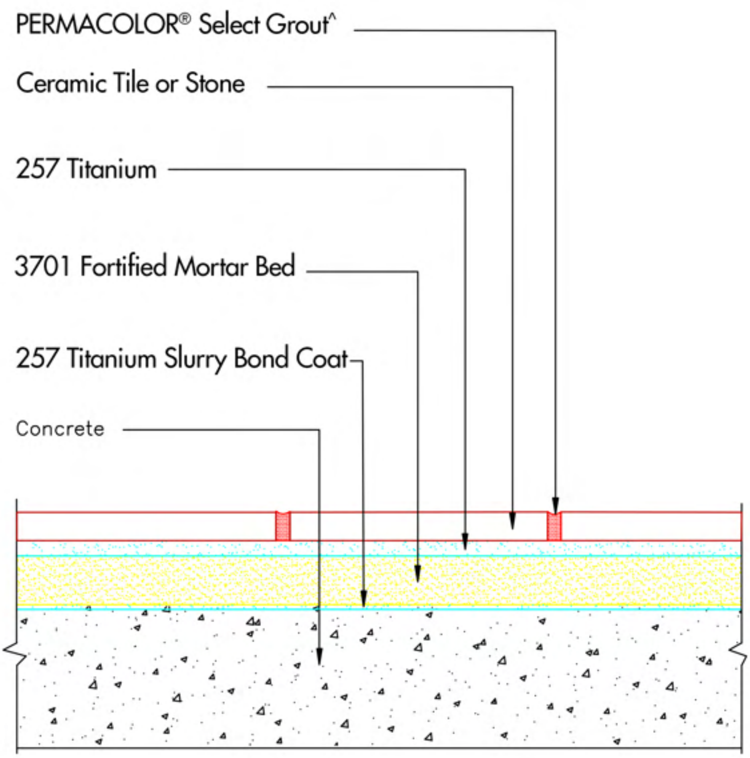
REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.9 CONCRETE – SLAB-ON-GRADE – BONDED THICK BED F101

Drawing No. ES F101



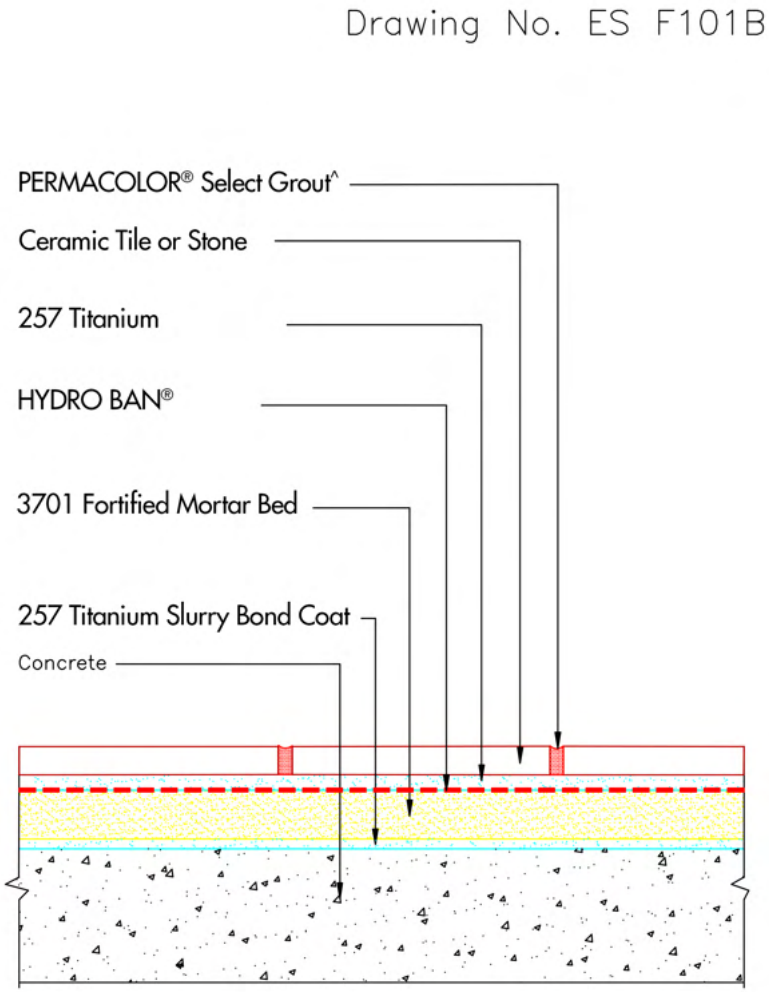
^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit www.laticrete.com/ag

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.10 CONCRETE – SLAB-ON-GRADE – BONDED THICK BED WITH WATERPROOFING MEMBRANE F101B



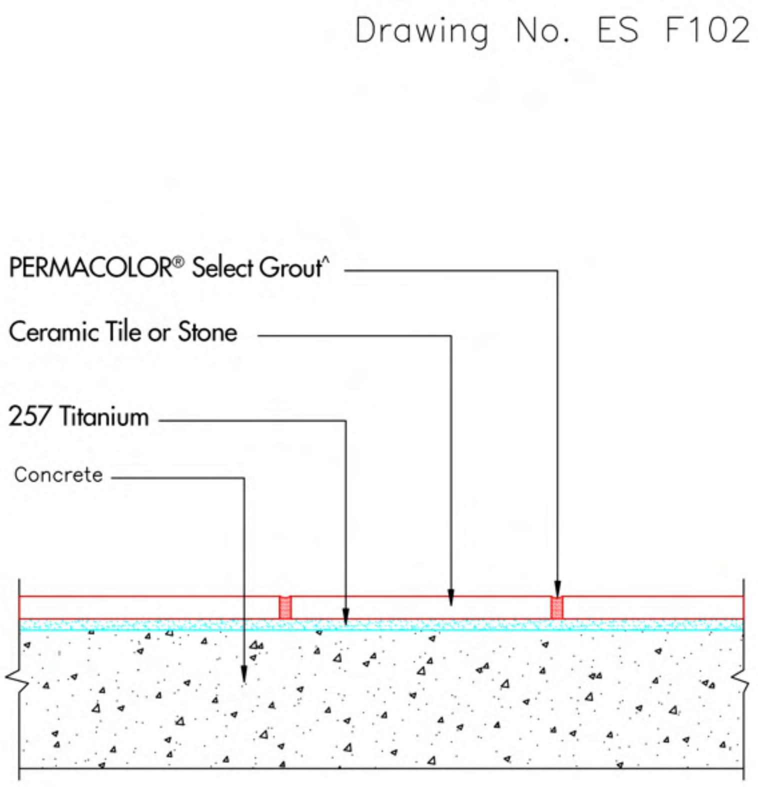
^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.11 CONCRETE – SLAB-ON-GRADE – THIN BED F102



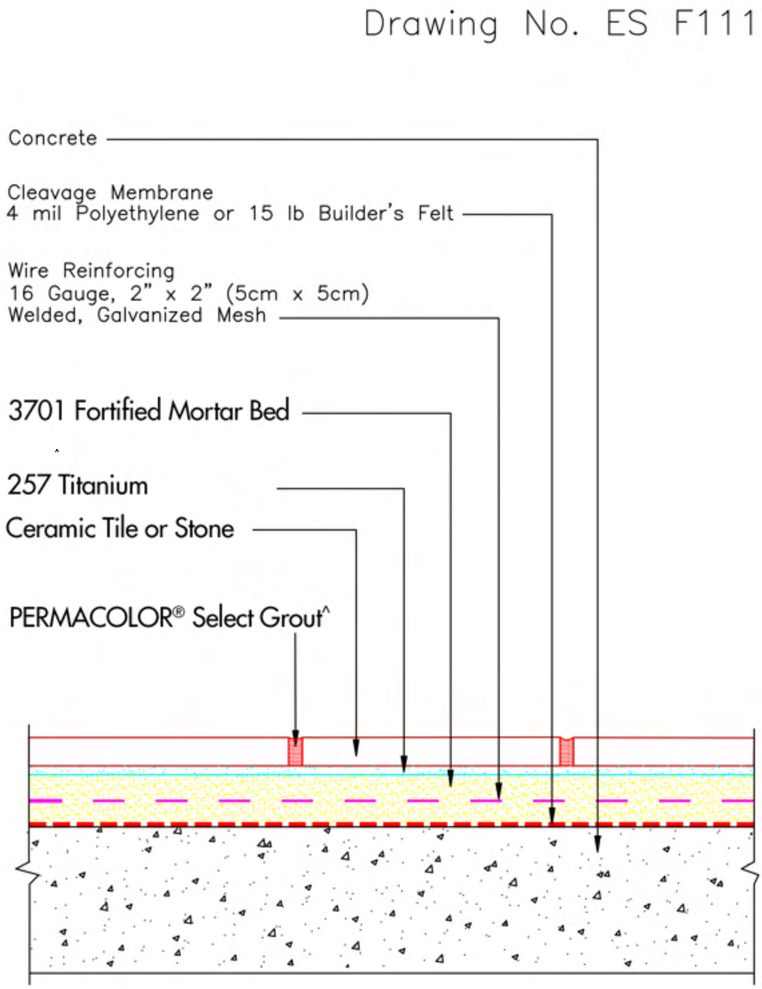
^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.12 CONCRETE – SLAB-ON GRADE OR SUSPENDED – UNBONDED THICK BED F111

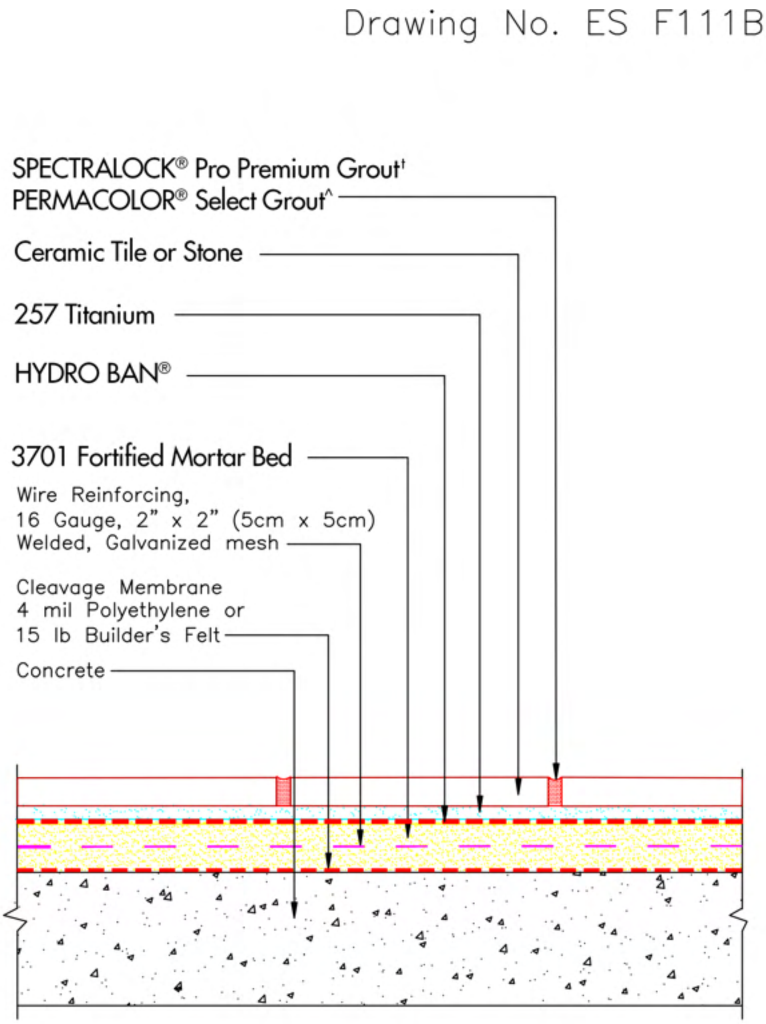


† United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.13 CONCRETE – SLAB-ON-GRADE OR SUSPENDED – UNBONDED THICK BED WITH WATERPROOFING MEMBRANE F111B



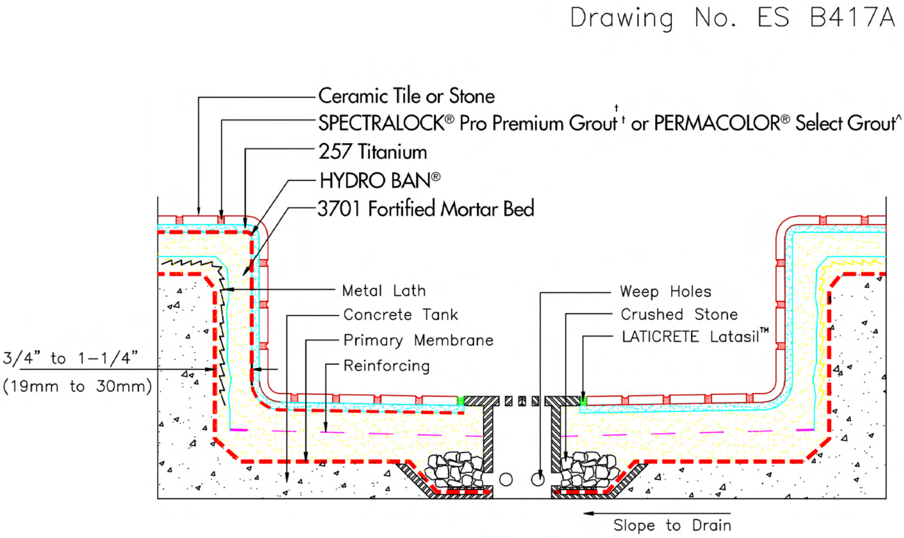
† United States Patent No.: 6881768 (and other Patents).
^ United States Patent No. 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit www.laticrete.com/ag

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.14 CONCRETE – TUBS, FOUNTAINS AND CURBS B417A



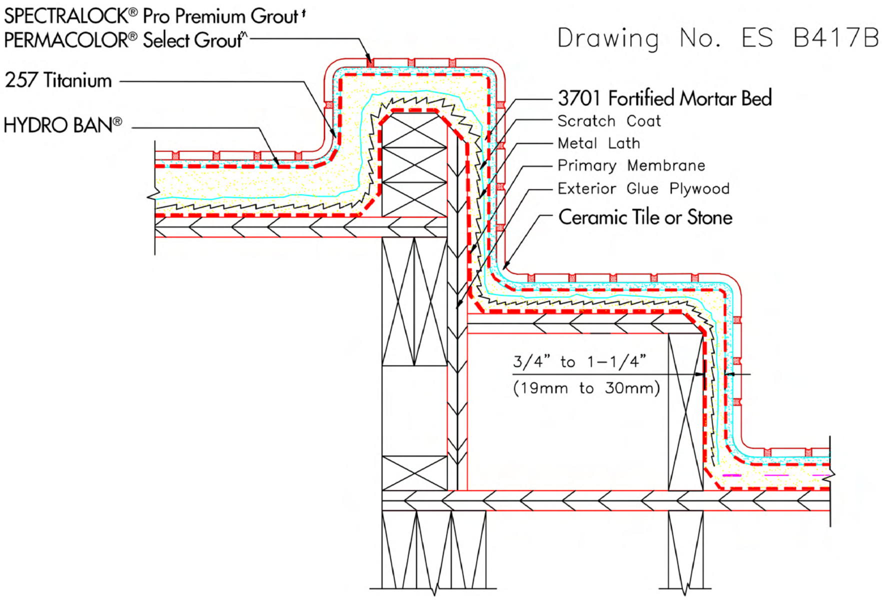
† United States Patent No.: 6881768 (and other Patents).
^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.15 WOOD FORM – TUBS, FOUNTAINS AND CURBS B417B



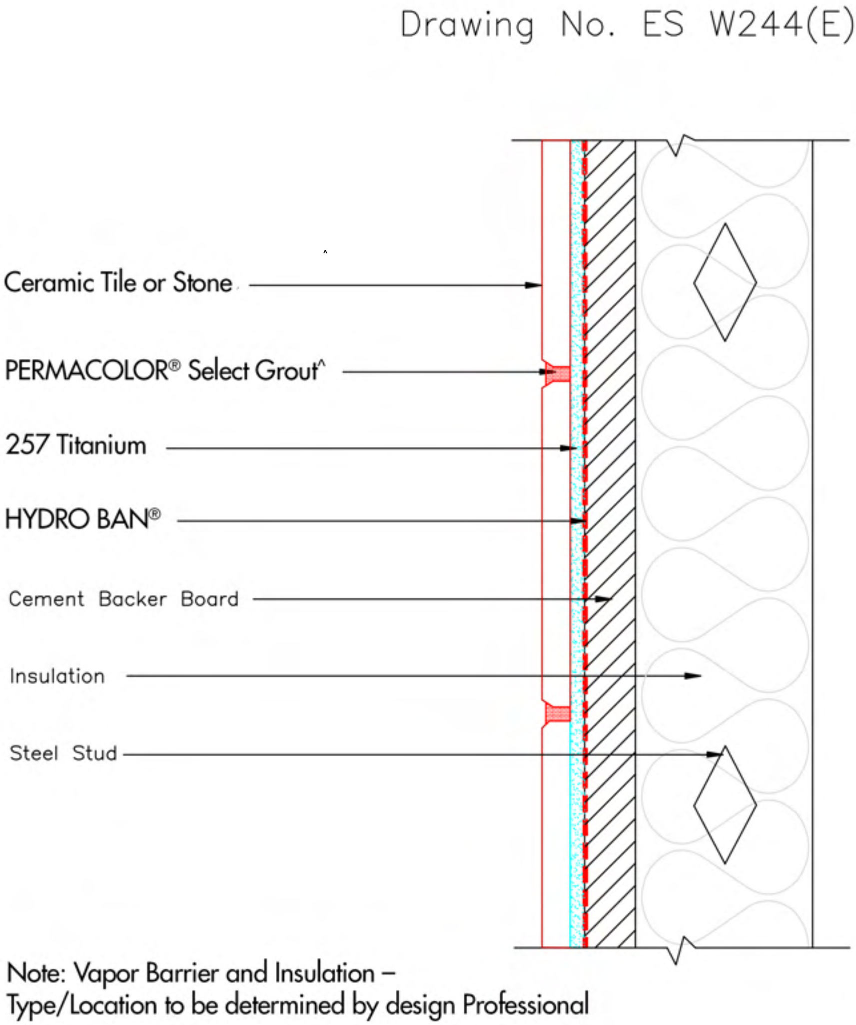
† United States Patent No.: 6881768 (and other Patents).
^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.16 CEMENT BACKER BOARD – STEEL FRAMING – EXTERIOR AND WET AREAS W244(E)



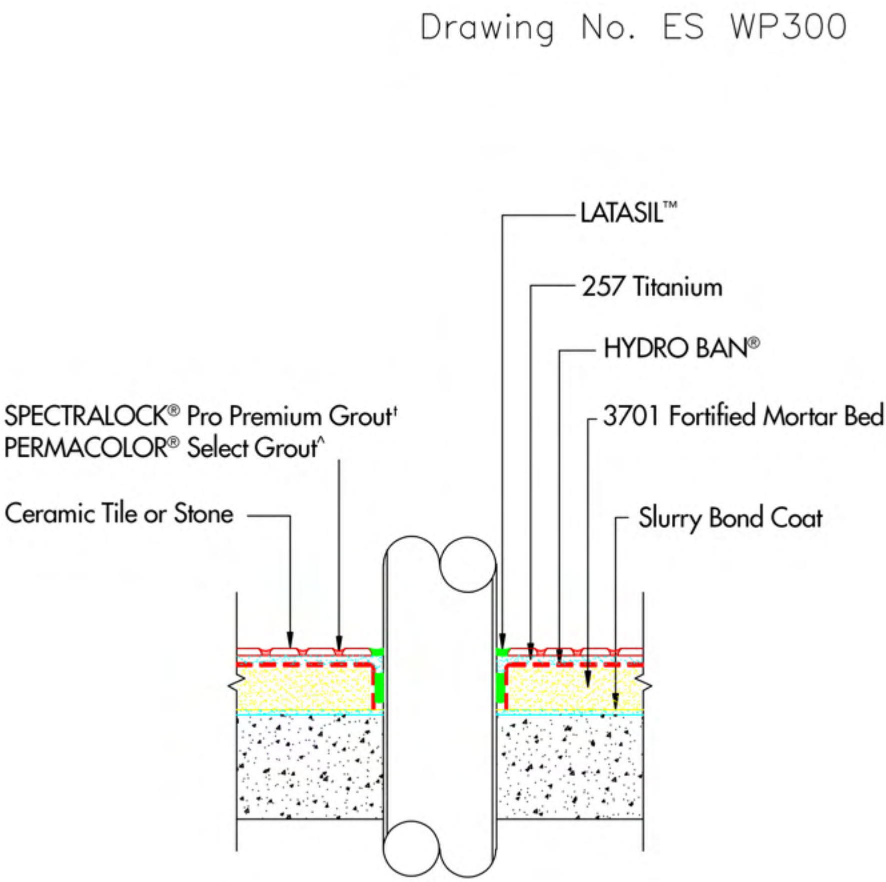
^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.17 TYPICAL PIPE PENETRATION WP300

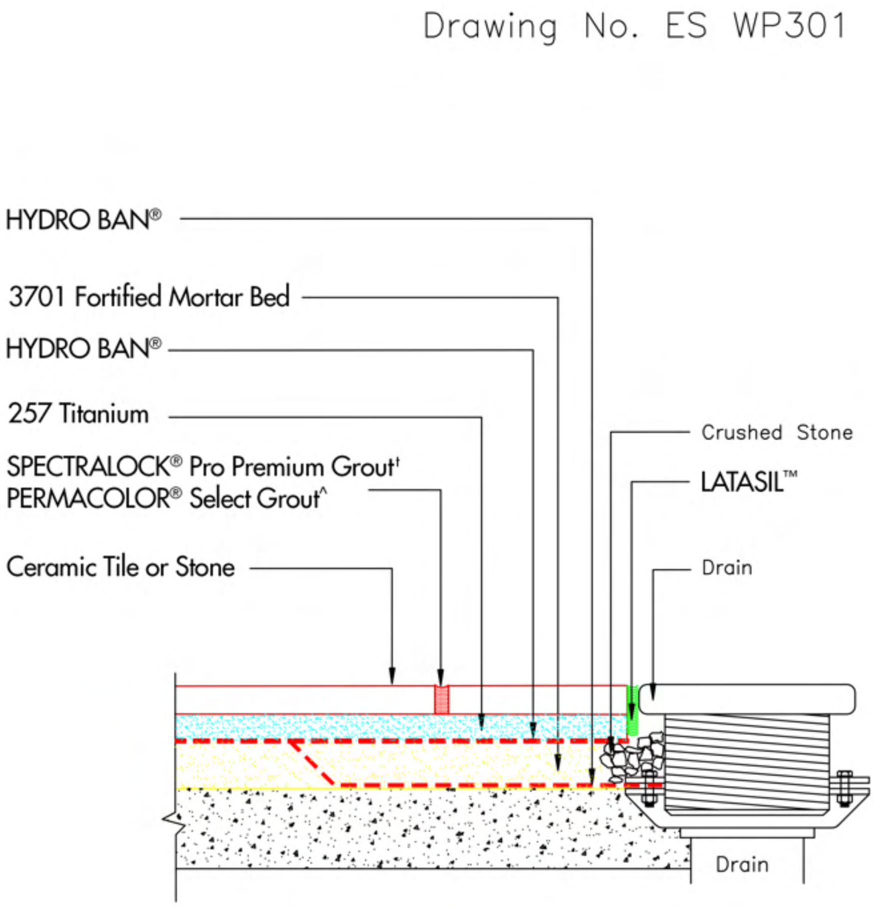


† United States Patent No.: 6881768 (and other Patents).
^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.18 TYPICAL DRAIN DETAIL WP301



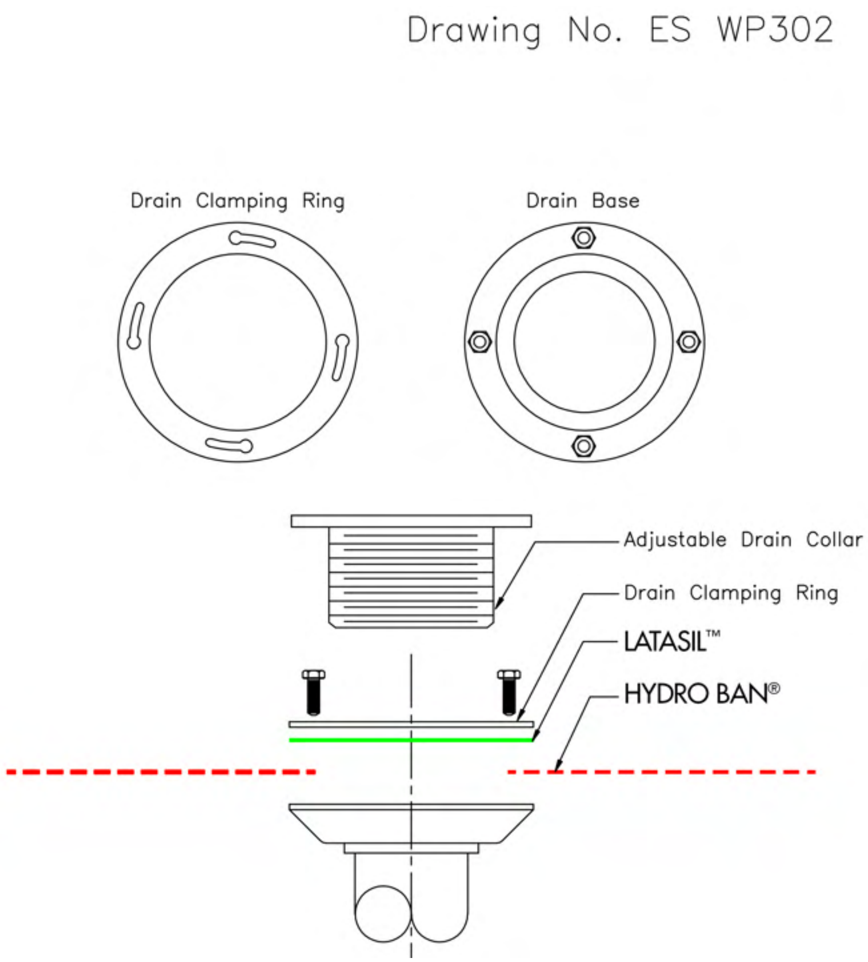
† United States Patent No.: 6881768 (and other Patents).
^ United States Patent No.: 6784229 B2 (and other Patents).

REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

10.19 DRAIN DETAIL – EXPLODED VIEW WP302



REVISION DATE: 2/2020 SCALE: NTS

For latest revision of this and all LATICRETE details please visit **www.laticrete.com/ag**

As a professional courtesy, LATICRETE offers technical services free of charge. The user maintains all responsibility for verifying the applicability and suitability of the technical service or information provided.

Section 11: Pool Water and Tile Installation Maintenance

11.1 Fill and Drain Rates

Swimming pools and fountains which have had tile and stone installed should be filled and drained at a prescribed rate of 1" (25 mm) per hour. Following this prescribed fill rate will help to alleviate the rapid expansion of the pool walls due to the weight of the water, moisture expansion of the tile and thermal gradient variation. Maintain a differential of 10°F (5.5°C) or less between the fill water and substrate temperatures during fill cycles. While the movement joints and sealant will accommodate most of this movement they will be stressed during the fill period so a slow fill can help the movement joints better fulfill their intended purpose.

During the drain periods the slow rate will allow the movement joints and tile system to shrink back at a slower and safer rate. As the tile or stone, immersed in water for extended periods, dry out they will experience shrinkage movement due to the loss of moisture. The weight of the water in the pool goes down and the walls can shrink back due to the loss of pressure. The slow empty rate allows for a normal process to take place without damage to the pool or tile system. The slow drain rate also helps to prevent hydrostatic pressure from causing delamination of tile in pools without a waterproofing membrane.

NOTE: The prescribed fill and drain rate described above is recommended for pools, fountains and water features which have received a tile or stone installation. Filling or emptying these vessels which have received other finish types may not be necessary or recommended. Please check with the finish material manufacturer for their recommended fill and drain rates.

While the prescribed rate of 1" (25 mm) per hour is rather slow, damage caused by filling or emptying too quickly can be far more time consuming and costly than waiting a few days longer to fill the pool.

Initial alkalinity of pool water may be very high, due to exposure to plaster, grouts and mortars so careful and frequent balancing of the pool water is required. The pool or fountain should not be filled if potential thermal gradients are present (e.g. very cold water source, pool exposed to direct sunlight for extended periods, etc…).

11.2 Opening and Closing Seasonal Swimming Pools and Water Features

Opening – Opening a swimming pool, depending on the climate, is an annual rite of spring for pool owners. The process of opening a swimming pool involves many different tasks and allows for routine inspection and maintenance to be performed.

For swimming pools in northern climates the list includes;

- Removing, Cleaning and Storing the Pool Cover
- Testing Water Balance, pH, Calcium, Cyanuric Acid, Calcium Hardness, and Alkalinity Levels
- Inspecting Electrical Service, Filters, Ladders, Diving Boards, Plugs, Gauges, and Other Important Components of the System
- Lubricate Fittings, Valves, O-Rings, and Plugs
- Inspect Tile and Grout Installations, and Clean Tiles and Skimmer With Cleanser
- Clean and Inspect Pool Deck
- Skim Pool Water Surface and Vacuum Pool Bottom
- Backwash Filter if Necessary
- Shock Pool Water to Breakpoint Levels

Failure to inspect and correct any problems during the opening may result in down time of the pool during the warmer season when the pool will be utilized the most.

For swimming pools in southern climates, where the pool will be open year round, it is still necessary for an inspection and maintenance regimen to be followed. This will help keep the pool sanitary and safe for the users and prevent significant down time due to improper upkeep.[1]

In many cases a professional pool maintenance company is utilized to make sure that the pool is running efficiently, the pool mineral and chemical levels are properly maintained, and that the entire pool system is working properly.

Closing – Closing a pool for the winter is also a common sight in cold weather climates. The process of closing a pool is just as important to the long term performance of the pool as the opening. Some of the steps to closing the pool properly typically include (check local guidelines for proper pool closing requirements);

- Balance the Pool Water Chemistry
- Remove Skimmer Baskets, Cleaners, Ladders, Wall Fittings, and Solar Blankets From the Pool
- Lower the Water Level in the Pool to Below the Skimmer Level in the Pool
- Drain All Pumping, Filtering, Heating, and Sanitizing Equipment to Prevent Damage Caused By Breezing
- Lubricate O-Rings, Valves and Plugs to Make Opening the Pool in the Spring Easier
- Clean and Vacuum the Pool
- Winterize the Plumbing by Blowing Out the Lines and Plug the Lines With Expansion Plugs
- Add Winterizing Algaecide
- Cover the Pool With a Tight Fitting Cover

In warmer climates many people simply reduce the amount of filtration times per day and also find that the pool requires fewer chemicals. As the use of the pool decreases, the opportunity to inspect and provide maintenance to the pool increases.[2]

NOTE: It is important to note that swimming pools and water features which are in use year round also require the same regular attention and maintenance as seasonal swimming pools and water features.

11.3 Water Treatments and Tile Installations

It is not the goal of this manual to provide advice or recommendations for the proper treatment of swimming pool, fountain, water feature, or spa water. The best advice that we can offer along these lines is to consult with a pool professional who knows the water conditions and best water treatment options available for your pool and geographical region. For more information on locating a qualified pool professional in your area, please contact The Association of Pool and Spa Professionals/ National Swimming Pool Foundation at www.apsp.org.

To get a better understanding of pool water balance we will look at several aspects of water treatment;

Sanitizers – A pool sanitizer and its accompanying shock is commonly referred to as either a sanitizer, a disinfectant or an oxidizer, but, these products must be able to perform all 3 tasks.

- **Sanitizing –** Killing all bacteria, living organisms and other contaminates that are present in water
- **Disinfecting –** Kills all potential disease-carrying capabilities of these bacteria, living organisms and other contaminates
- **Oxidizing –** Oxidizes any ammonia that is present in the pool due to environmental factors, fertilizers blowing into the pool, or swimmer waste (e.g. urine, saliva, perspiration, suntan lotions, saliva, body oils, etc…). Ammonia is usually only oxidized using a pool shock suitable for use with the sanitizer being used in the pool

There are currently several methods for sanitizing pools, fountains and water features;

Chlorine – Chlorine is the most commonly used pool sanitizer in the industry today. Chlorine will take a leadership role in sanitizing, disinfecting and oxidizing when present in any water. Unfortunately, it is not as easy as adding chlorine to your pool from time to time, expecting the water to stay crystal clear and sparkling. The chlorine levels must be monitored on a continual basis based on environmental conditions (e.g. temperature, humidity, sunlight, rain, wind, and evaporation) and bather load. Failure to do so can cause the water to turn murky and green with the growth of algae.

For a better understanding of chlorine and how it works we will look at some terminology regarding this type of chemistry;

Chlorine Demand – The amount of chlorine needed to kill bacteria, living organisms and other pollutants in the water.

Free Chlorine – The chlorine not presently being used to kill bacteria, living organisms or other pollutants in the water.

Chloramines – Formed when chlorine combines with ammonia in pool water. Chloramines are ineffective at sanitizing, disinfecting and oxidizing pool water.

Total Chlorine – The combined reading combination of Free Chlorine and Chloramines.

Chlorine levels are measured on two scales; Total Chlorine and Free Chlorine. The results of testing for Total Chlorine tells you when to shock the pool to get rid of excess chloramines and ammonia, and, the test results for Free Chlorine tells you when to add chlorine to the pool. When chlorine is added to water, a dissociation occurs. In other words, Cl2 (chlorine) + 2H2O (water) = HOCl (hypochlorous acid) + HCl (hydrochloric acid). Hypochlorous acid is the active by product of this reaction that is responsible for killing bacteria, living organisms or other pollutants in the pool water. The chlorine molecule or ion kills microorganisms by entering through cell walls and destroying inner enzymes, structures and processes. When this occurs the cell is effectively deactivated or oxidized. The hypochlorous molecule or ion continues working until it combines with a nitrogen or ammonia compound, becoming a chloramine, or is broken down into its component atoms, becoming deactivated itself.

Chlorine is available in many forms for use in a swimming pool;

- **Granular Chlorine –** Granular chlorine has many advantages; it is fast dissolving, typically has 63% available chlorine, contains cyanuric acid, has a long shelf life, has a pH level of 6.8 (fairly close to the desired level), does not add any by-products to the water, and can be used both for sanitizing and shocking. Disadvantages include a cost higher than chlorine tablets and less available chlorine than tablets
- **Chlorine Tablets –** Easily the most common form of chlorine sold for pool treatments. Chlorine tablets contain about 90% available chlorine, contains cyanuric acid, have long shelf life, and are less expensive than granular chlorine. The disadvantages are few and are easily corrected. Chlorine tablets have a pH between 2.8 – 3.0, which can lower the pH level in the pool water. If the pH level is not monitored and corrected often then degradation of metal in the pool, as well as cement based tile and stone installation materials (e.g. grout) can occur
- **Liquid Chlorine –** Liquid chlorine is inexpensive, easy to use, and begins working immediately after it is added to the pool or fountain. Disadvantages include the fact that liquid chlorine provides only about 12 – 15% available chlorine which can be exhausted quickly due to exposure to sunlight and a short shelf life. The use of liquid chlorine may also add unwanted salts to the pool water (a result of the production process of the liquid chlorine)
- **Chlorine Gas –** Chlorine gas is reasonably inexpensive, provides 100% available chlorine and adds no by-products to the pool water. This form of chlorine is rarely used in swimming pools mainly because of its one significant disadvantage – if misused, chlorine gas is deadly. Chlorine gas is difficult to handle, making misuse easy

Cyanuric acid is a necessary addition to any pool treated with a chlorine product. Chlorine tablets and granular chlorine are Cyanurates, which simply means they contain cyanuric acid. Typically sold as either “Conditioner” or “Stabilizer” cyanuric acid protects chlorine from being destroyed by sunlight. Cyanuric acid needs to be added whenever a pool is drained, cleaned and refilled because tap water contains almost none of this chemical. The recommended range for cyanuric acid is 30 – 80 ppm (30 – 80 ml/L) with a maximum of 100 ppm. If the level of cyanuric acid rises above 100 ppm the only way to achieve a suitable reading is to drain the pool completely and refill with new water. Cyanuric acid has a pH of 4.0, so if the pH level is not monitored and corrected often then degradation of metal in the pool, as well as cement based tile and stone installation materials can occur.

Bromine – Bromine is an effective alternative to chlorine that comes in both tablet (far more commonly used) and granular forms. Bromine is far more stable at higher temperatures, and, as such, is used more often than chlorine to sanitize, disinfect and oxidize spas. Due to the presence of ammonia in pool water, bromamines (like chloramines) will be present in pool water. But, unlike chloramines, bromamines are at least marginally effective at assisting in sanitizing, disinfecting and oxidizing the water. Unlike chloramines, bromamines will breakdown by themselves but they should be removed from the water by regular shocking to maintain a stable water environment.

The main drawback of bromine, coupled with its non-chlorine shock, Potassium Peroxymonosulfate (required to get rid of ammonia and bromamines), is its expense. Bromine is more expensive than chlorine and only equally effective at producing results. Another drawback is that it will be destroyed by sunlight and that it cannot be protected by the use of cyanuric acid. Bromine has a pH of 4.0, therefore, constant monitoring of the pool water will be necessary to avoid possible problems caused by low pH (acidic).

Bromine by itself, cannot oxidize. In other words, to be effective, bromine requires a catalyst; and the catalyst is often chlorine. The tablet mixture is typically around 60% bromine, 28% chlorine and 12% inert ingredients. Bromine levels should be maintained at 2.5 – 4.0 ppm (2.5 – 4.0 ml/L) with an industry accepted minimum level of 2.0 ppm (2.0 ml/L). It is best to add bromine when the level reaches 2.5 to avoid any potential problems.

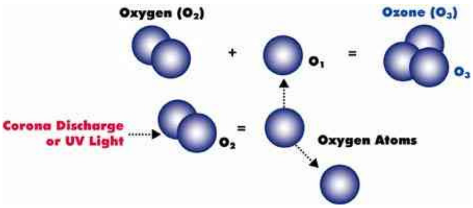


Figure 11.1 – Diagram of how ozone is created by an ozone generator.

Salt Water – Salt water pools are becoming more and more prevalent, and this method of sanitizing a pool is very effective. A salt water pool has 3 main components; salt, a salt cell and a control box.

First, it will be best to explain that the level of salt used to sanitize a swimming pool or fountain is not the same as ocean salt water. Ocean salt water contains about 20,000 ppm (20 ml/L) of salt, while a salt water pool contains only about 3,000 ppm (3 ml/L). At 3,000 ppm (3 ml/L) you generally cannot even taste the salt; in fact, your eyes contain about 9,000 ppm (9 ml/L) of salt. Any water under 6,000 ppm (6 ml/L) is still considered fresh water.

A salt water pool system works to sanitize a pool based on the fact that chlorine can be produced by running the salt water through a series of plates (the salt cell) with opposite electrical charges. As the water passes through these plates electrolysis takes place which releases the chlorine in the salt. The control box sends electricity to the salt cell and controls how much chlorine is produced by regulating how long the electricity is applied to the cell.

Salt water pools do not have the ability to shock the pool water so a chlorine shock (super chlorinator) is used to quickly raise the chlorine level when necessary. Cyanuric acid would also be required at 30 – 80 ppm (30 – 80 ml/L) since chlorine is the end result of the salt water electrolysis process. Another benefit of salt water pools is that the water is softer, since salts are commonly used to soften water. Salt water may have an effect on a tile or stone installation system as well as many other cement based finishes; efflorescence.

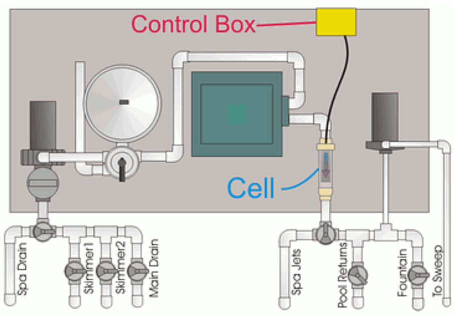


Figure 11.2 – A typical salt water circulation and treatment system4.

There are other water treatment options but these are used infrequently, and will not be mentioned in this text. However, choosing the water treatment option best suited for your conditions is very important and the decision should be after consultation with a qualified pool professional.

Supplemental Sanitizers Ozone – In its natural state, ultraviolet (UV) light from the sun converts oxygen molecules into ozone molecules. Ozone is the earth's natural purifier and cleaner; and this fact makes it a perfect choice to assist in the sanitization of swimming pool water. Ozone is a supplement to be used with chlorine or bromine to fully sanitize the pool water. In combination, the end result is crystal clear, sparkling water at a fraction of the cost of using chlorine and bromine alone. In fact, ozone has been proven to purify, clean and sanitize pool water faster and more effectively than traditional chlorine or bromine alone.

When used in conjunction with chlorine or bromine, ozone will kill or get rid of all bacteria, living organisms, ammonia, swimmer wastes, algae, dirt, debris, and other contaminants virtually on contact. This is done with no odor and without leaving any by-products in the water, other than oxygen.

The ozone sanitizing process works by placing an ozonator in line with the pool circulation equipment after the filter. Water flows through the pump and passes through the filter where any dirt, debris or particles are trapped. The water continues through the heater (if present) and then through the ozonator where the water will be exposed to a specific wavelength of UV light. The UV light converts oxygen molecules into ozone molecules where the water is cleaned naturally.

Ultraviolet Light (UV) – UV lamps are useful for supplemental sanitation in swimming pool and spa water. Although UV light is very effective against microorganisms, UV lamps cannot be used as stand-alone sanitizers since they do not impart a sanitizer residual into the water. As such, UV lamps can only be used in conjunction with a suitable EPA registered pool water sanitizer to ensure bathers are protected against disease and infection. For the UV lamp to be effective as a germicide it must emit UV light wavelengths in the 200 – 310 nanometer (nm) which is in the UV-C range, and to a lesser extent UV-B.

UV light inactivates microorganisms by damaging their nucleic acid, thereby preventing the microorganism from replicating which thereby prevents infecting a host.

Pool Water Chemistry

Water, by itself, is rarely free of harsh minerals and various chemicals or contaminants (e.g. bacteria, ammonia, living organisms, and other pollutants). Some of these contaminants are evident in the water used to fill the pool, some come from certain environmental factors, and others result from pool chemistry. The fact is that the majority of these minerals and impurities must be eliminated from your pool. To do this requires the addition of certain chemicals to combat the undesired effects caused by the contamination, and to have the proper amount of minerals to achieve "balanced water". Alkalinity, pH, and hardness are your water balancers and are responsible for creating optimal water chemistry. If these levels are within their desired ranges, if water circulation is adequate, and a proper maintenance program is followed, the result will be clean, clear sparkling blue water.

When water is considerably less than saturated (minerals) it is said to be in a corrosive or aggressive condition. When water is over saturated and can no longer hold the minerals in solution it is in a scaling condition. Balanced water is that which is neither over-saturated nor under-saturated. Water which is under-saturated will attempt to saturate itself by dissolving everything in contact with it in order to increase its own mineral content. Water which is over saturated will attempt to rid itself of this content by precipitating minerals out of solution in the form of scale. This gives a whole new meaning to the phrase "water seeks its own level".[3]

pH – Although a pH of 7.0 is considered "neutral" for everyday water, it is not ideal for pool water. The ideal pH range for pool water is 7.2 – 7.8, with pH of 7.4 – 7.6 being optimal. Therefore, for a swimming pool, the pH scale has to be revised:

- A pH Level Between 1.0 – 7.19 Will Be Considered Acidic (Having a Low pH)
- A pH Level Between 7.2 – 7.8 is Good For Pool Water
- A pH Level Between 7.81 – 14.0 Will Be Considered Alkaline (Having a High pH)

The pH affects three key aspects of pool operation as well as swimmer comfort and safety:

- Water maintained within the range of 7.2 – 7.8 is generally not irritating to eyes and skin.
- The pH range of 7.2 – 7.8 is good in terms of the sanitizing and oxidizing efficiency of chlorine sanitizers. At higher pH, only a small fraction of the free available chlorine will be in hypochlorous acid form, and hypochlorous acid is far more effective as a sanitizer and oxidizer than is hypochlorite ion. At lower pH, chlorine gas may form resulting in inefficiencies due to chlorine loss and possible breathing hazards for occupants. The effectiveness of other sanitizers (e.g. bromine, Polyhexamethylene biguanide [PHMB]) is not dependent on pH.
- pH is a key driver in maintaining water balance by avoiding conditions in which the water is excessively corrosive to plumbing and pool surfaces, or, predisposed to deposit scale on exposed surfaces.

pH can be raised or lowered with the addition of certain chemicals. Sodium Bisulfate is commonly used to reduce pH and Sodium Carbonate is commonly used to raise pH. At the conclusion of all surface preparation and prior to the installation of tile, measure the pH level of the substrate. This work should not commence until the pH value is 10 or less.

Total Alkalinity – Alkalinity is often confused with pH as a unified and singular water-balancing chemical. While alkalinity has a definite affect on pH, they are certainly not the same. A pH test will show the acidity or alkalinity of water, while the Total Alkalinity test will show the quantity of alkaline material in the water. Some alkaline material is required in the water to maintain proper water chemistry. Both pH and Total Alkalinity play a role in achieving and maintaining water chemistry; therefore both must be adjusted on a regular basis. It should also be known that the Total Alkalinity level must be adjusted first and then the pH. This is because Total Alkalinity is a measure of the pH buffering capacity of the water (the ability of the water to resist pH change); if Total Alkalinity is in range, the pH is far less likely to fluctuate. For adequate buffering of the pool pH, a Total Alkalinity level of 60 – 180 ppm as calcium carbonate (CaCO3) must be maintained. Ideally, the Total Alkalinity level should be between 80 – 100 ppm as CaCO3 where calcium hypochlorite, lithium hypochlorite and sodium hypochlorite are used because these sanitizers will cause the pH to rise.

Total Alkalinity is generally expressed in terms of the equivalent concentration of calcium carbonate in mg/L (or ppm). For protection of calcium based materials (cement based grouts, cement plasters, etc…) within the pool, it is important to maintain sufficient carbonate alkalinity.

Calcium Hardness – The Calcium Hardness of pool water is the measure of primarily calcium and magnesium combined. Maintenance of Calcium Hardness in the recommended range helps to keep water balanced per the Langelier Saturation Index, influencing the water's corrosiveness or tendency to scale, depending on the degree of calcium saturation. Low levels of Calcium Hardness are not as important for non-cement based surfaces, but, regardless of the pool surfaces, it is important to keep the calcium concentration below the maximum to avoid production of scale and cloudy water. Problems associated with low Calcium Hardness levels affecting the grout can be avoided by using SPECTRALOCK® PRO Premium Grout instead of a cement based grout.

Pool water Calcium Hardness shall be maintained between 150 – 1000 ppm as CaCO3, and ideally between 200 – 400 ppm for swimming pools. In spas, Calcium Hardness shall be maintained between 100 – 800 ppm as $CaCO_3$, and ideally between 150 – 250 ppm.

Typically, Calcium Hardness levels should be maintained between 200 – 450 ppm (0.2 – 0.45 ml/L) with a maximum of 500 ppm (0.5 ml/L). Maintaining Hardness levels within the accepted range is important and levels too high or too low can lead to a variety of problems.

If the Hardness level gets too low these problems may occur;

- Dissolved Metallic Parts of Your Pool
- Stained and Etched Concrete or Cement Products in Your Pool (Including Cement Based Grout)
- Stained Liner in Vinyl-Lined Pools
- Blistering or Delamination of Fiberglass in Fiberglass Pools
- Minimizes the Effects of Chlorine or Bromine
- Foam
- Eye and Skin Irritation

If the Hardness level in a pool is too low it can be raised with the addition of Calcium Chloride.

If the Hardness level gets too high the following problems can occur;

- Cloudy Water (Turbidity)
- Scale Formation (Heavy Metal Minerals in Suspension Which Form Deposits on Interior Pool Surfaces)
- Poor Filtration (Caused by Scale Build up in Plumbing Which Restricts Water Circulation)
- Minimizes the Effects of Chlorine
- Eye and Skin Irritation

If the Hardness level is too high then lowering it should be done immediately, but, it is not possible to lower the Hardness level with the addition of a chemical or treatment. The Hardness level can only be lowered by draining the pool, either partially or completely. The use of a Metal Sequestering Agent is recommended to rid the water of the excess minerals which lead to elevated Calcium Hardness levels.

Metal	Sources	Colors
Calcium	Plaster, grout, mortar, cal-hypo chlorine shock	White crystals or precipitate
Cobalt	Fiberglass shells	Red, blue, gray, or black
Copper	Copper algaecides, ionizers, corrosion of copper pipes, fittings and heaters	Blue, green, blue/green, black, dark red, or teal
Iron	Well water, corrosion of iron pipe and fittings	Dark red, brown, black, gray or green
Manganese	Well water	Pink, red, or black

Figure 11.3 – Heavy metals found in pool water, their sources and scale or water color with excessive levels[5].

Total Dissolved Solids – Total Dissolved Solids is a measurement of the total amount of matter (minerals, chemical residue and other particles) that remains in water after evaporation.

Total Dissolved Solids (TDS) – Total dissolved solids is a measure of all dissolved ions (total amount of solid matter) in the water and may or may not indicate a problematic condition. The following will contribute to TDS: source water, rain water, treatment chemicals, and bather waste. As water evaporates, only the water itself evaporates while the particulate matter (solids) remains in the pool water, thereby increasing concentration. High TDS levels (1500 ppm and above) may correlate with the presence of undesirable substances that may cause poor water quality and indicate the need for water replacement. It is necessary to replace water lost to evaporation with tap water, or other source, as well as additional chemicals. However, this new addition of water and chemicals will increase the TDS in the water.

This process will continue for extended periods and the TDS will continue to rise. However, if the amount of solids in the pool water gets too high then the particulate matter will act as a sponge and minimize the effects of new pool chemicals added to the water. Typically, it takes 6 – 8 years for the TDS level to reach a critical level, and the only way to correct the problem is to empty water from the pool and replace with new water and chemicals.

Salt water pools intentionally have high concentrations of sodium chloride which contribute to TDS, but will not cause decreased sanitizer efficiency or cloudy water.

If the Total Dissolved Solids get too high, the following indicators or problems may occur;

- Continual Addition of Excess Chemicals
- Water Chemistry Tests Fine But Water is Not Clean and Sparkling (Water Has Odd Tint But You Can Still See Pool Bottom)
- Algae Growth Despite a Good Chlorine Reading and Pool Water Chemistry
- Varying and False Readings on Chemical Tests

The Saturation Index (SI), also known as the Langelier Saturation Index (LSI), is used to equate the calcium carbonate solubility of pool water and its corrosive effect on pool surfaces and equipment. Premature failure of equipment can occur with excessive corrosion. Clogging restrictions in pipes due to excessive scaling can result in reduced flows, increased back pressures, or reduced heater efficiency.

The formula with cyanuric acid present is SI = pH + TF + CF + AF – CYA Factor - 12.1, or, Saturation Index = pH + Temperature Factor (TF) + Calcium Hardness Factor (CF) + Total Alkalinity Factor (AF) minus cyanuric acid correction factor (at current pH) minus 12.1. The 12.1 is a constant applied for Total Dissolved Solids between 0 and 1,000 ppm. When TDS is greater than 1,000 ppm, use the Table shown in Figure 11.3. The TF, CF and AF are factors based on the temperature, Total Alkalinity and Calcium Hardness levels in the water and are shown in Figure 11.4. The A result of between -0.3 and +0.5 indicates balanced water. The first step in properly balancing water is, knowing how to test the water. Once the test procedures are properly performed it is necessary to know how to read the data and treat the water accordingly. Tests for pH, alkalinity, water hardness, mineral content, and sanitizer levels must be performed on a regular basis. In order to combat the effects of bacteria, improper mineral levels, wrong pH levels, and poor sanitizer levels the person who is monitoring the pool water should know what treatment must be provided to correct the problems).

TDS	Factor
<1,000	12.10
1,000	12.19
2,000	12.29
3,000	12.35
4,000	12.41
5,000	12.44

Figure 11.4 – Factor conversions for elevated TDS levels.

Temperature		Total Alkalinity†		Calcium Hardness	
°F	TF	ppm	AF	ppm	CF
32	0.0	25	1.4	25	1.0
37	0.1	50	1.7	50	1.3
46	0.2	75	1.9	75	1.5
53	0.3	100	2.0	100	1.6
60	0.4	125	2.1	125	1.7
66	0.5	150	2.2	150	1.8
76	0.6	200	2.3	200	1.9
84	0.7	250	2.4	250	2.0
94	0.8	300	2.5	300	2.1
105	0.9	400	2.6	400	2.2
		800	2.9	800	2.5

Use the reading closest to your actual reading in choosing the factor.

† Total alkalinity in this context refers to the total of carbonate and bicarbonate alkalinity. If cyanuric acid is used, a correction factor must be used. Please refer to the table in Figure 11.6 for those values.

Source: ANSI/APSP-11 2009

Figure 11.5 – Conversion factors for Temperature, Total Alkalinity and Calcium Hardness when using the Langelier Saturation Index (LSI).

CHEMICAL	MINIMUM	IDEAL	MAXIMUM
Chlorine (Free Available Chlorine)	1 ppm (0.001 ml/L)	2 – 3 ppm (0.002 – 0.003 ml/L)	4 ppm (0.004 ml/L)
Cyanuric Acid	25 ppm (0.025 ml/L)	30 – 50 ppm (0.030 – 0.050 ml/L)	100 ppm (0.1 ppm)
Bromine	1 ppm (0.001 ml/L) for pools 2 ppm (0.002ml/L) for spas	3 – 4 ppm (0.003 – 0.004 ml/L) for pools 4 – 6 ppm (0.004 – 0.006 ml/L) for spas	5 ppm (0.005 ml/L) for pools 6 ppm (0.006 ml/L) for spas
Total Alkalinity	60 ppm (0.06 ml/L)	80 – 100 ppm (0.08 – 0.1 ml/L)	180 ppm (0.18 ml/L)
Calcium Hardness	150 ppm (0.15 ml/L) as $CaCO_3$	200 – 400 ppm (0.2 – 0.4 ml/L) as $CaCO_3$	1000 ppm 1.0 ml/L) as $CaCO_3$

Figure 11.6 – Figure 11.6 - Correction factor for cyanuric acid (if present in water)[5].

For example: The Langelier Saturation Index of pool water (without cyanuric acid correction factor) with a pH of 7.6, a temperature of 81°F (TF), Total Alkalinity (AF) of 100, and Calcium Hardness (CF) of 400, and a TDS of 850 is calculated as SI = 7.6 + 0.7 + 2.0 + 2.2 – 12.1 = 0.4.

The same formula and input values with a cyanuric acid correction factor of 0.27 would be: 7.6+0.7+2.0+2.2-0.27-12.1=0.13.

It should be noted that it is possible to have an ideal LSI and still have pool water that is corrosive or scaling. Each of the levels affecting pool water chemistry must be maintained within ideal ranges. For instance, an LSI which calculates as SI = 8.1 + 0.7 + 2.0 + 1.3 – 12.1 = 0.00 which states that the LSI is very good but the pH is high. In this state, the high pH can have a corrosive effect on cement based products if the calcium level is low.

Once water chemistry is balanced, it can be lost within 24 hours. Maintaining proper water balance requires constant monitoring, testing and chemical additions. Unfortunately, water chemistry balance is not as easy as adding one pound of treatment every other day; it requires knowledge, good record-keeping, patience, and dedication to keep the pool functioning properly and the users of the pool safe.

Mineral Balance – When discussing minerals in water chemistry the reference is usually to the presence of copper, iron, calcium, manganese, and magnesium, as well as various other minerals. Water is a solvent, in fact, it is often referred to as the universal solvent. As a solvent, when water chemistry is out of balance, water will dissolve any metallic material that it comes in contact with to satisfy its own needs for certain minerals and to achieve saturation point. After achieving saturation point, water will rid itself of any excess dissolved material (known as the precipitation point of water). In fact, water has the ability to dissolve, corrode, stain, scale, or calcify any surface in your pool in which the water comes in contact. This list of surfaces includes walls, floors, ladders, hand rails, light fixtures, internal pump and filter parts, grout, adhesives, and stone. The fact that water is volatile and must be kept under close supervision is critical to the long term performance of any pool system. The effects of improper mineral (metal) balance can also lead to colored water, stains and the formation of scale.

Measurement of pool chemicals and minerals utilize parts per million (PPM) as their reading , and pH is measured using the pH scale.

CHEMICAL	MINIMUM	IDEAL	MAXIMUM
Chlorine (Free Available Chlorine)	1 ppm (0.001 ml/L)	2 – 3 ppm (0.002 – 0.003 ml/L)	4 ppm (0.004 ml/L)
Cyanuric Acid	25 ppm (0.025 ml/L)	30 – 50 ppm (0.030 – 0.050 ml/L)	100 ppm (0.1 ppm)
Bromine	1 ppm (0.001 ml/L) for pools 2 ppm (0.002ml/L) for spas	3 – 4 ppm (0.003 – 0.004 ml/L) for pools 4 – 6 ppm (0.004 – 0.006 ml/L) for spas	5 ppm (0.005 ml/L) for pools 6 ppm (0.006 ml/L) for spas
Total Alkalinity	60 ppm (0.06 ml/L)	80 – 100 ppm (0.08 – 0.1 ml/L)	180 ppm (0.18 ml/L)
Calcium Hardness	150 ppm (0.15 ml/L) as $CaCO_3$	200 – 400 ppm (0.2 – 0.4 ml/L) as $CaCO_3$	1000 ppm 1.0 ml/L) as $CaCO_3$
pH	7.2	7.4 – 7.6	7.8

Figure 11.7 – Ideal PPM (parts per million) Readings for Successful Pool Water Chemistry (ANSI/APSP-112009).

11.4 Pool Water Chemistry and How It Affects Tile or Stone Installations

Maintaining pool water chemistry at proper levels is extremely important, not only to the owner and users of the pool, but also to the tile or stone installation or plaster located in the pool. Pool water which is out of balance can be unhealthy, unsightly, as well as time consuming and expensive to correct.

Correcting any problems with pool chemistry can actually take the pool out of use for a period of time until the proper balance is achieved to ensure the safety and well being of the pool users.

Tile and stone installations may also be affected by the pool chemistry. A big difference between correcting the pool water chemistry and fixing the tile or stone installation is how long the pool may be out of commission to make repairs. Let's look at how pool water chemistry can cause problems with a tile or stone installation;

The pH of pool water should be between 7.2 and 7.8 on the pH scale. If the pH level gets too low then any cementitious material within the pool can be affected. Portland cement is reactive when exposed to acids and this exposure can have a deteriorating affect on the concrete or cement based product (e.g. grout, plaster, gunite). While the level of acidity is usually not very strong, there can be cumulative effects if the problem is not treated promptly or repeats over periods of time. If the pH of the pool is too low (acidic) the effects on the tile or stone installation can be;

- Etched Cement Based Grout or Plaster
- Cement Based Grout or Plaster Erosion
- Blotchy Cement Based Grout or Plaster
- Fading Cement Based Grout Color
- Calcite Loss in Marble and Limestone (Loss of Stone Surface Material)
- Calcium Loss in Portland Cement Based Installation Materials Which Can Lead to Weakening and Erosion of Materials
- Stains on Horizontal Grout or Plaster

If the pH of the pool water gets too high (alkaline) the effects on the tile or stone installation can be;

- Scale Formation on Pool Walls and Floor
- Greater Potential for Algae Growth

If the Total Alkalinity and/or Total Hardness of the pool water get outside of their specific ranges there could be an effect on a tile or stone installation. If the Alkalinity or Hardness gets too low the effects on tile or stone can be;

- Staining and Etching of Cement Based Grout or Plaster
- Stains (in the Stone and/or Grout) Caused by Dissolving Metallic Components of the Pool

A problem resulting from Alkalinity and/or Total Hardness of the pool water being too high can lead to this effect on the tile or stone installations;

- Scale formation on pool walls and floors

Pool water balance issues are very common in public pools and water features. The use of epoxy based grouts and setting material is a great choice to help overcome some of these potential issues. Epoxy materials are typically not affected by the etching or erosion problems inherent in cement based products by pH, alkalinity and hardness imbalance. LATICRETE recommends the use of SPECTRALOCK® PRO Premium Grout† for all submerged pool, fountain, spa, or water feature installations. SPECTRALOCK PRO Premium Grout utilizes non-pigmented technology which means that the grout will not become blotchy or fade due to imbalanced pool water chemistry.

LATAPOXY® 300 Adhesive will provide the ultimate in adhesive performance in submerged installations. Providing incredible bond strength and high chemical resistance, LATAPOXY 300 Adhesive is the product of choice for installations in pools and spas with steel or fiberglass shells.

11.5 Tile Installation Maintenance and Repairs

It will be necessary, from time to time, to inspect the pool for possible problems with plumbing, lighting, fixtures, tile or stone, and fittings/connections. Improper water balance and exposure to chemicals can lead to potential problems with these installations so routine inspection is required. During some of these inspections, repairs and water balancing treatments it will be necessary to drain the pool.

Replacing tile, stone or grout should only be attempted when a pool is drained and sufficiently dry to accept a tile or stone installation. There should be no repairs or replacement attempted while submerged. To replace any tile, stone or grout in a pool, fountain, water feature or spa the use of any of the LATICRETE materials listed in Section 7 can be used for the particular substrate in question.

Proper maintenance of pool water chemistry will help to prevent problems and limit the down time of the swimming pool, fountain, spa, or water feature.

Unless otherwise noted, much of the information used in this section was excerpted from ANSI/APSP-11 2009, ANSI/NSPI-1 2003, and www.poolmanual.com.

1. Spring Pool Openings, Retrieved on September 24, 2008 from www.poolcenter.com.

2. Fall Pool Closings, Retrieved on September 24, 2008 from www.poolcenter.com.

3. Water Balancing, Retrieved on September 24, 2008 from www.poolcenter.com.

4. Benefits of Salt Water Pools, Retrieved on March 14, 2007 from www.poolcenter.com.

5. Correction factor for cyanuric acid on November 16, 2016 from blog.orendatech.com/langelier-saturation-index.

† United States Patent No.: 6881768 (and other Patents).

Section 12: Troubleshooting and Case Study

Section 12 – Troubleshooting and Case Study

This section will cover some of the most common installation issues and pitfalls surrounding swimming pool, fountain and spa applications. In contrast, the case study will highlight and stress the critical aspects of a tile or stone installation in wet area applications.

12.1 Troubleshooting Pictorial

Figure 12.1 – Exterior applications must be protected from the elements during the installation and installation materials cure periods. A temporary tent was erected over this swimming pool to protect the application from direct sunlight, wind and rain.

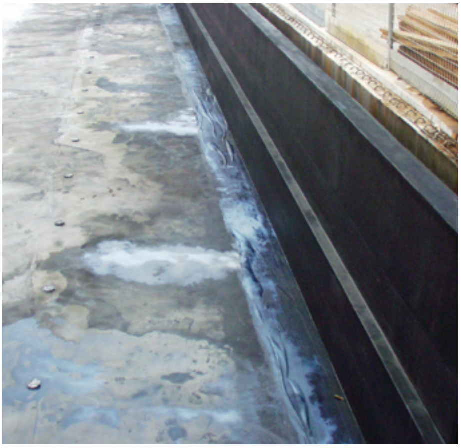


Figure 12.2 – Effects of exposure to rain prior to the waterproofing membrane reaching its full cure. This damaged waterproofing membrane will need to be removed, reinstalled, protected and allowed to reach its full cure.

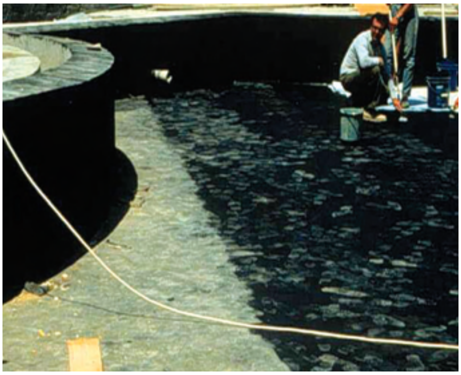


Figure 12.3 – Once the waterproofing membrane is applied, it should be protected from traffic and work from other trades.

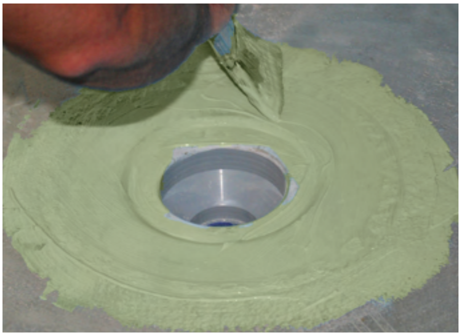


Figure 12.4 – The liquid applied waterproofing membrane must be flashed into a two part clamping style drain to create a watertight seal.

Figure 12.5 – Steel pool tank. Porcelain mosaic tiles are installed with a 100% solids epoxy thin set mortar adhesive (e.g. LATAPOXY® 300 Epoxy Adhesive) to achieve a suitable bond to the steel tank assembly.

Figure 12.6 – The increased use of prefabricated tubs (e.g. fiberglass or stainless steel) requires the use of a 100% solids epoxy adhesive (e.g. LATAPOXY 300 Adhesive). In this instance, a typical latex fortified portland cement based thin set mortar was used over a fiberglass tub that resulted in bond failure.

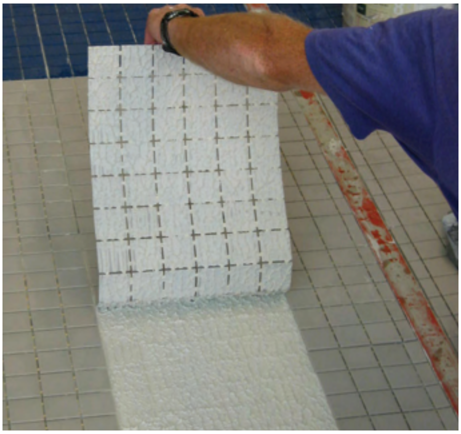


Figure 12.7 – Porcelain mosaic tiles installed on pool deck. Notice the ribbons of latex fortified thin set mortar combed in one direction to maximize coverage.

Figure 12.8 – Only enough latex fortified portland cement thin set mortar is spread to allow the installation of the porcelain mosaics within the mortar's typical open time – generally 15 minutes at 70°F (21°C).

Figure 12.9 – It is good practice to periodically lift / remove freshly installed tiles or stones to verify that a minimum 95% continuous adhesive mortar is achieved. If the desired coverage is not achieved, use a larger trowel to dispense adequate adhesive mortar and beat-in the tiles correctly to achieve the desired results.

Figure 12.10 – The effects of a mesh mounted glass tile utilizing an adhesive and mesh that are not suitable for continuous submersion. The adhesive has expanded and lost bond to the back of the tiles.

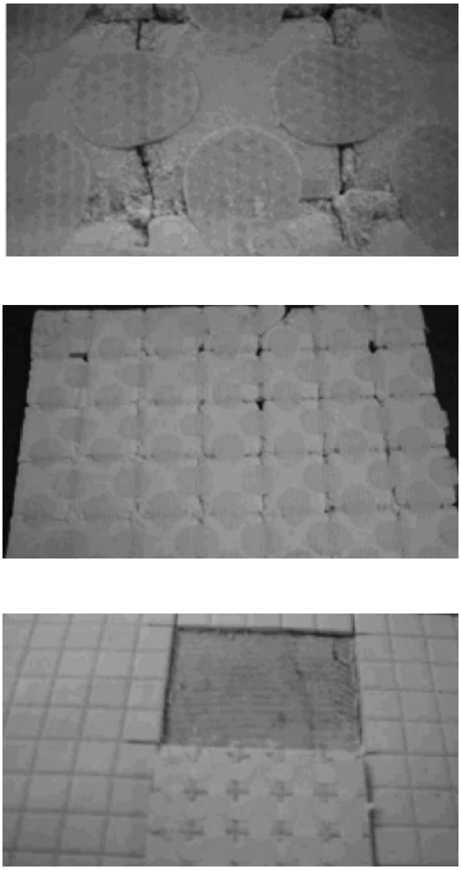


Figure 12.11 – Large PVC dots on rear/edge mounted porcelain mosaic tiles can lead to bonding issues as is evidenced from these photos. Latex fortified portland cement based thin set mortars may have a difficult time achieving a sufficient bond to the PVC rubber. The PVC dots are covering 50 – 60% of the tile back. An epoxy adhesive may be required to install tile mounted in this fashion in wet area and continuous submersion applications.

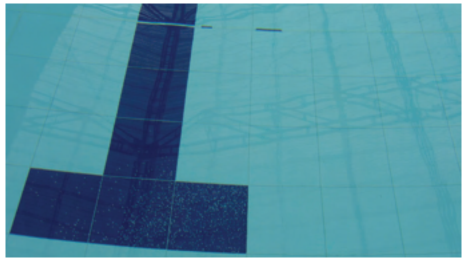


Figure 12.12 – Sealant in the movement joint is missing. In order for the sealant to maintain its functional ability, the joint must be correctly designed. Namely:

1. The joint depth must be at least 1/2 the width of the joint. Therefore, if a joint is 1/2" (12 mm) wide, the joint depth must be at least 1/4" (6 mm).
2. Closed cell polyurethane backer rod should be used in joints with sufficient depth. The backer rod must fit neatly into the joint without compacting. Bond breaker tape can be used in joints that will not allow the use of backer rod.
3. Sealant primer is generally used in wet area applications. Use non-solvent based primers.
4. The sealant and primer must be suitable for wet area applications and must not bond to the backup materials.
5. Use a class 25 sealant. This is a sealant that can withstand an increase and decrease of +/-25% of joint width.
6. Joint flanks (tile edges) to which the sealant will bond, must be kept clean and dry.
7. According to the Tile Council of North America's Movement Joints – Vertical and Horizontal Detail EJ-171, typical wet area movement joints should be spaced every 8 – 12' (2.6 – 4 m) in each direction and against all restraining surfaces. Movement joints that are 8' (2.6 m) on center should be a minimum of 3/8" (9 mm) wide and joints that 12' (4 m) on center should be a minimum of 1/2" (12 mm) wide.

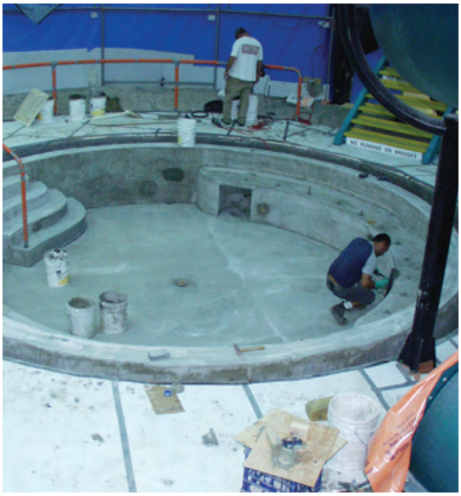
Figure 12.13 – Efflorescence becomes apparent in this baptismal font once the water is drained. When the vessel is full of water, the efflorescence remains in solution and is not visible. However, upon draining the water, the soluble salts crystallize and manifests as efflorescence. Proper attention to negative side vapor retarder placement is critical in wet applications. The proper placement and use of a suitable vapor retarder behind the concrete wall assembly would have minimized this unsightly issue.

Figure 12.14 – Notice the difference in color between the tile and grout above the water line and below the water line. This condition is typical because cement-based grout absorbs water and creates the darker look at the water line. Expectations should be managed accordingly.

Figure 12.15 – Erosion of grout joints is the diagnosis on this application. Possible causes are as follows:

1. Premature exposure to water or filling the vessel with water prior to the grout reaching its full cure (typically 14 days 70°F (21°C) if a latex fortified portland cement based grout is used or 10 days if an epoxy based grout is used.
2. Poor pool water maintenance. Improper balance of pool water pH, alkalinity and water hardness can all lead to this condition. Refer to section 11 for more information.
3. Edge mounted PVC dots that do not allow sufficient grout joint depth.
4. Insufficient packing of the joints during installation (e.g. bridging joints).

12.2 Case Study – Australian Pool Project

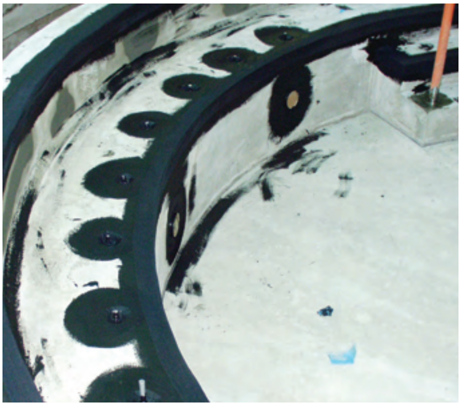


Case Study 1 – Concrete Pool Structure is being prepared to receive the tile finish. Examination of the concrete shell is made to evaluate and determine if leveling / preparation is required. The concrete shell is scheduled to receive a waterproofing membrane and subsequent porcelain tile finish. The concrete will require preparation prior to the installation of these materials. Notice the tile mechanic as he floats and shapes the contour of the pool utilizing templates, floats and screeds to achieve the desired form and height of the renders and mortar beds.

Case Study 2 – Mechanic is using a wooden template to shape and screed the swale in the water feature tank. Latex fortified portland cement mortars and renders are used for this purpose.

Skilled mechanics determine and set finished tile heights, spots, and intersections using lasers, levels and site line builder's transit levels.

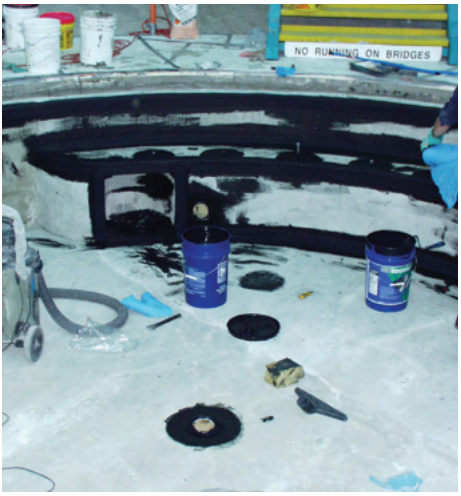
Case Study 3 – The use of a LATICRETE® liquid latex fortified portland cement based leveling mortar is used to correct any irregularities in the concrete shell. Proper surface preparation will result in an aesthetically pleasing tile or stone finish.



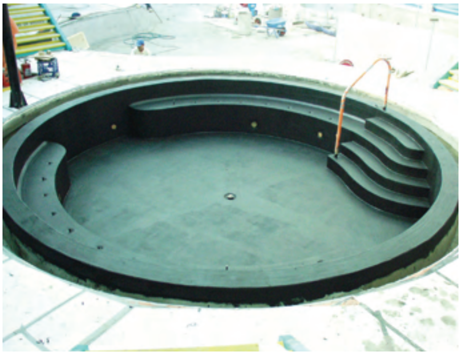
Case Study 4 – Once the concrete shell is prepared, it is now ready to receive the waterproofing membrane. The leveling mortars are typically allowed to cure 48 to 72 hours at 70°F (21°C) prior to the installation of the waterproofing membrane. The penetrations, drains, lights, windows, pipes, etc… are prepared first. In this instance 9235 Waterproofing Membrane, the gold standard in waterproofing membranes for tile and stone installations, is being used. The liquid component and fabric is used to first treat these areas.

Case Study 5 – Coves, corners, and any changes of plane are also pretreated.

Case Study 6 – Movement joints are also included in the pre-treated areas. The waterproofing membrane is looped down into the movement joint (to accommodate any potential movement). The waterproofing membrane must be given enough "slack" when looped into the joint to accommodate the anticipated movement. The waterproofing membrane is then lapped onto the concrete / mortar bed joint flanks and horizontal areas by at least 2 – 4" (50 – 100 mm) to receive the main waterproofing membrane treatment.



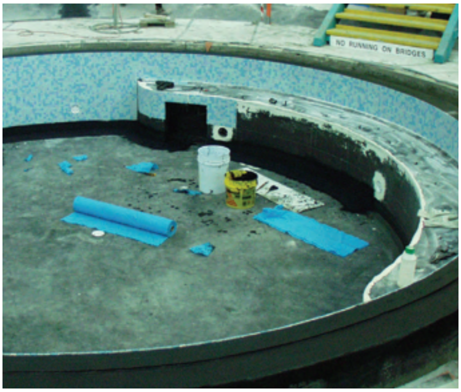
Case Study 7 – Once the pre-treated areas are dry, the main membrane application can commence. Notice how the fabric component is pre-cut in order to be placed quickly into the freshly applied liquid component. Generally, the waterproofing membrane is overlapped by a minimum of 2" (50 mm) onto adjacent areas. A vacuum cleaner is used to ensure that the concrete is cleaned of any dust or debris prior to the application of the waterproofing membrane. The concrete is then dampened with a sponge and clean water in an effort to reduce the suction effect of the concrete and allow the membrane to remain workable for an extended period of time.



Case Study 8 – The waterproofing installation is complete. The waterproofing membrane must be allowed to fully cure prior to the flood test. Full cure rates will vary by product type. Consult with the waterproofing manufacturer for full details.

Case Study 9 – The penetrations are sealed with a suitable flexible sealant. Generally, 100% silicone sealant (e.g. Latasil™ with 9118 Primer) or urethane sealant with non-solvent based primers can be used. All precautions to create a complete watertight tank must be taken to ensure a successful flood test.

Case Study 10 – The swimming pool is now in the flood test stage. The waterproofing membrane must be allowed to reach its full cure prior to flood testing. Full cure will vary by manufacturer and product type. The pool is filled at a rate of 1" (25 mm) per hour. Generally the water level will be continually monitored during the length of the flood test (typically 24 - 72 hours) to determine a vessel's 'water-tightness'. The water is then drained at a rate of 1" (25 mm) per hour.



Case Study 11 – The tile installation can now begin. Generally, work begins on the vertical areas first. A high strength liquid latex fortified thin set mortar (e.g. 257 Titanium) suitable for submerged applications is used. Care is required when working over the waterproofing membrane.

Case Study 12 – The installation of the tile in the horizontal areas is now complete. Once the tiles are installed and grouted; the installation must cure for a full 14 days after the final grouting period at 70°F (21°C) if a latex fortified portland cement based grout (e.g. PERMACOLOR™ Select Grout) is used or 10 days if an epoxy based grout (e.g. SPECTRALOCK® PRO Premium Grout*) is used.

After the installation materials have fully cured, the water feature can be filled with water. Use the same water fill and drain rate of 1" (25 mm) per hour whenever a tiled water feature is filled and drained.

Case Study 13 – The pool in its finished state and ready for the crowds.

* United States Patent No.: 6881768 (and other Patents).

Section 13: Appendix and Glossary

13.1 FAQs (Frequently Asked Questions)

To view the FAQS of LATICRETE, please visit our FAQs page on the LACTICRETE Website here.

13.2 Glossary[1]

ABRASION HAZARD – A surface that presents an unreasonable risk of irritation to the skin upon contact.

ACCESSIBLE – Designed to include physically challenged users.

ACID – A liquid or dry chemical used to lower the pH and/or alkalinity of pool or spa water.

ACIDIC – Having a pH below 7.0. Opposite of base.

ACID WASH – A procedure using an acid solution to clean the interior surface of a pool, with subsequent neutralization of the acid.

ACTION POOL – A wave pool that generates standing waves in an assortment of patterns.

ACTIVATED CARBON – A charcoal-like material used to remove colors, odors and/or excess oxidizer from water.

ACTIVITY POOL – A pool designed primarily for play activity that uses constructed features and devices, including lily pad walks, flotation devices, small slides and similar attractions.

ADMIXTURE – A material other than water, aggregates or hydraulic cement which is used as an ingredient of grout or mortar and which is added immediately before or during it's mixing.

AF – Abbreviation for the alkalinity factor in calculating the saturation index of water.

AGGLOMERATE TILE – A man-made stone product generally consisting of either crushed marble, granite or quartz chips with a matrix of resins and mineral pigments.

AGGRESSIVE WATER – Water that is corrosive because it is low in pH and/or calcium hardness and/or total alkalinity.

AIR CHANNEL – A system for introducing a volume of air into hollow ducting built into a spa floor, bench or other location, activated by a separate air power unit (blower).

AIR CONTROL – A means for spas and hot tubs to regulate air flow in the air induction system, thereby increasing or decreasing hydrotherapy action.

AIR INDUCTION SYSTEM – A plumbing system that provides the source of air for the air/water mixture to a hydrotherapy jet.

AIR PUMP ASSIST BACKWASH – The compression of a volume of air in the filter chamber (by means of an air compressor) which, when released, rapidly decompresses and forces water through the filter chamber elements in reverse. This dislodges the filter aid and accumulated dirt, allowing it to be carried to waste.

AIR SWITCH SYSTEM – An isolated device that sends a pulse of air down a tube to remotely operate electrical equipment.

ALGAE – Microscopic plant-like organisms that contain chlorophyll.

ALGAECIDE (Also Spelled Algicide) – Any chemical or material that kills algae.

ALGISTAT – Any substance or agent that inhibits the growth of algae.

ALKALI – A term applied to bases, usually carbonates and hydroxides, which raise the pH and alkalinity when added to water.

ALKALINE – Having a pH above 7.0.

ALKALINITY – see Total Alkalinity.

ALKALINITY FACTOR (AF) – Used to calculate the Saturation Index of water.

ALUM (Aluminum Sulfates) – A compound used to cause suspended solids in water to form filterable masses (flocculate).

AMPHOTERIC – Having the ability to serve as either an acid or a base.

ANCILLARY FACILITY – An area used in conjunction with a pool, such as a public locker, shower, bathroom or dressing area; equipment room; pool deck; or building space intended to be used by pool users.

ANTIVORTEX DRAIN COVER (Antivortex Plate or Cover) – A plate or cover that is affixed to the main outlet of a swimming pool or spa to prevent a vortex from forming as water passes through to the main outlet.

AVAILABLE CHLORINE – A rating of a chemical's total chlorine content, based on a comparison to elemental (gaseous) chlorine having 100 percent available chlorine.

BACK-BUTTER – The spreading of a bond coat to the back of tile or stone just before it is placed to improve coverage of the mortar.

BACK PRESSURE – Resistance to flow, normally expressed in pounds per square inch (kilograms per square centimeter).

BACTERIA – Single-celled microorganisms of various forms, some of which cause infections or disease.

BACTERICIDE – Any chemical that kills bacteria.

BACKWASH – The process of cleansing the filter medium and/or elements by the reverse flow of water through the filter.

BACKWASH CYCLE – The time required to backwash the filter medium and/or elements and to remove debris in the filter vessel.

BACKWASH RATE – The rate of flow water through the filter medium per unit of area (U.S. gallons per minute per square foot).

BALANCE – In pools and spas, refers to a condition of the water that is neither scaling nor corrosive.

BALL VALVE – A device that can partially or totally obstruct the flow of water, using a ball shaped diverter.

BARRIER – A means to limit, delay or restrict access to a pool, spa or hot tub (refer to ANSI/ NSPI-8 Model Barrier Code for Residential Swimming Pools, Spas and Hot Tubs).

BASE – A chemical used to raise the pH and/or total alkalinity of pool or spa water. Opposite of acid.

BASE DEMAND – A measure of the amount of alkaline material required to raise the pH to a predetermined level. This can be accomplished by use of a base demand test, whereby a standard base is added by drops to the pH test solution until the desired pH is reached.

BASIC – Having a pH above 7.0. Opposite of acidic.

BATHER – Any person using a pool, spa or hot tub and adjoining deck area for the purpose of water sports, recreation, therapy or related activities. Also user.

BATHER LOAD— See USER LOAD.

BEACH ENTRY or ZERO ENTRY – A sloping entry starting above the waterline at deck level and ending below the waterline in a pool or spa. (Does not refer to sand only.)

BEGINNER'S AREA – In a pool, a water area that is three feet or less in depth.

BLEACH (Sodium Hypochlorite) – Also called liquid chlorine. A chlorine source typically having between 5- and 16 percent available chlorine.

BODY COAT – A layer of diatomaceous earth or similar material on a filter element that acts as the filtering medium.

BODY FEED – A controlled amount of diatomaceous earth that is continuously added to the filter element during the course of a filter run to help maintain filter porosity.

BOND COAT – A material used between the back of the tile or stone and the properly prepared substrate.

BOND STRENGTH – A bond coat's ability to resist separating from the tile and setting bed, usually measured in pounds per square inch (psi).

BOOSTER PUMP SYSTEM – A pump that is completely independent of the filtration and heating system, used to provide support for hydrotherapy jets, cleaning systems and gas chlorinators or special water features.

BREAK IN GRADE – Occurs when the slope of a pool floor changes to a greater slope.

BREAKPOINT CHLORINATION – The practice of adding a sufficient amount of chlorine to water to destroy the combined inorganic chlorine present. Normally, the amount added is 10 times the combined chlorine concentration.

BRIDGING— Build up of body coat on diatomaceous earth filter elements to the point that the body coats of two adjacent elements touch.

BROADCAST – A method of applying chemicals to a pool or spa by spreading them uniformly over the water surface.

BROMIDE – A salt that contains a bromide ion. Bromide becomes hypobromous acid when reacted with oxidizers such chlorine, ozone or monopersulfates.

BROMINE – One of several chemicals that yield hypobromous acid when added to water.

BROMINE FEEDER – A device used to add or deliver bromine disinfectant at a controlled rate.

BTU (British Thermal Unit) – A unit of measurement used to define the capabilities of heaters. One BTU is capable of raising the temperature of one pound of water by 1°F (one liter of water by 1.2°C).

BUFFER – Any chemical that, when dissolved in water, will resist pH change. Also any chemical solution used to calibrate pH instruments.

BYPASS VALVE – A valve used to limit or adjust the amount of water flowing through a device in a bypass loop to divert flow to an alternate plumbing path.

CALCIFICATION – Formation of calcium carbonate on walls of pools or pipes, or in a filter or heater, due to precipitation of calcium carbonate.

CALCIUM CARBONATE – Insoluble calcium compound that is the major component of calcium scale. Also, a substance found in nature as limestone or marble.

CALCIUM CHLORIDE – A soluble white salt containing calcium ions and chloride ions, used to raise the calcium hardness of pool and spa water.

CALCIUM HARDNESS – A measure of the amount of calcium dissolved in water and expressed in parts per million (ppm) or mg/l as calcium carbonate.

CALCIUM HYPOCHLORITE – A solid white form of inorganic chlorine found in both granular and tablet forms (65–75% available chlorine). Because it is an alkaline compound, it will raise the pH of pool and spa water.

CARBON DIOXIDE – Common gas found in the air. Can be used to lower pH in a pool.

CARDIOPULMONARY RESUSCITATION (CPR) – A lifesaving technique involving both chest compressions to circulate blood and mouth-to-mouth breathing to restart a non-beating heart.

CARTRIDGE – A replaceable, porous element designed to retain suspended particles from water.

CARTRIDGE FILTER – A filter that uses a porous element to act as a filter medium.

CATCH POOL – A pool or designated section of a pool used as a terminus for water-slide flumes.

CAUSTIC – Sodium hydroxide, lye. In pools, an extremely high pH alkalizer. Generally refers to high pH.

CAUTION (Signal Word) – Indicates a potentially hazardous situation that, if not avoided, could result in minor or moderate injury. May also be used to alert against unsafe practices. (Reference ANSI Z535 Series of Standards for Safety Signs and Colors.)

CAVITATION – The formation of partial vacuums when pump capacity exceeds the water replacement supply.

CEMENT GROUT – A cementitious mixture of cement, sand or other ingredients and water or latex additive to produce a water-resistant, uniformly colored material to fill the joints of tile.

CENTRIFUGAL FORCE – The outward force exhibited by a circular motion.

CENTRIFUGAL PUMP – A pump that circulates water using a shaft-mounted impeller powered by an electric motor or gasoline engine. The centrifugal force of the spinning impeller creates the flow through the pump.

CF – Abbreviation for the calcium hardness factor in calculating the saturation index of water.

CHANNELIZATION – The undesirable process whereby filter sand is permeated by tubes or channels of calcified or oily material, allowing water to pass freely, without filtration.

CHECK VALVE – A valve allowing flow in one direction and obstructing flow in the other.

CHECKS (Surface) – Spider-web patterns in a surface that do not go all the way through; not an open crack.

CHELATING AGENT – A chemical used to bind (sequester) metals dissolved in water, to prevent them from precipitating and staining pool surfaces.

CHEMICAL FEED RATE INDICATOR – A mechanism that indicates units (weight or volume) of chemical being dispensed. May require a direct reading or the use of a reference chart.

CHEMICAL FEEDER – A device (floating or mechanical) used to add a chemical to pool/ spa water.

CHEMICAL FEEDER OUTPUT RATE – The weight or volume of active ingredients delivered by a chemical feeder, expressed in units of time.

CHEMICAL RESISTANCE – The resistance offered by products to physical or chemical reactions as a result of contact with or immersion in various solvents, acids, alkalis, salts, etc…

CHILDREN'S POOL/RIDE – A ride, flume ride or other slide attraction at a water theme park, designed primarily for the use of small children.

CHLORAMINE – A compound formed when chlorine combines with nitrogen-containing compounds, e.g., perspiration, ammonia. These compounds can cause eye and skin irritation, and have strong objectionable odors and very low sanitizing capability.

CHLORINATOR – A device used to add or deliver a chlorine disinfectant at a controllable rate. Chlorinators are designed for specific chlorine compounds and should only be used with the compounds for which they are designed.

CHLORINE – A chemical element that exists as a gas in its elemental form, or as a part of a chemical compound. Used as an oxidant and biocidal agent to disinfect pool and spa water.

CHLORINE DEMAND – The amount of chlorine necessary to oxidize all organic matter present in pool water at any given moment, or over a period of time.

CHLORINATED ISOCYANURATES (ISOS) – Sanitizer products that are self-stabilizing due to release of free available chlorine and cyanuric acid when they dissolve.

CHLORINE NEUTRALIZER – A chemical compound used to reduce chlorine in water, most commonly sodium thiosulfate.

CHLORINE RESIDUAL – The amount of available chlorine remaining in water after the chlorine demand has been satisfied.

CIRCUIT BREAKER – A device designed to open and close an electrical circuit manually, and to open a circuit automatically at a predetermined over-current level, thus providing protection to the wiring and electrical components.

CIRCULATION EQUIPMENT – The components of a circulation system.

CIRCULATION SYSTEM – A system of mechanical equipment and/or components designed to ensure even distribution of heat, chemicals and filtration of water throughout a pool. Includes filters, heaters, pumps, chlorinators, piping, inlets, drains, skimmers and other devices.

CLARIFIER – A chemical that coagulates and neutralizes suspended particles in water. See coagulant or flocculant.

CLARITY – The degree of transparency of pool water. Characterized by the ease with which an object can be seen through a given depth of water.

COAGULANT – A chemical, usually alum, used in pools to gather and precipitate suspended matter.

COAGULATE – To collect, via a chemical compound, suspended matter in pool, spa or hot tub water.

COEFFICIENT OF FRICTION (COF) – The measurement of a tile's frictional resistance, closely related to traction and slipperiness.

COLD JOINT – Any point in concrete construction where a pour was terminated and the surface lost its plasticity before work was continued.

COLLECTOR (SOLAR) – An assembly of components used to collect solar energy for heating.

COMBINED CHLORINE – The portion of the total chlorine in chemical combination with ammonia, nitrogen and/or organic compounds; mostly composed of chloramines.

COMMERCIAL/PUBLIC POOL – Any pool, other than a residential pool, that is intended to be used for swimming or bathing and is operated by an owner, lessee, operator, licensee, or concessionaire (regardless of whether a fee is charged or not). See ANSI/NSPI-1 for classifications.

COMPRESSIVE STRENGTH – A material's ability to withstand a load in compression.

CONCRETE SHELL – Various forms of concrete which, together with steel, form the structure of a pool or spa shell.

CONTACT CONCENTRATION – The concentration of a chemical flow of water. Depends on the rate of addition, the flow rate of the water and the efficiency of the mixing.

CONTAMINANT – An undesirable organic or inorganic, soluble or insoluble substance in water, including microbiological organisms. Examples: dirt, body oil, algae.

COPING – The cap on the wall that provides a finishing edge around a pool/spa often finished with tile or stone. Can be formed, cast in place, precast or prefabricated from metal or plastic materials, brick or stone. May be used as part of the system that secures a vinyl liner to the top of the pool wall.

CORROSION – The etching, pitting or eating away of a material.

COVE – The radius that joins the floor and wall of a pool/spa.

COVER – Something that covers, protects or shelters a pool, spa or hot tub.

Safety Cover – As defined by ASTM F1346 "Emergency Standard Performance Specification for Safety Covers and Labeling Requirements for All Covers for Swimming Pools, Spas and Hot Tubs." It is a barrier (intended to be completely removed before entry of users) for swimming pools, spas, hot tubs or wading pools, attendant appliances and/or anchoring mechanisms that will – when properly labeled, installed, used and maintained in accordance with the manufacturer's published instructions – reduce the drowning risk for children under 5 years of age. Specifically, safety covers are meant to inhibit small children's access to the water and to provide for the removal of any substantially hazardous level of collected surface water. (These covers may be powered or manual.)

Solar Cover – A cover that, when placed on a pool or spa surface, increases the water temperature by solar activity and reduces evaporation.

Thermal Cover – An insulating cover used to prevent evaporation and heat loss from a pool or spa.

Winter Cover – A cover that is secured around the perimeter of a pool or spa that provides a barrier to debris when the pool or spa is closed for the season.

CRACK (Surface) – A repairable break in the surface; not major, not self-curing.

CRACK (Structural) – A break or split that weakens the structural integrity of the pool.

CROSS CONNECTION – An unprotected connection involving a domestic water supply and pool water, or other non-potable water, where a contamination of the domestic system could occur.

CURING – Maintenance of humidity and temperature of the freshly placed mortar or grout during some definite period following the placing or finishing, assuring acceptable hydration of the cement and proper hardening of the mortar or grout.

CUSHION-EDGED TILE – Tile on which the facial edges have a distinct curvature that results in a slightly recessed joint.

DANGER (Signal Word) – A visual alerting device in the form of a decal, label placard or other marking such as an embossing, stamping, etching or other process. It advises the observer of the nature and degree of the potential hazard(s) that can cause property damage, injury or death. Can also provide safety precautions or evasive actions to take, or other directions to eliminate or reduce the hazard. Aquatic safety signage shall conform to ANSI Z535 specifications.

Signal Word – To convey the gravity of the risk.

Consequences – What will likely happen if a warning is not heeded.

Instructions – Appropriate behavior to reduce or eliminate a hazard.

Danger – Indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

Warning – Indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury.

Caution – Indicates a potentially hazardous situation that, if not avoided, could result in minor or moderate injury. May also be used to alert against unsafe practices.

DECKS – The areas immediately adjacent to or attached to a pool or spa that are specifically constructed or installed for sitting, standing or walking. Generally made of concrete, wood or masonry.

DEEP AREA – Water areas exceeding five feet in depth.

DESIGN RATE OF FLOW – The rate of flow used for design calculations in a system.

DIATOMACEOUS EARTH FILTER – A filter that uses a coating of diatomaceous earth (DE) over a porous fabric as its filter medium.

DIATOMITE – The filtering medium of a diatomaceous earth filter composed of microscopic fossil skeletons of the diatom, a tiny freshwater plankton used to trap solids while allowing clear water to pass through the filter. Also known as diatomaceous earth.

DIATOMITE FILTER ELEMENT – A device used in a filter tank called a filter grid or element, coated with a fabric that traps diatomite on its surface.

DIFFUSER – A pump component that reduces velocity and increases static pressure of fluid passing through a system.

DISCHARGE HEAD – Resistance to water flow encountered on the discharge side of a pump, measured in feet of head. Each foot of water on the suction side of the pump is equal to one foot of head on the discharge side.

DISINFECTANT – Any chemical used to kill undesirable or pathogenic (disease-causing) bacteria.

DISINFECTION – The killing of pathogenic organisms with chemicals or other proven means, such as ozone, copper or silver.

DIVE – A free-fall entry as a planned acrobatic maneuver into the designated diving area of a pool.

DIVING AREA – The area of a swimming pool that is designed to be used for diving.

DIVING BOARD – A flexible board secured at one end to be used for diving.

DIVING EQUIPMENT, COMPETITIVE – Includes competitive diving boards and adjustable fulcrum-setting diving stands intended for competitive diving.

DIVING PLATFORM – A stationary platform designed for diving.

DIVING STAND – Any supporting device for a springboard or diving board.

DOT-MOUNTED TILE – Tile packaged in sheet format and held together by plastic or rubber dots between the joints.

DPD (Diethylphenylene Diamine) – A chemical reagent that specifically measures bromine or free available and total chlorine; produces a series of colors from pale pink to dark red.

DRAFT HOOD – Part of an indoor heater used to vent to the outside to prevent a down draft.

DRY ACID (Sodium Bisulfate) – A granular material used to lower total alkalinity and pH in water.

DRY-SET MORTAR – A mixture of cement with sand and additives imparting water retentivity, often is used as a bond coat for setting tile.

DYNAMIC COEFFICIENT OF FRICTION (DCOF) – The frictional resistance of a person already in motion.

DYNAMIC HEAD – The resistance caused by the friction of the water flowing through an entire circulation system, including the plumbing and equipment and the head pressure measured from the suction and discharge side.

ELBOW – A plumbing fitting shaped at a 90° or 45° angle. Also known as an "ell."

EFFECTIVE FILTER AREA – The total surface area through which designed flow rate will be maintained during filtration.

Cartridge Type – The total effective filter area is the cartridge fabric area that is exposed to the direct flow of water, figured in square footage of fabric. This excludes cartridge ends, seals, supports and other areas where flow is impaired.

Diatomaceous Earth (DE) Type – The actual area of the filter element is the total effective area of the porous fabric septum, less any area of a septum support member greater than 1/4" wide contacting the septum during filtration.

Permanent Medium Type – The effective filter area is the filter surface that is perpendicular to the flow direction.

Sand Filtration Type – The effective filter area is the top surface area of the sand within the filter calculated in square inches or square feet.

EFFECTIVE PARTICLE SIZE – The theoretical size of sieve (in mm) that will pass 10 percent by weight of the sand.

EFFLORESCENCE – The residue deposited on the surface of a material by crystallization of soluble salts present in portland cement.

EFFLUENT – The outflow of water from a filter, pump or pool.

EGRESS – The means of exiting an area.

ELECTROLYTIC CHLORINATOR – A device that converts dissolved chloride salt (sodium chloride) into chlorine and its reaction products.

ENCLOSURE – A fenced-in, secured area.

ENERGY (Electric) – The amount of electricity consumed when power is used over a period of time, measured in kilowatt-hours.

ENTRY POOL – A pool at a water theme park that is provided at the entrance to a water slide or inner-tube ride.

EPOXY ADHESIVE – An adhesive system employing an epoxy resin and hardener.

EPOXY GROUT – A grout system employing an epoxy resin and hardener and powder.

EPOXY MORTAR – A system employing epoxy resins and hardener portions, often containing coarse silica filler and which is usually formulated where high strength is required or industrial and commercial installations where chemical resistance is of paramount importance.

EQUIPMENT AREA – An area used to house recirculation and disinfecting equipment and related appliances.

EROSION – 1. The act of destroying or dissolving by slow disintegration or wearing away. **2.** In an erosion feeder, the way water dissolves the chemical being fed.

EROSION FEEDER – A device that dispenses a sanitizer by directing a flow of water past tables, briquettes or pellets.

ETCHING – Corrosion on the surface; the pitting or eating away of a material such as the surface of plaster (marcite).

EVAPORATION – The conversion of liquid molecules into vapor.

EXPANSIVE SOIL – Clay soil that absorbs moisture and swells, creating the potential for structure damage.

FEET OF HEAD – In a hydraulic system, resistance based on the equivalent height a column of water that causes the same resistance (100' of head equals 43 pounds per square inch). The total dynamic head is the sum of all resistances in a complete operating system.

FENCE – A boundary between a pool/spa area and the outside, intended to deter unauthorized entry from the outside. Not intended as a structural barrier to be sat, walked or climbed on.

FERRIC IRON – Compounds of iron that are insoluble in water and will precipitate.

FERROUS IRON – Compounds of iron that are soluble in water and will impart a clear green color.

FILTER – A vessel that removes undissolved particles from water by recirculating the water through a porous substance (a filter medium or elements).

Cartridge Filter – Uses a porous element that acts as a filter medium.

Diatomaceous Earth Filter – Uses a thin coating of diatomaceous earth (DE) over a porous fabric as its filter medium.

Permanent Medium Filter – Uses a filter medium (sand).

FILTER AGITATION – Mechanical or manual movement to dislodge the filter aid and dirt from the filter element.

FILTER AID – A powder-like substance such as diatomaceous earth or volcanic ash used to coat a septum-type filter.

FILTER CARTRIDGE – A filtering element, usually of fibrous material.

FILTER CYCLE – The operating time between cleaning or backwash cycles.

FILTER ELEMENT – A device within a filter tank designed to entrap solids and conduct water to a manifold, collection header, pipe or similar conduit and return it to the pool, spa or hot tub. A filter element usually consists of a septum and septum support, or a cartridge.

FILTER MEDIUM – A finely graded material (such as sand, diatomaceous earth, polyester fabric, anthracite, etc.) that removes solid particles from water.

FILTER SAND – A hard, silica-like substance free of carbonates or other foreign material and used as the medium in sand filters.

FILTRATION – The process of capturing suspended particles and clarifying water.

FILTRATION FLOW – The design rate of flow, in volume over time (gallons per minute, gallons per hour), through the filter system when installed per the manufacturer's instructions with a new, clean filter medium.

FILTRATION RATE – The rate of water flowing through a filter during a given period of time, expressed in U.S. gallons per minute per square foot of effective filter area. Also known as filtration flow rate.

FLOAT COAT – The final mortar coat over which a skim coat is applied.

FLOAT VALVE – A valve controlled by the level of a fluid.

FLOATING – A method of using a straightedge to align mortar with screeds.

FLOCCULANT (Floc) – A chemical substance or compound that promotes the combination, agglomeration or coagulation of suspended particles in water.

FLOODED SYSTEM – An underwater pump that does not require priming.

FLOOR – The interior bottom surface of a pool or spa.

FLOOR SLOPE – The slope of the pool floor, usually expressed in feet or inches of vertical rise per feet or inches of horizontal distance.

FLOW – The rate of the movement of water, typically in gallons per minute.

FLOW METER – A device that measures the rate of flow of liquid through piping.

FLOW RATE – The volume of liquid flowing past a given point in a specified time period. Usually expressed as U.S. gallons per minute (gpm) or gallons per hour (gph).

FLOW RIDER – Pool at a waterpark that uses wave sheet technology for body boarding or body surfing activity.

FLOW SWITCH – A safety device that prevents a heater from firing if water flow through the system is not adequate.

FLUME – A trough-like or tubular structure, generally recognized as a water slide, that directs the path of travel and rate of descent of the rider.

FLUME SLIDE – Slides of various configurations that are characterized by having deep riding channels, vertical and lateral curves, and high water flows, and accommodate riders using or not using mats, tubes, rafts and other transport vehicles. Included but not limited to family raft rides, inner-tube rides, body slides, speed slides, etc.

FREE AVAILABLE CHLORINE – That portion of the total chlorine that is not combined chlorine and is available as a sanitizer.

FREEBOARD – In a sand filter, the clear vertical distance between the top of the filter medium and the lowest outlet of the upper distribution system.

FREEZE-THAW CYCLE – Seasonal weather and temperature changes that can cause stress to a surface.

FRICTION – Resistance created by liquid passing along the inner surface of a conductor pipe and fittings.

FRICTION HEAD – Head specifically caused by friction or drag.

GALVANIC ACTION – The creation of electrical current by the process of electrochemical action of dissimilar metals in a liquid.

GALVANIC CORROSION – The deterioration of metal produced when two dissimilar metals are exposed to the electrical current produced by electrochemical action.

GATE VALVE – A device in a pipe that can partially or totally obstruct the flow of water, using an internal "gate" that moves in and out as the valve is operated.

GFCI (Ground Fault Circuit Interrupter) – A mechanism that cuts the current to an electrical device the moment a change in voltage occurs.

GRAB BAR/RAIL – A rail used to enter or leave a pool/spa.

GRADE – A predetermined degree of slope that a finished surface should have.

GROUNDING – Connecting or providing a conducting path to earth or a conducting body that serves in place of earth.

GROUT – A cementitious, epoxy or other material used for filling joints between tiles.

GROUTING – The process of filing tile joints with grout.

GUNITE – A pneumatically applied (sprayed) concrete that is a dry mixture of cement, aggregate and/or sand. Water is applied to the mix at the hose nozzle.

GUTTER – Overflow trough in the perimeter wall of a pool, a component of the circulation system.

HAIR AND LINT STRAINER – Readily removable, perforated or otherwise porous container used to catch coarse material. (See NSF definition.)

HALOGEN – Any of the active chemical elements fluorine, chlorine, bromine and iodine, used as disinfectant or oxidizers.

HANDHOLD/HANDRAIL – A device that is intended to be gripped by a user for the purpose of resting and/or steadying him/herself. Typically located within or without the pool/spa or as part of a set of steps or deck installed equipment.

HARDNESS – The amount of calcium and magnesium dissolved in water, measured by a test kit and expressed as ppm of equivalent calcium carbonate.

HAZARD – A condition or set of circumstances that has the potential of causing or contributing to injury or death.

HEAD – A measure of the amount of pressure or resistance in a hydraulic system, expressed in feet.

HEAD LOSS – The amount that flow reduces as head increases.

HEADER – A manifold in a heater that directs the flow of water into and out of the heat exchanger.

HEAT EXCHANGER – A device with coils, tubes or plates that transfers heat from air or a fluid to another fluid without intermixing them.

HEAT LOSS – The natural drop in water temperature as heat is transferred to the surrounding air.

HEAT PUMP – A refrigeration compressor, usually electrically driven, that is operated in reverse. To obtain heat, the evaporator side (cooling coil) is exposed to water, air or ground. The coil transfers the heat from this source to the condenser coil, where it discharges the heat to a pool or spa.

HEATER – An electric, fossil-fueled or solar device used to heat pool or spa water.

Electric Heater – Uses a heating element immersed in water.

Fossil-Fueled Heater – Uses natural, propane gas or fuel oil and an open flame to heat a heat exchanger.

Solar Heater – Uses the ultraviolet rays of the sun as a heat source. Other ways to categorize heaters:

* Direct heaters heat the tubes in which water circulates.
* Indirect heaters circulate steam or hot water inside a heat exchanger, through which pool water flows.

HIGH LIMIT SWITCH – A temperature control switch that can deactivate a control circuit at a preset temperature. Normally preset at the factory and nonadjustable; must be manually reset.

HIGH PERMEABILITY ELEMENT – Mechanically interlocked, nonwoven filter material designed to remove suspended solids.

HOOP – A circumferential constraint that prohibits the staves of a hot tub from separating. Also, a device used to secure two halves of a filter together. See band.

HOOP CONNECTOR – A tightening and connecting device.

HOT TUB – A spa constructed of wood with sides and bottom formed separately, and joined together by pressure from surrounding hoops, bands or rods; as distinct from spa units formed of plastic, concrete, metal or other materials.

HYDRAULICS – An engineering process used to pump, filter and return water to the pool that ensures effective circulation of water and chemicals and a lack of dead spots.

HYDROCHLORIC ACID – A very strong acid used in pools or spas for pH control and certain specific cleaning needs, a byproduct of adding chlorine to water. Use extreme caution in handling. Called muriatic acid when diluted. See also muriatic acid.

HYDROGEN – The lightest chemical element. A component of water and a frequent product of chemical reactions. Used as a measure of acidity and pH in its ionic form in solution.

HYDROGEN PEROXIDE – A compound of hydrogen and oxygen usually supplied in an aqueous solution, used as a disinfectant.

HYDROSTATIC PRESSURE – The upward pressure of a liquid, commonly ground water, on the bottom of an empty pool or spa.

HYDROSTATIC RELIEF VALVE – A fitting installed in the bottom of a main drain, designed to open automatically or manually to relieve upward ground-water pressure by allowing water to flow into the pool or spa.

HYDROTHERAPY JET – A fitting that blends air and water, creating a high-velocity turbulent stream of air-enriched water.

HYDROTHERAPY SPA – A spa unit having a therapeutic use, but which is not drained, cleaned or refilled for each user. Includes, but is not limited to, hydrotherapy jet circulation, hot water, cold water mineral baths, air induction bubbles or any combination thereof, industry terminology includes, but is not limited to, "therapeutic pool," "hydrotherapy pool," "whirlpool," "hot spa," etc. NSPI standards exclude facilities under direct supervision and control of licensed medical personnel.

HYPOBROMOUS ACID – The most powerful disinfecting form of bromine in water.

HYPOCHLORINATOR – A chemical feeder through which liquid solutions of chlorine bearing chemicals are fed into the pool water at a controlled rate. Types of hypochlorinators include: positive displacement, which are usually motor-driven; aspirator, which work off a pressure difference in the hydraulic system; and metering, which are connected to the pump suction and use a timing mechanism.

HYPOCHLORITE – Any of a family of chemical compounds including calcium hypochlorite, lithium hypochlorite, sodium hypochlorite, etc., used in various forms as chlorine carriers in pool and spa water.

HYPOCHLOROUS ACID – The most powerful disinfecting form of chlorine in water.

IMPELLER – The rotating vanes of a centrifugal pump; its action creates the flow of the water.

IMPERVIOUS TILE – Tile with water absorption of 0.5% or less. This type of tile is ideal for submerged installations.

INFLUENT – The water entering a filter or other device.

INGRESS – Means of entry into an area.

INLET, RETURN – See return inlet.

INLET FITTING – The fitting aperture through which water under positive pressure returns to a pool or spa.

INSULATOR – In electricity, any device that serves as a nonconductor, usually made of glass or porcelain.

INTERMITTENT IGNITION DEVICE – An electrical spark device used to ignite a gas heater.

IODINE – A chemical element that exists as a grayish-black granule in its elemental state, or as a part of a chemical compound. In the form of liquid iodine and in iodide compounds, a biocidal agent used to disinfect pool and spa water. Chlorine used with iodides releases elemental iodine.

IONIZATION – The process whereby a compound, in solution, separates into charged ions.

ISOCYANURATES – See Chlorinated Isocyanurates.

JETS – See hydrotherapy jet.

KINETIC ENERGY – The energy from the motion imparted to a liquid by the action of impeller vanes, causing the liquid to flow out of the pump casing and away from the impeller.

LADDER – "A-Frame " Ladder – An entry ladder that straddles an aboveground/on ground pool wall and is either removable (Type A) or has a built-in, entry-limiting feature (Type B).

Double Access Ladder (Type A) – An "A-Frame" ladder that straddles the pool wall of an aboveground pool and provides pool ingress and egress, and is intended to be removed when not in use.

Limited Access Ladder (Type B) – A removable "A-Frame" ladder that straddles an aboveground/on ground pool wall with a built in, entry-limiting provision for making the pool inaccessible when not in use (i.e., swing-up, slide-up, "pick off" or equivalent). Staircase

Ladder (Type C) – A "ground-to-deck" staircase ladder that allows access to an aboveground pool deck and has a built-in, entry-limiting feature. Used with a Type E "in pool" staircase ladder to provide a means of ingress and egress from the pool to the deck.

In-Pool or Spa Ladder (Type D) – An "in pool" ladder located in a pool or spa to provide ingress and egress from the deck staircase

Ladder (Type E) – An "in-pool" staircase ladder located in the pool to provide a means of ingress and egress from the pool to the deck.

LAITANCE – A layer of weak and non-durable material containing cement and aggregate fines, brought by bleed water to the top of wet concrete, the amount of which is generally increased by overworking or over manipulating concrete at the surface.

LANGELIER INDEX – A numerical calculation based on the Langelier water balance equation, which indicates whether water is corrosive or scaling. See also SATURATION INDEX.

LATEX-PORTLAND CEMENT GROUT – A combination of portland cement grout with a latex additive.

LATEX-PORTLAND CEMENT MORTAR – A mixture of portland cement, sand and either a liquid latex additive or dry, redispersible latex polymers used as a tile setting mortar.

LATH – Metal mesh which acts as a backing or reinforcing agent for the scratch coat or mortar.

LIFELINE – A rope line which is laid across a pool to designate a change in slope at the bottom, especially where deep water begins.

LINE LEVEL – A small spirit level that can be suspended from a string line. When the string line is level, the bubble will be centered within the tube.

LINER – See vinyl liner.

LINT STRAINER – A device attached to the front of a pump to which the influent line (suction line) is connected, used to entrap lint, hair or other debris that could damage the pump.

LIQUID ACID – A chemical used to lower pH and total alkalinity, most commonly muriatic acid.

LIQUID CHLORINE – Sodium hypochlorite.

LIQUID PROPANE GAS – The liquid form of propane gas, a heavy hydrocarbon that occurs naturally in petroleum.

LITHIUM HYPOCHLORITE – A solid, white, granular form of inorganic chlorine that has a pH of approximately 9 and contains an available chlorine content (ACC) of 35 percent.

LOWER DISTRIBUTION SYSTEM (Under Drain) – A device in the bottom of a permanent medium filter used to collect water during filtering and distribute it during backwashing.

MAGNESIUM HARDNESS – A measure of the amount of magnesium dissolved in water.

MAIN DRAIN – An outlet located at the bottom of a pool or spa that conducts water to the recirculating pump.

MAKE-UP WATER – Fresh water used to fill or refill a pool or spa. See also source water.

MANIFOLD – A pipe with several openings for making multiple connections.

MANOMETER – An instrument that measures vacuum or pressure differential across an orifice by means of a column of liquid, usually mercury. In pools, usually calibrated to show rate or flow of water in gallons per minute (gpm).

MARBLE TILE – Marble cut into tiles and available in several finishes; including polished, honed and split face.

MARCITE – See plaster.

MASTER GRADE CERTIFICATE – A certificate which states that the tile listed in the shipment and described on the certificate are made in accordance to industry standards.

MECHANICAL SEAL – A device used to prevent the passage of water in or out of a centrifugal pump at the motor shaft.

MICRON – One-millionth of a meter. Used to describe the size of particles that filters are capable of trapping.

MICROORGANISM – A microscopic plant or animal.

MORTAR BED – The layer of mortar on which a waterproofing membrane or tile is set.

MOTOR – A machine that converts electrical energy into mechanical energy. When electrical current is supplied to a series of wires (windings), a magnetic field is created that drives the rotor and shaft of a pump impeller.

MUD – A slang term for a mortar bed.

MULTIPLE FILTER-CONTROL VALVE – A multiport valve having a number of control positions for various filter operations, combining the function of two or more single valves in one unit.

MULTIPORT VALVE – A device that allows for the multidirectional control of the passage or flow of water through a system.

MURIATIC ACID – Used to lower pH and/or total alkalinity in pool and spa water. See also hydrochloric acid.

NEW POOL and/or CONSTRUCTION – The activity of building or installing a pool and/or spa structure and its component parts where no such structure has previously existed.

NITROGEN – An element introduced into the pool or spa via perspiration, hair spray, cosmetics, etc. Easily combines with chlorine to form chloramines.

NONSWIMMING AREA – Any portion of a pool where water depth, offset ledges or similar irregularities prevent normal swimming activities.

NON-TOXIC – Having no adverse physiological effect on human beings or other living organisms.

NON-VITREOUS TILE – Tile with a water absorption rate of more than 7.0%. Typically not suitable for submerged installations.

NOTCHED TROWEL – A trowel with a serrated or notched edge which is used for the application of a gauged amount of tile mortar or adhesive in ridges of a specific dimension.

OPEN TIME – The period of time during which the bond coat retains its ability to adhere to the tile and bond the tile to the substrate.

ORGANIC MATTER – In a pool or spa, material introduced to the water by users and the environment such as perspiration, urine, saliva, suntan oil, cosmetics, lotions, dead skin and similar debris.

ORGANISM – Plant or animal life. Usually refers to algae or bacteria-like growth in pool water.

ORIFICE – An opening, usually carefully calibrated in size, through which water flows.

ORIFICE PLATE – A disc, placed in a water flow line, with a concentric, sharp-edged circular opening in the center that creates a differential pressure used to measure flow and operates feeders and instruments or other hydraulic equipment.

ORP (also called Redox) – Oxidation reduction potential produced by strong oxidizing agents in a water solution. Derived from the oxidation level measured in millivolts by an ORP meter.

OTO (Orthotolidine) – A colorless reagent that reacts with chlorine or bromine to produce a series of yellow to orange colors, indicating the amount of chlorine or bromine in water. Effectively measures total chlorine.

OUTLET – An aperture or fitting through which water under suction is drawn from a pool, spa or hot tub.

OUTLET, SUCTION – See Suction Outlet.

OVERFLOW SYSTEM – A system for the removal of pool/spa surface water through the use of overflows, surface skimmers, and surface water collection systems of various design and manufacture.

OXIDIZERS – Products used to destroy organic waste in water.

OZONE – A gaseous molecule composed of three oxygen atoms, generated on site and used for the oxidation of water contaminants.

OZONE, LOW OUTPUT GENERATING EQUIPMENT (Ozonator) – A device that will produce ozone in air at a concentration of less than 500 ppm. Usually refers to ultraviolet

(UV) generators.

OZONE CONTACT CONCENTRATION – A measure of the amount of ozone dissolved in pool/spa water.

OZONE GENERATOR – A device used to produce ozone.

PATHOGENS – Disease-producing microorganisms. pH – A value for the relative acidity or alkalinity of a substance, such as water, as indicated by the hydrogen ion concentration. Expressed on a scale of 0 to 14, 0 being most acidic, 7 being neutral and 14 being most basic.

pH METER – An instrument that measures pH by electrical conductivity across a membrane of an electrode.

PHENOL RED – A dye used in measuring pH.

PILOT GENERATOR – The component in a millivolt system that transforms heat from the pilot into electrical energy. Also referred to as a thermal coupling or thermocouple.

PILOT LIGHT – A small constant flame used to ignite gas at the first burner.

Residential Pool – Any constructed pool, permanent or non-portable, that is intended for noncommercial use as a swimming pool by not more than three owner families and their guests and that is more than 24" in water depth, and has a volume more than 250 gallons (refer to ANSI/NSPI-5 Standard for Residential Swimming Pools). Residential pools shall be further classified into types as indication of the suitability of a pool for use with diving equipment.

Type O – Any residential pool where the installation of diving equipment is prohibited.

Type I-V – Residential pools suitable for the installation of diving equipment by type. Diving equipment classified at a higher type is not prohibited from being used with a pool of lesser type (i.e., Type III equipment with a Type II pool). Commercial /Public

Pool – Any pool, other than a residential pool, that is intended for swimming or bathing and is operated by an owner, lessee, operator, licensee or concessionaire, regardless of whether a fee is charged for use. References within the standard to various types of public pools (refer to ANSI/NSPI-1 Standard for Public Swimming Pools) are defined by the following categories:

Class A: Competition Pool – Any pool intended for use for accredited competitive aquatic events such as Federation Internationale De Natation Amateur (FINA), U.S. Swimming, U.S. Diving, National Collegiate Athletic Association (NCAA), National Federation of State High School Associations (NFSHSA), etc. The use of the pool is not limited to competitive events.

Class B: Public Pool – Any pool intended for public recreational use.

Class C: Semipublic Pool – Any pool operated solely for and in conjunction with lodgings such as hotels, motels, apartments, condominiums, etc.

PITTING – A form of etching.

PLASTER – A type of interior finish, made from a mixture of white cement and aggregate that will accept a tint or color; applied to a concrete pool or spa. Also called marcite or Marbleite.

PLUMB – Perpendicular to true level.

POINT OF THE FIRST SLOPE CHANGE – Shall be at a minimum water depth of two feet nine inches and at least six feet from the shallow end, except as stated in NSPI's Article 6.3.

POOL – Aboveground

Pool – Type O – A removable pool of any shape that has a minimum water depth of 36" and maximum water depth of 48" at the wall. The wall is located on the surrounding earth and may be capable of being disassembled or stored and reassembled to its original integrity. Diving and waterslides are prohibited (refer to ANSI/NSPI-4 Standard for Aboveground Residential Swimming Pools). In ground Swimming

Pool – Any pool whose sides rest in partial or full contact with the earth (refer to ANSI/NSPI-5 Standard for Residential Swimming Pools or ANSI/NSPI- 1 Standard for Public Swimming Pools as applicable). On-Ground Residential Swimming

Pool-Type O – A removable pool package whose walls rest fully on the surrounding earth with an excavated area below the ground level. Diving and water slides are prohibited (refer to NSPI-4 Standard for Aboveground Swimming Pools). The slope adjacent to the shallow area shall have a maximum slope of 3:1, and the slope adjacent to the side walls shall have a maximum slope of 1:1.

Permanently Installed Swimming Pool – A pool that is constructed in the ground or in a building in such a manner that it cannot be readily disassembled for storage (refer to ANSI/NSPI-1 Standard for Public Swimming Pools or ANSI/NSPI-5 Standard for Residential In ground Swimming Pools as applicable).

Class D: Other Pool – Any pool operated for medical treatment, therapy, exercise, lap swimming, recreational play and other special purposes, including, but not limited to, wave or surf action pools, activity pools, splasher pools, kiddie pools and play areas. These pools are not intended to be covered within the scope of NSPI standards.

Public Pools – May be diving or non-diving. If diving, they shall be further classified into types as an indication of the suitability of a pool for use with diving equipment.

Type VI–XI – Public pools suitable for the installation of diving equipment by type. Diving equipment classified at a higher type is not prohibited from being used on a pool of lesser type (i.e., Type VIII equipment with a Type VI pool).

Type N – A non-diving public pool (no diving allowed).

Splasher (Wader) Pools – A pool that has a minimum water depth of 24" and a maximum water depth of 36".

Wading Pool – A pool that has a shallow depth used for wading. There are no requirements for residential wading pools (refer to NSPI-1 Standard for Public Swimming Pools for public wading pools).

POOL USER – Any person using a pool and adjoining deck area for the purpose of water activity such as swimming, wading, diving or other related activities.

POT LIFE – The period of time during which a material maintains its workable properties after it has been mixed.

POTABLE WATER – Any water, such as an approved domestic water supply, which is bacteriologically safe and otherwise suitable for drinking.

PPM – Abbreviation for parts per million, the unit of measurement used in chemical testing that indicates the parts by weight in relation to one million parts by weight of water. Essentially identical to the term milligrams per liter (mg/l).

PRECIPITATE – A solid material that is forced out of a solution by some chemical reaction and settles out or remains as a haze in suspension (turbidity).

PRE-COAT – The coating of filter aid on the septum of a diatomaceous earth-type filter at the beginning of each filter cycle.

PRE-COAT FEEDER – A chemical feeder designed to inject diatomaceous earth into a filter in sufficient quantity to coat the filter septum at the start of a filter run.

PRE-FLOAT – The term used to describe mortar that has been placed and allowed to harden prior to bonding tile to it with thin-set or adhesive.

PRESSURE – In a liquid, a form of energy proportional to the depth of a column of liquid. Expressed as pounds per square inch, feet of liquid or feet of head.

PRESSURE CHECK – A test for the rate of water flow; also a test for leaks in a system.

PRESSURE DIFFERENTIAL – The difference in pressure between two parts of a hydraulic system, such as the influent and effluent of a filter.

PRESSURE GAUGE – A gauge that measures the amount of pressure built up within a closed container, such as a filter.

PRESSURE SWITCH – A device that will not allow a heater to fire unless there is adequate water pressure in the system. See Flow Switch.

PRIMING – Refers to re-establishing the water flow by the recirculating pump.

PSI – Abbreviation for pounds per square inch.

PUMP – A mechanical device, usually powered by an electric motor, which causes hydraulic flow and pressure for the purpose of filtration, heating and circulation of pool and spa water. Typically, a centrifugal pump design is used for pools and spas.

PUMP CAPACITY – The volume of liquid a pump is capable of moving during a specified period of time against a given total head.

PUMP CURVE – A graph of performance characteristics of a given pump under varying power, flow and resistance factors. Used in checking and sizing a pump.

PUMP STRAINER – A device, placed on the suction side of a pump that contains a removable strainer basket designed to trap debris in the water flow with a minimum of flow restriction. Sometimes called a hair/lint pot or trap.

PUNCTURE HAZARD – Any surface or protrusion that is capable of puncturing a user's skin under casual contact.

PVC (Polyvinyl Chloride) – A thermoplastic resin commonly used for pool piping and plumbing components.

QUATERNARY AMMONIUM (also Quats) – Organic compounds of ammonia used as an algae stat and germicide.

RATE OF FLOW – The quantity of water flowing past a designated point within a specified time, such as the number of gallons flowing in one minute (gpm).

RATED PRESSURE – Pressure that is equal to or less than the pressure designated on the data plate of the equipment.

REAGENTS – The chemical agents or indicators used to test various aspects of water quality.

REHABILITATION – The activity of restoring all or part of a pool or spa structure and its components to the original design condition, including the rebuilding and/or replacing of worn and broken parts or components.

REMOTE SWITCH – Any switching device used to activate an apparatus from a distance.

RESIDUAL – The measurable sanitizer present in water.

RESPONSE TIME – The time between pool user distress and rescue by a lifeguard.

RETURN INLET – The aperture or fitting through which the water under positive pressure returns into a pool or spa.

RETURN PIPING – Effluent piping.

REVERSE CIRCULATION – A circulation system in which water is taken from the surface and returned through inlets at the bottom of the structure.

RING BUOY – A ring-shaped floating buoy capable of supporting a user.

ROPE AND FLOAT LINE – A continuous line, not less than 1/4" in diameter that is supported by buoys and attached to opposite sides of a pool to separate the deep and shallow ends.

RUBBER FLOAT (Float) – The rubber trowel used to force grout into the joints of a tile installation, remove excess grout from the surface and form a smooth grout finish.

SALINITY – The sodium chloride or salt content of water.

SAND FILTER – A filter that uses sand, or sand and gravel, as the filter medium.

SATURATION INDEX – A rating that indicates whether water will have a tendency to deposit calcium carbonate from a solution, or whether it will be potentially corrosive. Four factors are used in the computation: pH, total alkalinity, calcium hardness and temperature. When correctly balanced, water will be neither scale forming nor corrosive.

SCALE – The precipitate that forms on surfaces in contact with water whose calcium hardness, pH or total alkalinity level is too high.

SCARIFY – A mechanical means of roughing a surface to obtain better adhesion of mortar to the substrate.

SCRATCH COAT – A mixture of cement, sand and water or latex additive as the first coat of mortar on a wall or ceiling which is usually scratched or roughened so that the subsequent coat will bond properly.

SEALANT – An elastomeric material used to fill and seal expansion and control joints and allow for the horizontal and lateral movement.

SEDIMENT TRAP – A device for trapping sediment that is required on all gas-heater piping.

SELF-PRIMING – A rating given to centrifugal pumps to indicate that the pump is capable of operating above pool water level, after the initial filling with water.

SEPTUM – The part of a filter made of cloth, wire screen or other porous material on which the filter medium or aid is deposited.

SEQUESTERING AGENT – Synonymous with a chelating or metal complexation agent, reacts with potential stain-producing metal ions (i.e., copper, iron, etc.) to reduce staining of pool/ spa surfaces and associated colored water.

SERVICE FACTOR – The degree to which an electric motor can be operated above its rated horsepower without danger of overload failure.

SETTING BED – The layer of mortar on which the tile is set.

SHALLOW AREAS – Areas of a pool or spa with water depths less than 5'.

SHOCK – Product used to treat microbial infestations and inorganic contaminants in water. Must be registered by EPA.

SHOCK OXIDIZER – Product ,used to destroy non-living organic and inorganic contaminants in water, which is neither a sanitizer nor algaecide.

SHOCK OXIDIZER TREATMENT – The practice of adding a shock oxidizer product to water.

SHOCK TREATMENT – The practice of adding a shock product to water.

SHOTCRETE – A mixture of cement and sand that is applied to contoured and supported surfaces to build a pool or spa. Shot-crete is premixed and pumped wet to the construction site.

SHUT-OFF HEAD – The amount of head at which the pump can no longer circulate water.

SIGHT BARRIER – The available open space in any given or total fence area.

SKIMMER (also Surface Skimming System) Thru-wall – A device installed in the wall of an in ground pool or spa or aboveground/ on ground pool that allows for continuous removal of floating debris and surface water to the filter.

Over-the-Wall – A device installed over the wall of an aboveground/on ground pool that allows for continuous removal of debris and surface water to the filter.

SKIMMER COVER – A device or lid to close the deck opening to the skimmer housing.

SKIMMER EQUALIZER PIPE – The connection from the skimmer housing to the pool, spa or hot tub below the weir; sized to satisfy pump demand and prevent air lock or pump loss of prime.

SKIMMER EQUALIZER VALVE – The check valve on the equalizer line that opens to draw water when the water level inside the skimmer body drops below operating level, and remains closed during normal skimming.

SKIMMER HOUSING – The structure that attaches to or contains the skimmer weir, strainer basket, float valve and other devices used in the skimming operation. 13 – Appendix

SKIMMER SYSTEM – The waterline is at the midpoint of the operating range of the skimmers when there are no users in the pool/ spa.

SKIMMER WEIR – The part of a skimmer that adjusts automatically to small changes in the water level to ensure a continuous flow of water to the skimmer.

SLAKE – Allowing the mixture of mortar, thin-set or grout to stand for a brief period of time after the ingredients have been thoroughly combined and before final mixing occurs. This enables the moisture in the mix to penetrate lumps in the dry components, making it easier to complete the mixing procedure.

SLIP-RESISTING – Refers to a surface that has been treated or constructed so as to significantly reduce the chance of a user slipping. The surface shall not be an abrasion hazard.

SLOPE – An inclined surface.

SLURRY COAT – A bond coat for installation of or onto a mortar bed.

SLURRY FEED – Diatomaceous earth continuously added to filter elements during the course of a filter run to help maintain filter porosity. Also body feed.

SODA ASH (also Sodium Cargonate) – A chemical compound in white powder form used to raise pH of water.

SODIUM BICARBONATE (Baking Soda) – A chemical compound in white powder form used to raise total alkalinity of water.

SODIUM BISULFATE (also Dry Acid) – A granule used to lower the pH and/or total alkalinity of water.

SODIUM CARBONATE – See soda ash.

SODIUM DICHLORO-ISOCYANURATE (also Sodium Ichloro-S-Triazinetrione) – An organic chlorine that in granular form has approximately 62 percent chlorine, and in dehydrate form has approximately 56 percent chlorine. Contains 58.7% stabilizer by weight and has a pH of 6.0.

SODIUM HYPOCHLORITE – The clear, liquid form of an inorganic chlorine compound obtainable in concentrations of 5- to 16% available chlorine.

SODIUM THIOSULFATE – A chemical compound used to destroy chlorine.

SOFT WATER – Water that has very low calcium and magnesium content – less than 6 grains per gallon (less than 100 ppm).

SOOT – A black, powdery, carbonaceous substance created by an improper air-fuel mixture in the combustion of fossil fuels. A byproduct of incomplete combustion.

SOURCE WATER – Water used to fill or refill a pool or spa. See also make-up water.

SPA (also Hydrotherapy Spa) – A hydrotherapy unit of irregular or geometric shell design.

Permanent Residential Spa – A spa in which the water-heating and water-circulating equipment is not an integral part of the product. Intended as a permanent plumbing fixture and not intended to be moved (refer to ANSI/NSPI-3 Standard for Permanently Installed Residential Spas).

Public Spa – Any spa, other than a permanent residential spa or residential portable spa, intended to be used for bathing and operated by an owner, lessee, operator, licensee or concessionaire, regardless of whether a fee is charged for use (refer to ANSI/NSPI-2 Standard for Public Spas).

Residential Portable Spa (Two Types) – Non-Self-Contained Spa – A spa in which the water-heating and water-circulating equipment is not an integral part of the product. Non-self-contained spas may employ separate components such as an individual filter, pump, heater and controls, or they may employ assembled combinations of various components (refer to ANSI/ NSPI-6 Standard for Residential Portable Spas).

Self-Contained Spa – A spa in which all control, water-heating and water-circulating equipment is an integral part of the product. Self-contained spas may be permanently wired or cord-connected.

SPLASH POOL – A pool having a water depth not exceeding 18 inches, primarily intended for the use of small children. May include constructed play devices such as small, flume type waterslides.

SPREAD – The clear distance between the sides rails of a ladder.

STABILIZER (also CYANURIC ACID, Isocyanuric Acid, Conditioner or Triazenetrione) – A chemical that helps reduce the excess loss of chlorine in water due to the ultraviolet rays of the sun.

STATIC COEFFICIENT OF FRICTION (SCOF) – the frictional resistance one pushes against when starting in motion.

STATIC HEAD – Head loss caused by the weight of a standing water column to be moved; encountered on both the suction and discharge sides of a pump.

STATIC SUCTION HEAD – The vertical dimension between the pump center line and the level of the liquid being pumped when it is below the impeller plane, expressed in feet of head.

STATIC SUCTION LIFT – The vertical distance in meters (or feet) from the center line of the pump impeller to the pool water level.

STEPS, RECESSED STEPS, LADDERS and RECESSED TREADS – Means of pool and spa ingress and egress. These elements are intended to be used separately or in conjunction with one another.

Step(s) – A riser/tread or series of risers/ treads extending down from the deck and terminating at the pool or spa floor. Includes recessed steps with risers located outside of user areas.

Ladder – A series of vertically separated treads or rungs connected by vertical rail members or independently fastened to an adjacent vertical pool wall (see ladder for definitions of particular ladder types).

Deck Ladder – Provides deck access from outside the pool or spa.

Recessed Treads – A series of vertically spaced cavities in the pool or spa wall, creating tread areas for step holes.

STRAINER BASKET – An easily removable, perforated or otherwise porous container used to catch coarse material in the pump lint strainer.

SUBSTRATE – The underlying support for ceramic tile installations.

SUCTION HEAD – Resistance to water flow encountered on the suction side of a pump, measured in feet of head. Reflects the vertical lift required by the pump's intake.

SUCTION OUTLET – An aperture or fitting, other than a skimmer, on the side wall of a pool or spa through which water under negative pressure (vacuum) is drawn from the pool or spa to the pump or circulation system.

SUCTION PIPING – Influent piping.

SUPERCHLORINATION – The practice of adding a sufficient amount of chlorinating compound to water to destroy chlorine demand compounds and any combined chlorine present. Generally, the level of chlorine added is 10 times the level of combined chlorine in the water. See also breakpoint chlorination.

SURFACE SKIMMING SYSTEM – Refers to perimeter-type overflows, surface skimmers and surface-water collection systems of various design and manufacture. See skimmer.

SWIMMING AREA – Any area of a pool more than three feet in water depth that is devoted to swimming.

SWIMMING POOL – Any structure intended for swimming or recreational bathing that contains water over 24" (610 mm) deep.

SWIMMING POOL (Indoor) – A swimming pool which is totally contained within a structure and surrounded on all four sides by the walls of the enclosing structure.

SWIMMING POOL (Outdoor) – Any swimming pool which is not an indoor swimming pool.

TAMPER-PROOF – Refers to equipment that requires the use of tools to alter or remove portions of the equipment.

TEMPERATURE FACTOR (TF) – Used when determining the Saturation Index.

TEMPERATURE RISE – The difference between the desired water temperature and the current water temperature.

TEST KIT – A device used to monitor specific chemical residual or demands in pool or spa water.

THERMOSTAT – A temperature-control device that cycles the heater on and off to maintain the desired temperature.

TIME CLOCK – A mechanical device that automatically controls the time periods that a pump, filter, heater, blower or other electrical device is in operation.

TIME DELAY – A time-controlled switch used to provide a rest period or to stop repeated false starts.

TITRATION – A method of testing the total alkalinity and calcium, and magnesium hardness, of pool, spa or hot tub water.

TOTAL ALKALINITY – A measure of the pH buffering capacity of water. Alkalinity is generally expressed in terms of the equivalent concentration of calcium carbonate in mg/l (or ppm).

TOTAL ALKALINITY FACTOR (TA) – Used when determining the Saturation Index.

TOTAL CHLORINE – The sum of both the free available and combined chlorine.

TOTAL DISSOLVED SOLIDS (TDS) – A measure of the total amount of dissolved matter in water, e.g., calcium, magnesium, carbonates, bicarbonates, metallic compounds, etc.

TOTAL DYNAMIC HEAD – See feet of head.

TOXIC – Having an adverse physiological effect on human beings or other living organisms.

TRICHLORO-ISO-CYANURATE (also Trichloro-S Triazinetrione) – A form of organic chlorine, most common in compressed form (tablets or sticks), that has 90 percent or more available chlorine, approximately 55.5 percent stabilizer by weight, and an approximate pH of 2.9. See also sodium dichloroisocyanurate.

TURBIDITY – A cloudy condition of water due to the presence of extremely fine particles in suspension that interfere with the passage of light.

TURNOVER RATE – The period of time (usually expressed in hours) required to circulate a volume of water equal to the pool/spa capacity.

TWO-SPEED PUMP – A centrifugal pump with a motor that operates at two different RPM speeds.

ULTRA-VIOLET LIGHT – A component of sunlight which can be generated artificially. It can stimulate many types of organic molecules to become chemically reactive and can decompose a variety of chemical species. Can be used as a sanitizer supplement to inactivate microorganisms.

UNDERWATER LIGHT – A fixture designed to illuminate from beneath the water surface.

Dry Niche Light – A light unit placed behind a watertight window in a pool, spa or hot tub wall.

Wet Niche Light – A watertight and water-cooled light unit placed in a submerged niche in a pool, spa or hot tub wall and accessible only from the pool.

UPPER DISTRIBUTION SYSTEM – A system designed to distribute the water entering a permanent medium filter while preventing movement or migration of the filter medium. Also properly collects water during filter backwashing unless other means are provided.

URETHANE – An elastomeric polymer with excellent chemical and water resistance. It can be difficult to install tile or stone directly to this type of membrane.

USER – Any person using a pool, spa or hot tub and adjoining deck area for the purpose of water sports, recreation, therapy or related activities.

USER LOAD – The number of people in the pool or spa area at any given moment or at any stated period of time.

VACUUM – The reduction of atmospheric pressure within a pipe, tank, pump or other vessel. Measured in inches of mercury. One inch of mercury equals 1.13' of head. The practical maximum vacuum is 30" of mercury, or 33.9' of head.

VACUUM FILTER – A filter, usually of diatomite type, through which water is pulled by a pump mounted on the effluent side of the filter.

VALVE – Any device in a pipe that will partially or totally obstruct the flow of water (as in a ball, gate or glove valve) or permit flow in only one direction (as in a check or foot valve).

Bleeder Valve – Allows air to be vented from a system.

Multiport Valve – Allows for multidirectional control of the flow of water through a system.

Push-Pull Valve – Allows for dual directional control of the flow of water through a system.

VELOCITY – The speed at which a liquid flows between two specified points, expressed in feet per second.

VELOCITY HEAD – The equivalent distance a liquid must fall to attain a given velocity. The amount of energy, expressed in feet of head, required to accelerate the liquid to a given velocity.

WATERPROOFING MEMBRANE – A covering applied to a substrate before tiling to protect the substrate and framing from damage by water.

WATER PRESSURE SWITCH – A switch that, from water flow, detects abnormally low pressures on a piece of equipment and can shut it off.

WATTS VALVE – A mechanical valve that opens with high pressure or high temperature, used as a safety device on fossil-fuel heaters.

WEIR – A device included with a through-the wall or over-the-wall skimmer that controls the amount of surface water (flow) drawn into the skimmer and filtration system. See also skimmer weir.

WET AREAS – Surfaces that are either soaked, saturated, or regularly and frequently subjected to moisture or liquids (usually water).

WET NICHE – See underwater light.

WINTERIZED LINER – A plastic liner that is manufactured with sufficient plasticizers to withstand exposure to its lowest rated temperature of -20°F (-29°C).

WINTERIZING – The process of preparing a pool or spa for freezing weather. Includes chemical treatment of the standing water, plus physical and chemical protection against freezing of the pool or spa, and its equipment.

WRINKLE – A small ridge or crease in an otherwise smooth surface.

1 http://www.allbusiness.com/arts-entertainment-recreation/507693-1.html

13.3 RESOURCE GUIDE – TRADE ORGANIZATIONS AND TECHNICAL RESOURCES

Technical Design Manual

Direct Adhered Ceramic Tile, Stone and Thin Brick Facades Technical Design Manual
LATICRETE Technical Services
c/o LATICRETE International, Inc.
1 LATICRETE Park North
Bethany, CT 06524
+1.203.393.0010
www.laticrete.com

Ceramic Tile Materials and Methods

Tile Council of North America, Inc. (TCNA)
100 Clemson Research Blvd.
Anderson, SC 29625
+1.864.646.8453
www.tileusa.com

Terrazzo, Tile & Marble Association of Canada (TTMAC)
30 Capston Gate, Unit 5
Concord, Ontario, Canada L4K 3E8
+1.905.660.9640
www.ttmac.com

Ceramic Tile Institute of America, Inc. (CTIOA)
12061 West Jefferson
Culver City, CA 90230-6219
+1.310.574.7800
www.ctioa.org

Tile Contractors Association of America (TCAA)
4 East 113th Terrace
Kansas City, MO 64114
800.655.8453
www.tcaainc.org

National Tile Contractors Association (NTCA)
P.O. Box 13629
626 Lakeland East Dr.
Jackson, MS 39236
+1.601.939.2071
www.tile-assn.com

International Masonry Institute (IMI)
The James Brice House
42 East St.
Annapolis, MD 21401
+1.410.280.1305
www.imiweb.org

Natural Stone Methods and Materials

Marble Institute of America (MIA)
28901 Clemens Rd.
Westlake, OH 44145
+1.440.250.9222
www.marble-institute.com

Masonry Institute of America
22815 Frampton Ave.
Torrance, CA 90501-5034
800.221.4000
www.masonryinstitute.org

Thin Brick Masonry Materials and Methods

Brick Institute of America (BIA)
11490 Commerce Park Dr.
Suite 300
Reston, VA 22091
+1.703.620.0010
www.bia.org

International Masonry Institute (IMI)
The James Brice House
42 East St.
Annapolis, MD 21401
+1.410.280.1305
www.imiweb.org

Masonry Institute of America
22815 Frampton Ave.
Torrance, CA 90501-5034
800.221.4000
www.masonryinstitute.org

National Concrete Masonry Association (NCMA)
13750 Sunrise Valley Dr.
Herndon, VA 20171-4662
+1.703.713.1900
www.ncma.org

Concrete, Pre-Cast Concrete

Portland Cement Association
5420 Old Orchard Rd.
Skokie, IL 60077
+1.847.966.6200
www.cement.org

Pre-cast/Pre-stressed Concrete Institute (PCI)
209 West Jackson Blvd.
Chicago, IL 60606
+1.312.786.0300
www.pci.org

Wire Reinforcement Institute (WRI)
942 Main St.
Hartford, CT 06103
800.542.4974
www.wirereinforcement.org

American Concrete Institute (ACI)
P.O. Box 9094
Farmington Hills, MI 48333-9094
+1.248.848.3700
www.concrete.org

Test Standards and Building Codes

American Society for Testing & Materials International (ASTM)
100 Barr Harbor Dr.
P.O. Box C700
West Conshohocken, PA 19428-2959
+1.610.832.9585
www.astm.org

Materials and Methods Standards Association (MMSA)
P.O. Box 350
Grand Haven, MI 49417-0350
+1.616.842.7844
www.mmsa.ws

International Code Council (ICC)
4051 West Flossmoor Rd.
Country Club Hills, IL 60478-5795
888.422.7233
www.iccsafe.org

United States Green Building Council (USGBC)
1015 18th St., NW
Suite 508
Washington DC 20036
+1.202.828.7422
http://www.usgbc.org

American National Standards Institute (ANSI)
1819 L St., NW 6th Floor
Washington, DC 20036
+1.202.293.8020
ansi.org

International Organization for Standardization (ISO)
1, rue de Varembé, Casa postale 56
CH-1211 Geneva 20, Switzerland
41 22 749 01 11
www.iso.org

National Institute of Building Sciences (NIBS)
1090 Vermont Ave., NW
Suite 700
Washington, DC 20005-4905
+1.202.289.7800
www.nibs.org

Sealants, Waterproofing and Adhesives

Sealant, Waterproofing & Restoration Institute (SWRI)
14 West 3rd St.
Suite 200
Kansas City, MO 64105
+1.816.472.7974
www.swrionline.com

Adhesive & Sealant Council, Inc.
7979 Old Georgetown Rd.
Suite 500
Bethesda, MD 20814
+1.301.986.9700
www.ascouncil.org

Cement Plaster/Render

International Institute for Lath & Plaster
P.O. Box 3922
Palm Desert, CA 92260-3922
+1.760.837.9094
www.iilp.org

Expansion Joints

Expansion Joints Manufacturers Association
25 North Broadway
Tarrytown, NY 10591
Fax: 914.332.1541
www.ejma.org

Swimming Pools and Spas

The Association of Pool and Spa Professionals (APSP)
2111 Eisenhower Ave.
Suite 500
Alexandria, VA 22314-4695
+1.703.838.0083
Fax: 703.549.0493
www.apsp.org

Plumbing

American Society of Mechanical Engineers (ASME)
Three Park Ave.
New York, NY 10016-5990
800.843.2763 (USA/Canada)
001.800.843.2763 (Mexico)
973.882.1170 (Outside North America)
www.asme.org