



Tiled Steam Room and Steam Shower – Technical Design Manual



Globally Proven Construction Solutions



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Section 1: Introduction



1.1 Preface

LATICRETE International, Inc. a leading manufacturer of globally proven construction solutions, has long recognized the need for a technical manual to provide comprehensive guidelines and recommendations for the design, specification and installation of tile and stone in steam rooms and steam showers. Technical advances in materials, manufacturing and construction methods have made the use of steam rooms and steam showers practical and cost-effective in residential applications as well as health facilities and other commercial installations. In keeping with their position as an industry leader, LATICRETE International is publishing this second edition of Tiled Steam and Steam Shower Technical Design Manual to provide more comprehensive and up-to-date information available to architects, specifiers, construction professionals, tile contractors, and manufacturers/distributors of ceramic tile and stone. It is the goal of this publication to encourage new ideas, research and technology, for the purposes of improving the future of steam room installations of tile and stone.

1.2 Steam Room History, Facts and Health Benefits

Since the time of the ancient Romans and Greeks, people have been enjoying the healthful benefits of steam baths. In fact, the benefits of steam have been experienced by many ancient cultures including the Mayans, Alaskan Eskimos, Russians, Turks, and Chinese.¹

Bathing played a major part in ancient Roman culture and was one of the most common of daily activities for people across a wide variety of social classes. In fact, Romans used steam facilities as a form of social networking and communal activity. Typically built over natural hot springs, these facilities can be looked at as the first type of spa and were spread throughout the Roman Empire. Small bathhouses, called *balneum*, and the large baths, called *thermae*, were available for use by almost everyone for a modest fee. Most of the large *thermae* were owned by the Roman state government and often covered several city blocks.²

Other variations of steam rooms or hot spas emerged in the millennia that followed include;

Turkish bath (Turkish; Hammam) which involves first sitting in a warm room of dry heat prior to moving to a hot room with steam or moist heat and then finally moving to a cold room where they splash themselves with cool water to close the pores.

Onsen is a Japanese bath house which draws water from natural hot springs. Onsen have a history dating back to China and Japan during the eighth century.

A Banya has been a traditional experience in the Russian culture dating back to the early 12th century. A typical banya (Russian: баня [banj e]) is split into three separate rooms; the *predbannik* (предбанник) or pre-bath, where bathers leave their clothes and belongings, the wash room where bathers clean themselves prior to entering the steam room. The steam room historically utilized a wood burning stove to create the steam. A wood burning stove emits negative ions while an electric heater produces positive ions. To many Russians, the presence of negative ions was just as important as the steam for beneficial physiological results. The stove heated rocks onto which water is poured to create the steam.

These are three examples of steam exposure for physiological improvement purposes but they are certainly not the only examples. It is clear that exposure to steam in certain environments is excellent for maintaining a healthy body and mind. The high temperature in steam rooms stimulates sweating, which removes unwanted materials from the blood and improves kidney function. Sweating also releases excess water and salt from the body and opens pores, cleansing it and making the skin feel softer and fresher. This process also helps rid the body of lactic acid, dilates blood vessels to improve blood circulation, reduces swelling and aids in repair of muscle tears.

Steam bathing also stimulates protein circulation thereby improving the digestibility of proteins, fats, carbohydrates and minerals. There has even been an emphasis on the use of steam to rid the body of viruses and bacteria because they can only live in a very narrow temperature range. A steam room can be interpreted by the viruses or bacteria as an "artificial fever" and may aid the human body in getting rid of these microscopic invaders. Finally, endorphins are released to help the body deal with stress and pain more effectively.³

The American Journal of Public Health, in August 1991, cited 16 articles about the effects of steam rooms and saunas. Simply stated, warmth (including steam) induces a feeling of euphoria (endorphins), relaxation and tranquility in many people. Bathing in a sauna is a pleasant and relaxing experience, which combines psychic, physical and social pleasures; reduces aggressive behavior, and enables bathers to forget the common pressures of everyday life.

Some studies have suggested that long-term sauna and steam room bathing may help lower blood pressure in patients with hypertension and improve left ventricular ejection fraction in patients with chronic congestive heart failure. They also state that sauna bathing is safe for most people with coronary heart disease, stable angina pectoris

or myocardial infarction (MI).⁴

The addition of a steam room in residential applications can raise the value of the property, as well as:

- Relieve nasal, sinus and chest congestion
- Can include aromatherapy (to improve mood)
- Rejuvenates mind, body and soul
- Deep cleans and moisturizes skin
- Reduces aches and pains
- Promotes healing of muscles
- Reduces swelling
- Eases tension and daily stress
- Requires little maintenance
- Provides a low cost means to feeling better

1.3 Challenges of Steam Room and Steam Shower Applications

With all of the benefits that steam rooms offer, they do present some challenges for their designers, installers and building owners. The major challenge is to make sure that the moisture stays in the steam room and is not allowed to escape into adjacent spaces unless designed to do so. The second big challenge is to keep the heat created by the steam generator in the steam room. The designer and builder must also keep the steam room occupants comfortable, safe and in control of all facets of the steam room environment.

In some ways, steam rooms can be compared to a swimming pool. Let's consider that both steam rooms and pools have moisture under pressure in them; the moisture in pools is in the form of water and the moisture in steam rooms is as water vapor. In swimming pools the pressure is caused by the weight of the water pushing out in all directions, while, in a steam room the pressure is created by the steam generator pumping water vapor into the room. If there is any opportunity for water or water vapor to escape, it will! If water vapor gets into adjacent spaces (e.g. studded walls, ceilings, etc...) it will condense. Water in contact with building materials or any organic matter can cause significant problems. Proper design, construction and maintenance are critical to the long-term performance of the steam room, without needing to deal with fixing the root cause of the problem, repairing/remediating any structural problems caused by the water, or, deal with health issues caused by mold and mildew.

It is the purpose of this technical design manual to explain the proper design, construction, installation of tile or stone, and

maintenance of steam rooms and steam showers in an easy to understand format. Section 3 will explain some of the components required (e.g. vapor diffusion retarder [vapor barrier], waterproofing membrane, insulation, slopes, etc...) for steam rooms and steam showers. These components will help to make sure that the water and water vapor stay within the confines of the steam room walls and not cause potentially serious problems.

1.4 Finish Surfaces in Steam Rooms

The finish material used in steam rooms and steam showers must be hard, durable, slip-resistant, aesthetically pleasing, moisture insensitive, and be able to be cut to accommodate pipes, sensors, windows, doors, and more... In many cases, the finish material of choice is ceramic or glass tile, which meets all of the requirements listed previously. With its' ability to be used in wet, hot and humid areas as well as an almost unlimited choice of sizes, shapes and colors, tile is the perfect choice. Proper installation of tile using the recommended LATICRETE products will help to ensure that the installation will perform as required for the life of the steam room. While other options for steam room finishes exist (e.g. fiberglass shell or thermal glass) they do not have the aesthetic qualities which only ceramic or glass tile can deliver. We will more comprehensively explain tile that can be used in steam rooms/steam showers in Section 4, and the proper installation of tile in these environments is explained in Section 6.

1.5 Summary – Content of Manual

Section 2 – Types of Steam Room Construction

This section provides an overview of the different types of modern steam room construction commonly used around the world today. These include solid backing (e.g. concrete, concrete block, etc...) with mortar bed, framed construction, stainless steel, and fiberglass and a brief description of each.

Section 3 – Steam Room Project Design Considerations

This section provides a comprehensive look at the requirements and considerations for proper design and construction of steam rooms that will receive tile, glass or stone. The information contained in this section will include structural considerations, movement and movement joints, vapor barriers, steam room safety, "Green" considerations, and much more...

Section 4 – Selection of Steam Room Tile

Recommendations for choosing the best tile, glass or stone for the demanding steam room environment. Different types of tile include porcelain, glass and certain types of stone.

Section 5 – Tile Installation Preparation & Equipment

This section provides insight on how to properly prepare and inspect the substrate prior to installation of tile or stone in a steam room/steam shower application. There is also a brief description of the proper tools and installation materials suitable for steam room use.

Section 6 – Steam Room Tile Installation

An in-depth look of tile installation methods including installation of the mortar bed, waterproofing, tile, grout, sealant application, and properly sealing penetrations, as well as post installation requirements.

Section 7 – Specifications for Steam Rooms/Steam Showers

Individual specifications for the installation of tile in the different types of steam room construction types.

Section 8 – Steam Room/Steam Shower Detail Drawings

Individual details showing the installation of tile for the different types of steam room types, as well as drain and pipe penetrations.

Section 9 – Steam Room Tile Maintenance

A brief description of the inspection and maintenance typically required and performed in steam room applications.

Section 10 – Appendix

Case study, glossary, troubleshooting, and frequently asked questions related to steam room applications.



Section 2: Types of Steam Room Construction



There are several common types of steam room/steam shower construction used in modern times. The intent of this section is to explain the different types of construction and why one would be used over another.

2.1 Concrete / Concrete Masonry / Mortar Bed

Steam rooms, which are constructed of concrete or concrete masonry and subsequently covered with a mortar bed, has the longest tradition and history of all of the types that we will mention. In fact, pozzolanic concrete was used to create the Roman baths going back thousands of years. Today, these types of steam rooms do not rely so much on mass of structure to prevent moisture infiltration as they rely on properly specified, detailed and installed construction components. Despite what some believe, proper detailing of this type of steam room MUST include a properly specified and placed vapor diffusion retarder (vapor barrier) or low perm waterproof membrane. Steam unit design must take into consideration the affect of moisture vapor transmission (MVT) on the opposite side of the steam room walls. MVT can increase the occurrence of efflorescence and may affect paint or other adhered finishes on the side of the steam room wall.⁵ This means that paint may start to blister off of walls or certain types of finishes on the outside walls of steam rooms can be damaged without proper use of a vapor diffusion retarder (vapor barrier).

It is important to note at this time that some membranes suitable for the direct adhesion of tile or stone also act as a vapor diffusion retarder (vapor barrier) and do not require the use of a vapor diffusion retarder (vapor barrier) immediately over the concrete/concrete block construction. This type of membrane is defined as a Low Perm Waterproof Membrane by the Tile Council of North America (TCNA), and includes HYDRO BAN[®] Sheet Membrane. Please consult the membrane manufacturer for their specific guidelines for steam room and steam shower applications, and follow their directions for installation of this membrane exactly. Currently, LATICRETE waterproofing membranes (e.g. 9235 Waterproofing Membrane and HYDRO BAN) require the use of a vapor diffusion retarder (vapor barrier) on the concrete/concrete block walls and on the ceilings as well. It is also required that the vapor diffusion retarder (vapor barrier) be installed so that any moisture condensing on this material drains into the shower pan liner and not behind it. Please see Section 3.5, Section 7 and Section 8 for more information.

Steam rooms/steam showers designed for continuous use applications should specify a low perm waterproof membrane (a

waterproof membrane meeting ANSI A118.10 and with a water vapor permeance rating of 0.5 perms or less when tested per ASTM E96, Procedure E, tested at 90% relative humidity). When a waterproof membrane with a water vapor permeance rating greater than 0.5 perms is specified, a vapor retarder behind the wall assembly is required, and vapor retarder must have a water vapor permeance rating of 0.1 perm or less when tested per ASTM E96, Procedure A, tested at 50% relative humidity. Consult waterproof membrane manufacturer for water vapor permeance rating and vapor retarder requirements.⁶

Concrete/concrete block steam room construction has an Environmental Classification of Com 4 and Res 4 according to the TCNA Handbook for Ceramic, Glass and Stone Tile Installation. For more information on classifications, please refer to the Environmental Classifications section of the TCNA Handbook.

2.2 Cement Backer Board

A type of steam room construction, which has become extremely popular in recent years is steel or wood framing with a suitable backer board. It is critical that a vapor diffusion retarder (vapor barrier) and sufficient insulation be properly specified, designed and installed in this type of construction to prevent moisture from penetrating into adjacent spaces or condensing within the wall cavity and insulation. While this type of construction is rated Res4 by the TCNA, framed construction with backer board is the most popular choice for residential steam rooms, it may also be used for commercial steam room applications when good design and construction methods are used.

Prior to construction of the steam room, check with the board manufacturer to make sure that the backer board being used is suitable for use in a steam room environment, and ensure that the tile and tile installation materials selected are recommended for use in this type of harsh environment. LATICRETE manufactures a complete system of materials, which are ideally suited for steam rooms, steam showers and other wet or continuously submerged areas. Please refer to Section 4, Section 6, Section 7, and Section 8 for more information.

2.3 HYDRO BAN[®] Board

HYDRO BAN Board is an ideal option for both commercial and residential steam rooms. 2" (50mm) thick HYDRO BAN Board, when installed properly using HYDRO BAN Sheet Membrane Sealing Tape, HYDRO BAN Board Screws, HYDRO BAN Tab Washers (for ceilings), and HYDRO BAN provides insulation and a low perm

waterproof system for steam rooms and steam showers. For more information on HYDRO BAN® Board, please visit <https://laticrete.com/en/shower-installation-systems/accessories/hydro-ban-board>.

2.4 Stainless Steel

Stainless steel has become another option for steam room construction in both residential and in commercial projects. When you think about it, stainless steel is an almost ideal material from which to construct steam rooms; it does not allow moisture to penetrate, it will not corrode or rust (when a suitable high grade stainless steel and proper welding techniques and materials are used), it is not affected by the heat or moisture generated in a steam room, can be pre-manufactured in a factory (to maintain the highest construction standards) or welded together on-site, easily customized for exact requirements, requires little maintenance, and is much lighter than typical concrete construction.

The quality of the stainless steel (typically a 304L grade for fully tiled steam rooms) and choosing the best welding technique for the

stainless steel are important to ensure that there is no rust, steel corrosion or loss of durability over time.

There are two methods for tile installation with a stainless steel shell steam room/steam shower; direct adhered using epoxy setting materials, or, the mortar bed method using a sand/cement mortar bed which is installed over diamond metal lath which has been tack welded to the stainless steel shell. Please refer to Section 7 and Section 8 for more information.

2.5 Pre-manufactured Acrylic/Fiberglass Units

Another option for the residential steam room/steam shower market is the acrylic tub with fiberglass reinforcement. These are typically self-contained units which are lightweight, easy to install and economical. These units can contain many features including whirlpool jets, multiple shower heads, radios, massage therapy, aroma therapy and more. . . Acrylic/fiberglass units are pre-manufactured with a decorative acrylic finish and rarely, if ever, contain any tile or stone.



Figure 2.4.1 An acrylic tub and fully self-contained steam shower⁷

Section 3: Steam Room Design Considerations



3.1 Tile Industry Standards

The Tile Council of North America (TCNA) provides methods for the proper installation of tile, glass and stone in steam rooms and steam showers. TCNA provides Method SR613 for steam rooms and steam showers over masonry or concrete construction, and, Method SR614 for steam rooms and steam showers over steel or wood framed construction. 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, (F) +1.864.646.2821, 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 (F) +1.864.646.2821 or by e-mail at literature@tileusa.com.

Please refer to International Residential Code (IRC), International Building Code (IBC), International Plumbing Code (IPC), or, contact your local building officials for steam room codes and requirements.

The International Organization for Standardization (ISO) 13007 provides common performance standards for tile adhesives and grouts and uses a Performance classification rating for these product types. For more information or to purchase ISO 13007, please visit <https://www.iso.org/standards.html>.

LATICRETE International also provides installation methods and details for steam rooms and steam showers and is available at <https://laticrete.com/ag>; Methods ES-SR613, ES-SR614, ES-SR313, ES-SR314, ES-SR 614 Sheet Membrane BFD, ES-SR613 Sheet Membrane, ES-SR614 Sheet Membrane, ES-SR614 Sheet Membrane Linear Drain, ES-SR613 Sheet Membrane Linear Drain, ES-SR613 Sheet Membrane BFD, ES-SR614 HYDRO BAN Board BFD, ES-SR614 HYDRO BAN Board Linear Drain, ES-SR614 HYDRO BAN Board.

3.2 Structural Considerations

Loads — Steam rooms and steam showers are fairly unique for what is considered a wet area installation; the lack of large amounts of liquid water. Unlike swimming pools, fountains, tubs, and water features, the water in steam rooms exists primarily in a gaseous state, as steam. If properly designed and constructed, the steam, when it condenses into liquid water ends up going down the drain where it belongs. While this is not a significant revelation, it does

mean that the expected loads are considerably less than a fountain, pool or water feature with the same area footprint. This reduces some of the requirements for designing to meet heavier load carrying capacity and makes life somewhat easier for the structural engineer(s) and/or project architects.

In many cases, steam rooms and steam showers are constructed to the same load requirements as are considered for a standard shower or tub. Some elevated steam rooms and steam showers may require that different load requirements be considered (e.g. stainless steel steam rooms) but these are typically only under certain circumstances.

Requirements of Design — Steam rooms and steam showers can be somewhat complex in design. Although they appear to be simple (essentially a room within a room) they are far more than that. Steam rooms have to take into consideration the proper design, placement and installation of insulation, plumbing, low perm waterproofing membrane (e.g. HYDRO BAN® Sheet Membrane, or, waterproofing membrane and vapor diffusion membrane (vapor barrier), electrical/lighting, as well as proper air circulation and dehumidification in areas outside of the steam room/steam shower.

Failure to anticipate all of the requirements for steam room design can certainly lead to problems, sometimes excessive in nature, in the not too distant future. When designing such critical areas it may be in the best interest of all involved parties to either over-engineer or to seek the advice and counsel of industry professionals who have considerable experience with both the design and implementation of steam rooms/steam showers.

Deflection — Systems over which tile or stone will be installed, shall be in conformance with the International Building Code (IBC), International Residential Code (IRC) for One- and Two- Family Dwellings 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. In both cases “L” represents the clear span length of the supporting member per applicable building code.

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(s), including in-service loads or information to allow a project design professional to calculate such. The project design professional and general contractor must make necessary allowances for the expected live loads, concentrated loads, impact loads, and dead loads, including

maximum allowable loads during construction and maintenance. The tile installer 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 the 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. In many cases, problems in the substructure may not be obvious, and the tile contractor shall not be responsible for designing flooring assembly, unless specifically engaged to do so in writing. Tile contractor cannot determine possibility of an overloaded condition. In addition to deflection considerations, above-ground installations are inherently more susceptible to vibration.⁹

Section 3.3 Types of Structural Movement

Steam rooms and steam showers are structures (or part of 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 application.

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 steam room.

While a steam room is on and steam is being produced, the exposed surfaces can experience significant thermal movement. Temperature changes can go from 70°F (21°C) to 110°F (43°C) in less than 20 minutes so thermal movement can be rapid. The structure of the steam room, and any tile installed in the steam room, must be able to adjust to this temperature change. The tile immediately around the steam vent and supply pipe may see even higher temperatures and, therefore, more significant thermal movement. Movement caused by thermal expansion and contraction can create problems with a tile or stone installation, including cracking and/or loss of bond.

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 steam room/steam shower installations. Tile with a low absorption rate (<3%) would be better suited for use in steam room installations (see Section 4.1 for more information) as moisture expansion would be minimized.

Steam rooms/steam showers are very susceptible to moisture movement because the moisture is being forced into the room. This raises the pressure in the room and subsequently pushes the moisture vapor through the walls, ceiling and floor. Using tile, adhesive and grout that are recommended for submerged installations is very important to ensure that the tile installation remains in its intended place for the life of the steam room.

Differential Movement — Differential movement is another factor to take into consideration when installing tile or stone in steam rooms/steam showers. Some of the forces that act upon most types of construction will act upon a steam room to a much greater degree; along with normal live loads and dead loads, the thermal movement and the moisture expansion/contraction in a steam room are much greater than any typical application. This means that forces acting in different planes can have a greater effect on the tile or stone installation, as well as on the structure of the steam room. Proper allowance for movement within the steam room, and in its structural components, is critical to long and problem-free use of the facility.

3.4 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 building materials, etc. . .) as well as displacement against each other to occur without causing damage to the tile or stone installation within the steam room/steam shower. 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.⁹

Slip Joints — A slip joint is really nothing more than a movement joint which is constructed in such a way to allow a greater amount of movement to occur without compromising the waterproofing

Section 3: Steam Room Design Considerations

membrane or its ability to prevent water from getting through the system. For steam room applications there are several factors which require slip joint treatments. These factors include excessive thermal expansion/contraction, excessive moisture expansion/contraction, movement of multiple planes, dead loads, live loads, and pressure caused by the steam generation pushing out on the walls and ceilings.

Proper design and construction of slip joints will allow for the steam room/steam shower to operate properly and prevent damage within the wall space or to adjacent areas. (See Figure 3.4.1)

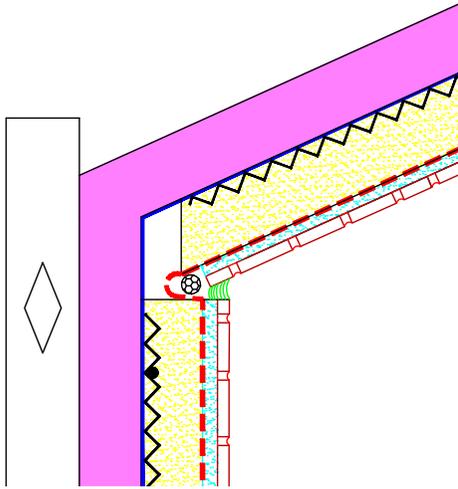


Figure 3.4.1 — Typical slip joint at ceiling-wall transition. Loop in waterproofing membrane allows for greater amount of movement within steam room construction.

Guidelines for Movement Joints — As a guide, when no project specific movement joint design exists for steam room/steam shower 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, seats, door jambs, 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 steam room/steam shower and these joints should be carried to the surface of the tile or stone installation directly in line with their original placement in the construction (see Slip Joints). Depending upon the size and construction method of the steam room, some of the joints in the structure may require a certain configuration (e.g. slip joint). This configuration will allow for a significant amount of movement to occur in the steam room but will not allow water (moisture vapor will pass through if the waterproofing membrane perm rating is too high) 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.

Movement Joint Treatment — Movement joints should be treated with a suitable sealant and installation should be done in conjunction with TCNA Handbook for Ceramic, Glass and Stone Tile Installation EJ-171 "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 given above. Therefore, follow recommendations of experienced manufacturers as to specific sealants suitable in the job environment. In some severe environments, a program for regular maintenance of sealant in joints may be required.¹⁰ In most cases, the use of a 100% silicone (e.g. LATICRETE LATASIL™ used with LATASIL 9118 Primer) or urethane sealant will be recommended for steam room/steam shower installations. Please refer to Section 6.6 for more information.

3.5 Steam Room Design Considerations

While some may think that steam rooms are essentially like any other application, it is absolutely not true!! Steam rooms are extremely unique and require special attention to detail during the entire design, construction, maintenance, and use process.

Steam rooms are highly specialized applications. Design and installation are critical to avoid damage to adjoining spaces and/or materials from vapor migration and condensation. Design criteria must include consideration of necessary insulation and temperature and humidity differential.¹¹

Residential vs. Commercial Steam Rooms

In steam room classifications there are two types; commercial steam rooms and residential steam rooms. While they provide essentially the same function, the scale to which each is required to perform are considerably different. As such, some of the construction requirements are different for each type.

Commercial steam rooms are typically larger in scale, utilize a large steam generator and tend to operate for extremely long periods of time. In fact, some commercial steam rooms in fitness clubs, spas and athletic facilities are rarely, if ever turned off. The amount of water that enters the room under pressure and at high temperatures can be extraordinary. If the steam room is not constructed properly or mistakes are made during the design phase the resulting problems can manifest themselves very quickly, can be catastrophic in scope and very, very expensive to correct. Fixing the problem(s) can take months and the downtime of the steam room facility can mean lost revenue for the host facility.

Residential steam rooms/steam showers, although performing the same function as commercial steam rooms, are typically much

Section 3: Steam Room Design Considerations

smaller in size, utilize a small steam generator and are operated only as needed (not continuously). The amount of steam that enters these rooms is usually less than the commercial units but can still be significant when compared to a regular shower unit. Proper design and construction are equally critical in residential steam room/steam shower applications because damage caused by moisture intrusion can be just as devastating in a home as in a commercial project.

The TCNA Handbook for Ceramic, Glass and Stone Tile Installation now utilizes Environmental Exposure Classifications to rate tile and stone assemblies as to the environment in which they should be used. Steam room method SR613 has Environmental Classifications of Com4 and Res4, while SR614 has an Environmental Classification of Res4.

Res4 (Residential High Humidity, Heavy Moisture Exposure): Tile surfaces that are subject to continuous high humidity or heavy moisture exposure. Examples include intermittent-use steam room/steam shower walls, ceilings and floors; enclosed pool area walls.

Com4 (Commercial High Humidity, Heavy Moisture Exposure): Tile surfaces that are subject to continuous high humidity or heavy moisture exposure, especially in enclosed areas. Examples: Continuous use steam room/steam shower walls and ceilings, enclosed pool areas, natatoriums, and gang showers.¹²

While the TCNA states that method SR614 is for Res4 applications only, proper design, implementation, construction, and maintenance of a commercial steam room utilizing framed construction is entirely possible. However, it is absolutely critical that high quality design and construction techniques are used to maintain the ultimate level of performance.

Steam Room Height

Since heat rises, so does steam. When a person is seated on a standard height steam room bench or seat, their head is usually 44 – 54" (1.12 – 1.37m) above the floor. In rooms that are greater than 96" (2.44m) in height, there will be at least 43" (1.09m) of space for steam and heat to accumulate before reaching an effective height for the user(s). In some cases, this can lead to extended warming times and wasted energy.¹³

Typical steam rooms rarely exceed 96" (2.44m) in height and may require special design considerations or equipment (e.g. higher output steam generator). In cases where steam room height will exceed 96" (2.44m) please consult with steam generator manufacturer for specific guidelines.

Low Perm Waterproofing Membrane/Vapor Diffusion Retarder (Vapor Barrier)

In an effort to more effectively define the use of membranes and their roles in steam room and steam shower applications, the TCNA has added guidance on what type of membrane, and its'

performance characteristics would be most suitable.

The TCNA Handbook now states "Steam showers designed for continuous use applications should specify a low perm waterproof membrane (a waterproof membrane meeting ANSI A118.10 and with a water vapor permeance rating of 0.5 perms or less when tested per ASTM A96 Procedure E, tested at 90% relative humidity). When a waterproof membrane with a water vapor permeance rating greater than 0.5 perms is specified, a vapor retarder behind the wall assembly is required, and the vapor retarder must have a water vapor permeance rating of 0.1 perm or less when tested per ASTM E96 Procedure A, tested at 50% relative humidity. Consult waterproof membrane manufacturer for water vapor permeance rating and vapor retarder requirements".¹⁴ LATICRETE offers HYDRO BAN® Sheet Membrane as a low perm sheet type waterproof membrane and acts as both the vapor diffusion retarder and as the waterproofing membrane.

A vapor diffusion retarder (commonly referred to as a vapor barrier) is a material that reduces the rate at which water vapor can move through the material. By limiting the amount of moisture to move through the system into adjoining spaces, a vapor diffusion retarder (vapor barrier) can eliminate (or extremely minimize) the amount of damage which can occur due to water penetration into wall cavities and adjoining spaces.

Keep in mind that a steam room/steam shower utilizes a steam generator, which forces hot water vapor into the room under pressure. This pressure forces the hot water vapor through the wall system to areas of lower pressure, or, areas of higher moisture concentration to areas of lower concentration. If a vapor diffusion retarder is not installed, is improperly installed or is not placed

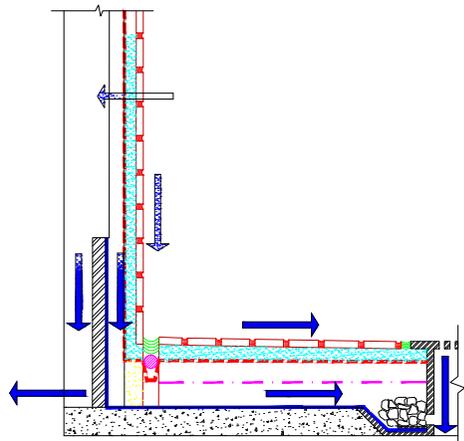


Figure 3.5.1 — Movement of moisture in a steam room application without insulation, low perm waterproofing membrane or vapor diffusion retarder.

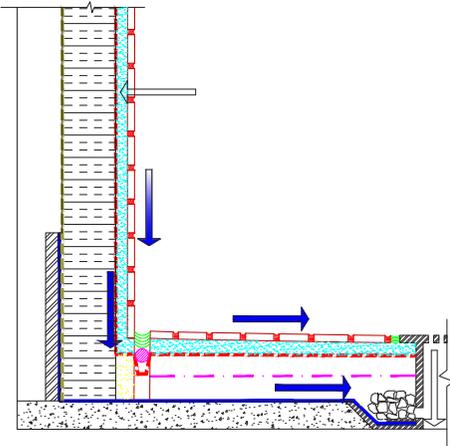


Figure 3.5.2 – Movement of moisture in a steam room application with a vapor diffusion retarder (green dotted line) properly installed to drain into the pan liner.

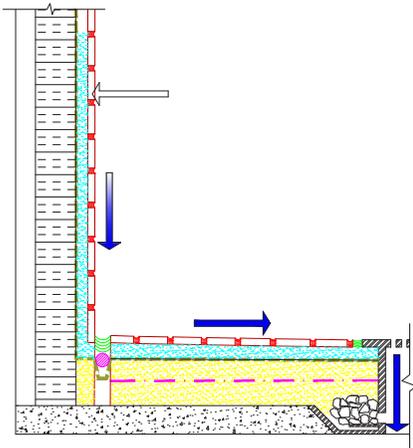


Figure 3.5.3 – Movement of moisture in a steam room application with a low perm waterproofing membrane (green dotted line) so that it drains into the primary shower pan liner, then water infiltration into the wall cavities will occur. The proper use of a suitable vapor diffusion retarder, along with suitable (and properly placed) insulation is critical to the long term performance of the steam room/steam shower and the protection of adjacent or ancillary spaces. Refer to Section 6.3 and Section 8 for proper placement of a vapor diffusion retarder (vapor barrier).

Waterproofing

Waterproofing membranes are designed to prevent the movement

of water molecules through the membrane and into the surface to which they are adhered. Many of these waterproofing membranes (e.g. HYDRO BAN, HYDRO BAN Sheet Membrane, HYDRO BAN Quick Cure, and 9235 Waterproofing Membrane) do allow for the movement of moisture vapor through the membrane, thereby making them an ideal choice for use steam rooms but only in conjunction with a properly installed vapor diffusion retarder (vapor barrier). Steam or moisture vapor molecules are much smaller than liquid water molecules and will therefore penetrate a substrate and many waterproofing membrane much easier than water.

Steam rooms and steam showers must also be waterproofed to keep the water within the vessel and from causing damage to surrounding areas. The proper placement of a low perm waterproofing membrane, or, a vapor diffusion retarder (vapor barrier) AND a suitable waterproofing membrane are essential to keeping water and water vapor where they belong; inside the steam room and then down the drain! The specified waterproofing membrane should be installed on every surface – walls, floor, ceiling, and seats, and must be properly tied into the drain and any penetrations through the walls, ceiling or floor to prevent water from escaping the confines of the steam room. The floor must be pre-pitched to the drain prior to installation of the shower pan liner and subsequent mortar bed and waterproofing membrane.

As stated in the TCNA Handbook for Ceramic, Glass and Stone Tile Installation, “Specifier shall indicate how waterproofing and vapor retarding is to be achieved, including details for membrane penetrations, such as penetrations for plumbing, lighting fixtures, fasteners, etc. . . . Specifier shall also indicate where and how to waterproof curbs and jambs and where membrane terminates. Area outside steam shower door is a wet area and should be treated accordingly.”¹⁵

The waterproofing membrane must be ideal for use in a steam room/steam shower environment and be compatible with the tile or stone thin-set. HYDRO BAN®, HYDRO BAN Sheet Membrane, HYDRO BAN Quick Cure, and 9235 Waterproofing Membrane are all excellent choices and are designed to be used with LATICRETE thin-sets (e.g. 254 Platinum, 257 Titanium or MULTIMAX™ LITE) or epoxy adhesive (e.g. LATAPOXY® 300 Adhesive) suitable for use in this challenging application. For installation of glass tile or glass mosaics, we would recommend using HYDRO BAN Cementitious Waterproofing Membrane followed by installation of the glass tile or glass mosaics using LATICRETE Glass Tile Adhesive, 254 Platinum, 257 Titanium, or LATAPOXY 300 Adhesive.



Figure 3.5.4 – Installation of tile in a steam room directly onto 9235 Waterproofing Membrane.

Insulation

Insulation within the walls and ceiling of the steam room is also an important consideration in the design of steam rooms and steam showers. Insulation helps to minimize temperature differentials, raise dew point, decrease condensation on the vapor diffusion retarder (vapor barrier), and, depending on the type and placement of the insulation, can act as something of a vapor reducing material itself.

Thermal energy moves from hot to cold, so we lose heat from inside

to outside in cold months and lose coolness in the summer as heat attempts to come inside a building. The same concept will apply to a steam room application, the heat in the steam room will try to leave the room, so proper placement of a suitable insulation works well to keep the heat in the room and to control dew point within the wall structure.

As stated in the TCNA Handbook for Ceramic, Glass and Stone Tile Installation, “Design professional to specify adequate insulation on walls and ceilings to reduce condensation. Consult the insulation manufacturer for application suitability.”¹⁶

For installations following method ES-SR613, the use of a rigid foam insulation board is frequently specified to be installed over the concrete or concrete block construction over the vapor barrier. For installations following method ES-SR614, the use of either rigid foam insulation or batt type insulation is employed within the framed construction and placed underneath the vapor retarder, or, on top of the wood construction with the vapor retarder behind it. It is the responsibility of the project design team to determine the exact configuration of all elements of the steam room wall, ceiling and floor configuration.

Dew Point

The use of a vapor diffusion retarder (e.g. 6 mil polyethylene,

Air Temperature °F (°C)	Dew Point Temperature in °F (°C) At A Relative Humidity Of						
	40%	50%	60%	70%	80%	90%	95%
104 (40)	75 (24)	82 (27.7)	87 (30.8)	92 (33.5)	97 (35.9)	101 (38.1)	102 (39.1)
100 (38)	72 (22)	78 (25.7)	84 (28.9)	89 (31.6)	93 (34)	97 (36.1)	99 (37)
97 (36)	69 (20)	75 (24.1)	81 (27)	85 (29.7)	90 (32)	94 (34.2)	95 (35.1)
93 (34)	65 (18)	72 (22.2)	77 (25.2)	82 (27.9)	86 (30.1)	90 (32.1)	92 (33.1)
90 (32)	62 (17)	69 (20.3)	74 (23.3)	78 (25.8)	83 (28.2)	86 (30.2)	88 (31.2)
86 (30)	59 (14.9)	65 (18.4)	71 (21.4)	75 (23.9)	79 (26.1)	83 (28.2)	84 (29.1)
84 (29)	57 (14)	64 (17.6)	69 (20.5)	73 (23)	77 (25.2)	81 (27.3)	83 (28.2)
82 (28)	56 (13.1)	62 (16.6)	67 (19.4)	72 (22.1)	76 (24.3)	79 (26.2)	81 (27.2)
81 (27)	54 (12.3)	60 (15.7)	65 (18.6)	70 (21.1)	74 (23.3)	77 (25.2)	79 (26.1)
79 (26)	53 (11.4)	59 (14.8)	64 (17.7)	68 (20.1)	72 (22.3)	76 (24.3)	77 (25.2)
77 (25)	51 (10.5)	57 (13.8)	62 (16.7)	66 (19.1)	71 (21.4)	74 (23.3)	76 (24.2)
75 (24)	49 (9.6)	55 (12.9)	60 (15.7)	65 (18.2)	69 (20.3)	72 (22.3)	74 (23.2)
73 (23)	48 (8.7)	54 (12)	59 (14.9)	63 (17.3)	67 (19.4)	70 (21.3)	72 (22.2)
72 (22)	46 (7.8)	52 (11.2)	57 (13.9)	61 (16.3)	65 (18.4)	69 (20.3)	70 (21.2)
70 (21)	44 (6.9)	50 (10.2)	55 (12.9)	60 (15.4)	63 (17.4)	67 (19.3)	68 (20.2)
68 (20)	43 (6)	49 (9.3)	54 (12)	58 (14.4)	62 (16.5)	65 (18.4)	67 (19.2)
66 (19)	41 (5.1)	47 (8.3)	52 (11.1)	56 (13.4)	60 (15.5)	63 (17.4)	65 (18.2)
64 (18)	40 (4.2)	45 (7.4)	50 (10.1)	54 (12.4)	58 (14.6)	61 (16.3)	63 (17.3)
63 (17)	38 (3.3)	44 (6.5)	49 (9.2)	53 (11.5)	56 (13.6)	60 (15.4)	61 (16.2)
61 (16)	37 (2.5)	42 (5.6)	47 (8.3)	51 (10.6)	55 (12.7)	58 (14.6)	60 (15.5)
59 (15)	35 (1.6)	40 (4.7)	45 (7.4)	49 (9.6)	53 (11.7)	56 (13.5)	58 (14.4)

Figure 3.5.4 – Dew point temperature chart¹⁸

polyolefin, etc. . .) will help to minimize the amount of moisture, which can transpire through the system. However, moisture vapor movement through the system is not the only way that moisture can manifest inside walls, floor or ceiling. Since some moisture will transpire through the vapor diffusion retarder (vapor barrier), some moisture will naturally exist in the air within a wall cavity, and some moisture will exist in adjacent spaces beyond the walls. This means that dew point can play a role in moisture development within a wall cavity.

Dew point is defined as the temperature to which a given amount of humid air must be cooled, at constant barometric pressure, for water vapor to condense into water. Dew point is associated with relative humidity and temperature (i.e. high relative humidity indicates that the dew point is closer to the current air temperature). Relative humidity of 100% indicates the dew point is equal to the current temperature and that the air is maximally saturated with water.¹⁷

What this means is that water can condense within a wall cavity if the dew point is reached, so controlling the amount of moisture that gets through the vapor diffusion retarder (vapor barrier) and maintaining control over the temperature in the air space will help to minimize or prevent any condensation which may occur. A high quality, properly installed vapor diffusion retarder (vapor barrier) along with a suitable type and thickness of insulation, or, a low perm waterproof membrane with a suitable type and thickness of insulation are the best defense to problems caused by fluctuating temperature and relative humidity.

The dew point table (Figure 3.5.4) below shows clearly at what point condensation will begin at specific RH and temperature. For example, if excessive moisture and heat is getting through the steam room wall, insulation and vapor diffusion retarder (vapor barrier), thereby raising the air temperature and the relative humidity (RH) in the wall cavity to 86°F (30°C) and 90% RH then water will condense on any surface that is 83°F (28.2°C) or below. Since surface temperatures are typically colder than the air temperature, it simply means that water will be present on all surfaces in a very short amount of time. Over time, this water accumulation may well become an issue of water damage and mold proliferation, unless the wall cavity is somehow vented or conditioned to remove the water.

Maintaining humidity in the wall cavity at low levels, and keeping the temperature moderate, means that condensation will not form within the wall cavity. As stated earlier, properly specifying and installing insulation and a high quality vapor diffusion retarder (0.1 Perms or lower as tested per ASTM E96 - Procedure A) helps to

maintain a healthy and safe environment for all to enjoy. Based on the chart on previous page (Figure 3.5.4), if the temperature in the wall cavity of a steam room is 82°F (28°C) and the RH in the wall cavity is 80%, typically because a high perm (>0.5 perms) vapor diffusion retarder (vapor barrier) is used, the dew point is 76°F (24.3°C) or below. This means that there is an excellent chance that moisture will condense on any surface at or below the dew point temperature. Conversely, if a low perm (<0.1 perms) vapor diffusion retarder (vapor barrier) is utilized in the wall assembly, and the resulting RH within the wall cavity is 40% at a temperature of 82°F (28°C), the resulting dew point temperature is 56°F (13°C). This simply means that the temperatures on the surfaces in the wall cavity should remain high enough so that the dew point temperature is not reached and condensation does not take place.

There is no better way to control the amount of condensation inside a wall cavity than to properly specify a high quality vapor diffusion retarder (vapor barrier) with a waterproofing membrane, or a low perm waterproof membrane (such as HYDRO BAN® Sheet Membrane) along with controlling the temperature of the wall cavity with suitable insulation.

Floor (Shower) Pan

Due to the amount of moisture to which a steam room/steam shower will be subjected, reason dictates that a primary shower pan liner must be installed underneath the mortar bed floor. This shower pan liner is designed to prevent water from migrating through the floor of the steam room/steam shower and get into the structure where damage may occur.

Like any shower application, the subfloor must be pre-pitched to make sure that any water which gets down to the shower pan liner will eventually work its way, via gravity, to the weep holes of the drain. If the subfloor is not properly pre-pitched, water that may accumulate in the mortar bed will tend to remain in place and can lead to health and safety issues. The pre-pitch can be created using 3701 Fortified Mortar, 226 Thick Bed Mortar gauged with 3701 Mortar Admix or a proprietary material specifically manufactured to provide a pitch to drain underneath a shower pan liner and mortar bed. Check with product manufacturer for suitability and acceptability as well as proper installation instructions.

Once the pre-pitch is established, the installation of the shower pan liner can begin. The shower pan liner in a steam room/steam shower application usually consists of a proprietary sheet type membrane if steel or wood framed construction is used to make the steam room/steam shower, or, a liquid applied membrane (e.g. HYDRO BAN®, HYDRO BAN Quick Cure, or 9235 Waterproofing

Membrane) if concrete or concrete block construction is used. The shower pan liner must be turned up walls a minimum of 3" (75mm) above shower curbs or flood point. Liquid applied membranes can be used in steam rooms with framed construction if an approved suitable sheathing is applied to the framing prior to installation of the vapor diffusion retarder (vapor barrier).

A critical design consideration for steam rooms and steam showers is that the vapor diffusion retarder (vapor barrier), if placed behind the backer board or wall render, **MUST** be placed so that it laps into the shower pan. This allows for any moisture that condenses on the vapor diffusion retarder (vapor barrier) to go into the shower pan liner. Failure to follow this recommendation means that any accumulated moisture will get into the wall cavity and possibly into ancillary or adjacent spaces. Please refer to Sections 7 & 8 for more information on the proper design and LATICRETE materials for use in steam rooms/steam showers.

Slope to Drain

To make sure that water flows to the drain at a rate that allows for constant and rapid removal of water, the Tile Council of North America recommends a slope to drain of 1/4" per foot (21mm per m) or a ratio of 1:48 for floors. As stated above, the pitch to drain should be established in the pre-pitch, which allows the mortar bed, installed over the shower pan liner, to remain a consistent thickness. Installation of a liquid waterproofing membrane (e.g. HYDRO BAN, HYDRO BAN Quick Cure or 9235 Waterproofing Membrane) onto the cured mortar bed and then onto the finished walls and ceiling creates a seamless waterproofing. This secondary waterproofing helps minimize the amount of water that can infiltrate through the tile and into the mortar bed. Water will evacuate through the top of the drain at an acceptable rate if proper pitch has been established.

According to Uniform Plumbing Code (UPC) 411.8; All lining materials shall be pitched one-quarter (1/4)" per foot (21mm per m) to weep holes in the sub-drain of a smooth and solidly formed sub-base.

As stated in UPC 411.6; The finished floor of the receptor shall slope uniformly from the sides toward the drain not less than one-quarter (1/4) inch per foot (21mm per m), nor more than one-half (1/2) inch per foot (42mm per m).

2012 International Plumbing Code (IPC) 417.5.2 states: "Liners shall be pitched one-fourth unit vertical in 12 units horizontal (2% slope) and shall be sloped toward the fixture drains and be securely fastened to the waste outlet at the seepage entrance, making a watertight joint between the liner and the outlet".

American National Standards Institute (ANSI) A108.01.2.2 states: Specify floor drains to comply with ANSI A112.21. Slope in subfloor

shall be specified in sections such as concrete or carpentry and not with the mortar setting bed. Mortar bed to be of uniform thickness.

ANSI A108.01 3.6.2 states: Prior to applying waterproofing membranes. Most plumbing codes require that floors of showers and roman tubs be sloped, by means of a smooth and solidly-formed sloping sub-base, to weep holes located in clamp style drains.

Note: All horizontal ledges/rimms shall have a slope such that any fluid on their surfaces flows towards the drain.¹⁹ This includes not only floors and ceilings, but also niches, seats/benches, curbs, and shelves. Follow all building code and ADA requirements for load bearing capacity and for grate free area of the drain(s).

Ceiling Slope

Since rising steam will condense and collect on the ceiling of a steam room/steam shower and then drip on steam room users, it is necessary that a slope is established in the ceiling. As stated in the TCNA Handbook for Ceramic, Glass and Stone Tile Installation "Slope ceiling minimum of 2" per foot (164mm per m) to avoid condensate dripping onto occupants; sloping ceiling from center can minimize rundown on walls.²⁰

Steam Generator Unit

The steam generator is the "heart" of a steam room/steam shower and is the source of the water vapor and heat around which a steam room is designed. These steam generator units can range in size, steam output capacity, amount of energy required, and amount of steam generated. The size and output capacity of the steam generator is determined almost entirely on the size of the steam room, as measured in cubic feet (ft³) or cubic meters (m³).

Steam generators for small residential steam rooms/steam showers can be the size of a small briefcase and weigh as little as 30 lbs (13.6 kg), or, for large commercial steam rooms the steam generator can be approximately 40" long x 22" wide x 30" high (1015 x 560 x 762 mm) and weigh about 250 lbs (113.6 kg). Steam generators are available in a wide range of sizes to meet all types steam room demands. Some of the large steam generators can provide enough steam for up to 3,000 ft³ (85 m³). Larger steam rooms can use multiple steam generators to meet the specific requirements. Check with the steam generator unit manufacturer or supplier for proper selection of the unit in regards to size of the steam room/steam shower, finish type, and with electrical and water supplies. To properly size a steam room, for determination of the steam generator output, it is necessary to use the following guidelines;

1. Calculate the cubic ft (cubic m) by multiplying height (H),

Section 3: Steam Room Design Considerations

width (W) and length (L): $H \times W \times L = \text{ft}^3 \text{ (m}^3\text{)}$;

- Do not deduct the area assumed by benches or other solid materials within the room as their surfaces represent area to heat;
- Due to varying thermal values of the steam room/steam shower finish or wall location, use the following multipliers to ensure proper steam and heat generation;

Acrylic or Cultured Marble	$\text{ft}^3 \text{ (m}^3\text{)} \times 0\%$
Glass or Glass Block Wall	$\text{ft}^3 \text{ (m}^3\text{)} \times 15\%$
Exterior Wall Exposed To Freezing Temperatures	$\text{ft}^3 \text{ (m}^3\text{)} \times 15\%$
Ceramic Tile (non-porcelain)	$\text{ft}^3 \text{ (m}^3\text{)} \times 20\%$
Natural Stone (Granite, Marble) or Porcelain Tile	$\text{ft}^3 \text{ (m}^3\text{)} \times 100\%$

Steam generators require plumbing, electricity and placement within approximately 25 ft (7.6 m) of the steam room for maximum efficiency. Steam outlet plumbing (steam feed) should be insulated if it is greater than 10' (3 m) in length and should never form a gully or trap between the steam generator and the outlet. The steam outlet plumbing should always angle toward the steam outlet head or to the steam generator. They must be installed indoors, in an area where the unit will not freeze and is located away from flammable materials or compounds. It should also be placed where it is easily accessible for installation, inspection and maintenance. Follow local building code requirements for accessibility and minimum clearance from walls, ceilings and doors. Some local code requirements for large steam generators state that a blow-down tank be used to cool hot water (above 140°F [60°C]) before it is dumped into a drainage system.

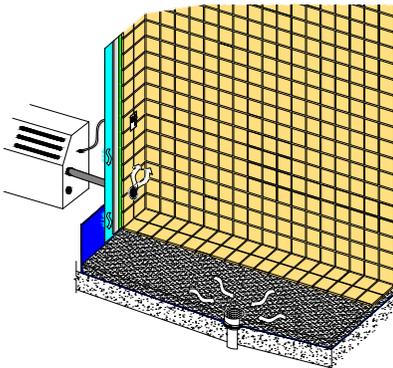


Figure 3.5.5 – How steam enters steam room and the condensate water evacuates.



Figure 3.5.6 – Steam outlet head with diffuser²¹

The steam outlet head should be placed on a wall which is opposite from where bathers will be seated and as far away from the occupants as possible. In small steam rooms/steam showers (3' x 4' or 4' x 4' [0.9 x 1.2 m or 1.2 x 1.2 m]), a steam diffuser should be installed to protect the user.

Doors

Steam room doors must be able to allow easy access and keep steam and water within the confines of the steam room/steam shower. A door manufactured for use in steam rooms/steam showers should be constructed of moisture and corrosion resistant materials, tempered safety glass, and vapor tight gaskets. These doors should be specifically designed for use in steam rooms/steam showers. In most cases, it is recommended that the steam room be fully constructed and finished prior to ordering the door. Waiting for the tile to be installed, when actual finished measurements can



Figure 3.5.7 – Glass steam room door²²

be taken, will better guarantee superior fit and performance of the door. Steam room doors are typically self-closing and vented at the bottom where steam should not escape. Choosing a door incorrectly or placing it improperly can cause problems within the steam room and in the room in which the steam room is located.

Both door types are equally effective at maintaining a suitable seal and preventing the loss of steam and heat. Doors used in steam rooms/steam showers should always open out (away from the steam room) to maintain a safe environment and to maximize the space inside a steam room/steam shower.

Seats

Seating inside a steam room/steam shower should meet certain requirements to maintain safety and functionality. Seats must be comfortable and made from products that are impervious to moisture (e.g. HYDRO BAN® Seat for residential steam showers). Tile or stone are a perfect choice for finishing steam room/steam shower seats, but the grout joints should be kept at a minimum width to facilitate comfort and maintain aesthetic qualities.

Steam room/steam showers seats, like shower seats, should be sloped towards the drain at an angle that allows water to flow but is still comfortable to sit on. The tile installed where the seat meets the riser must be rounded for greater comfort, and many seats provide a lip of 1" to 2" (25 to 50mm) which overhangs the seat. Generally, steam room/steam shower seats can range from 18" – 21" (455 – 530mm) off the floor and from 14" – 24" (350 – 610mm) deep. Some commercial steam rooms are large enough to have two-tiered seating, in which case the tile installed on the lower seat should be slip-resistant in wet areas.

Plumbing

Like any shower or wet area, plumbing is required to bring the water into the system and take it away safely and effectively. In a steam shower, plumbing is required to bring the water into the room in two ways; as steam vapor and as liquid. It is highly recommended that a professional plumbing contractor be used to ensure that shower pan liners, drains, pipes, diverters, shower heads, steam generator, and all required pipes are installed properly and per local plumbing codes. Failure to properly control the water and vapor coming into and leaving the steam room/steam shower could result in considerable damage over a very short amount of time. Check with the steam generator and/or steam room manufacturer (for modular units) for any plumbing requirements and guidelines.

Lights and Electrical

It makes perfect sense that water and electricity do not go together

well and steam rooms require electricity to provide lighting and allow for regulation of many electronically controlled steam room environments. It is highly recommended that a professional electrician be brought in to ensure that the steam generator, lights, electronic thermostats and steam controls, speakers (if so equipped), aroma oil pumps (for aromatherapy), timers, and any other electrical components are installed properly and per local electrical codes. Failure to install electrical components properly can result in serious injury or worse. All electrical equipment must be installed with Ground-Fault Circuit Interrupter (GFCI) protection or as required by local electrical code.

All electrical equipment, located within the steam room or wall cavity, must be water and vapor proof and constructed of materials that are sealed and corrosion resistant (e.g. stainless steel). Lighting can be mounted in the ceiling or on the walls of steam rooms to help set the mood and ambiance of a steam room environment, and can help add to the relaxing experience. Please make sure that any electrical equipment used in the steam room environment is manufactured or recommended for use in a steam room environment.

3.6 Building Code and Safety Considerations

Although there are no specific requirements or references to steam room/steam shower applications in the International Residential Code (IRC), International Building Code (IBC) and National Electrical Code (NEC) Handbook, it would be recommended to follow the code requirements for Spas and Hot Tubs. Please consult local building codes which may have requirements for steam room enclosures. For example, the following is from the Long Beach (CA) Development Services Building Code;

"Glazing in doors and enclosures for hot tubs, whirlpools, saunas, steam rooms, bathtubs and showers. Glazing enclosing these compartments shall be safety glazing where the bottom-exposed edge of the glazing is less than sixty inches (60) above a standing surface and drain inlet."²³

The following is from the London (UK) Borough of Hillingdon Code of Practice;

"The electrical safety, including the adequate earthing and insulation of all equipment, should be examined periodically by a qualified engineer who should report in writing the result of his inspection. Equipment must be regularly serviced in accordance with the manufacturer's instructions and a record of such services and copies of the electrical engineer's report must be kept on the premises for inspection if required in accordance with the latest IEE (Institute of

Electrical Engineers) requirements.”²⁴

Codes may not only define construction requirements but also safety considerations. The following is also taken from the Borough of Hillingdon Code of Practice and addresses safety concerns;

“The operator must be aware of the temperature the unit is operating at. Ideally there should be a thermometer located inside the unit. If this is not fitted the temperature inside the unit must be checked regularly and in accordance with usage and a log maintained of the temperature.”

“Sauna/steam room doors must have a glazed panel to allow safe access and egress by clients and supervising staff.”

“The door must have an internal handle to allow the client to exit the room when required.”

“The licensee shall have a written policy detailing the action to be taken in the event of the alert mechanism being used. This shall be communicated to all relevant personnel.”

“All equipment shall be of sound mechanical construction.”

“A clock or timer must be visible in order to monitor time elapsed in the sauna/steam room.”

“A notice providing accurate information on the safe use of the sauna/steam room must be clearly displayed near each unit.”

The safe use of steam room/steam showers is paramount to those who own, operate, use and maintain these beneficial facilities. There are several steps which must be taken into account so that nobody who uses a steam room/steam shower will ever be injured:

- Anyone with pre-existing medical conditions should consult with their physician prior to using the steam room facility. Some of these conditions include (but are not limited to) high blood pressure, heart disease or other cardiovascular issues, and fever.
- Individuals who may be especially prone to problems in steam rooms include the elderly, young children and pregnant women. Check with your physician prior to using the steam room facility.
- Open cuts may become infected in the moist warm environment of a steam room.
- Sweating, even in a steam room, can lead to dehydration. Drink lots of water after leaving a steam room/steam shower.
- Steam rooms/steam showers should not be used as a part of weight loss program. Any weight loss due to time in a steam room would be from water loss, which will return when body fluids are replenished.

- Drugs, tobacco and alcohol should never be used prior to entering a steam room/steam shower or while in the steam room/steam shower.
- Consult your physician about the use of medications and steam room exposure.
- Do not consume heavy meals prior to steam room exposure.
- Exit immediately if you feel uncomfortable, dizzy, sluggish or sleepy. Staying in a steam room environment for too long can cause overheating and other health issues.
- Do not stay in a steam room/steam shower for longer than 10 – 12 minutes and follow with a cool shower to lower body temperature to normal levels.
- Remove all jewelry prior to entering the steam room/steam shower.
- Supervise any children while they are in the steam room/steam shower.
- Do not make contact with the steam head during operation.
- Use caution when entering, exiting and moving around in steam room/steam shower as floor and other horizontal surfaces (e.g. seats) may be slippery.

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

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 steam room as part of a 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 steam room/steam shower to become sick. Occupants who utilize facilities inside buildings constructed with high VOC materials 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 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 organic compounds. 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-lead/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 GREENGUARD® Gold) 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

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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 has also introduced 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. Please visit www.laticrete.com to use this incredible tool.

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 GREENGUARD as such. LATICRETE manufactures UL GREENGUARD Gold certified products in the underlayment, membrane, thin-set, 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 steam room/steam shower suitable products are UL GREENGUARD Gold certified for low VOC; HYDRO BAN[®], 9235 Waterproofing Membrane, HYDRO BAN Quick Cure, 3701 Fortified Mortar Bed, 257 TITANIUM[™], 254 Platinum, MULTIMAX[™] LITE, LATAPOXY[®] 300 Adhesive, LATAPOXY BIOGREEN[™] 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. LATASIL 9118 Primer also meets the LEED EQ Credit 4 requirements for low VOC content for architectural, porous sealant primers.

Section 4: Selection Of Steam Room/ Steam Shower Tile



4.1 Considerations for Tile Selection

The beauty, durability, resistance to heat and moisture, and functionality of tile or stone makes them the most suitable finishes for cladding steam rooms/steam showers. While there are other suitable cladding materials, none are as versatile, long lasting and affordable as tile. There are many types of tile and stone in the world, but not all of them are suitable or functional in a steam room/steam shower installation. Choosing a tile or stone that is suitable for steam room/steam shower applications is important for the long-term performance of the tile or stone installation. In some ways, steam rooms/steam showers (especially commercial steam rooms) are similar to swimming pools, fountains and spas based on the amount of moisture to which they will be subjected.

Generally speaking, tile or stone used in steam room/steam shower installations must have a low absorption rate, a high coefficient of friction, an acceptable coefficient of thermal expansion, resistant to moisture expansion, and chemical resistant. Tile used in steam rooms/steam showers 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 Whiterware Products” and ISO 10545-3 “Ceramic Tiles – Determination of Water Absorption, Apparent Porosity, Apparent Relative Density, and Bulk Density” and is important for selecting tile or stone for steam room/steam showers or any wet areas. These test methods determine the percentage difference between dry and wet weight of the tile.

Tile for use in steam room/steam shower installations should also be tested to ASTM C370 “Standard Test Method for Moisture Expansion of Fired Whiterware Products” and ISO 10545-10 “Ceramic Tiles – Determination of Moisture Expansion” to determine the extent to which tile will expand when exposed to moisture. Moisture expansion is directly proportional to absorption; the lower the absorption, the greater the resistance to moisture expansion and vice versa. 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 these demanding environments. The most commonly used tile types for steam room/steam shower installations are porcelain since they provide the lowest absorption rates. Glass tile is also used in steam shower/steam room installations, but it would be recommended to check with the glass tile manufacturer for use in steam room/steam shower environments. It is also important to check with the manufacturer, distributor or quarry (for stone) to see if a particular type of stone would be unsuitable for steam room/steam shower applications. Ceramic and porcelain tile characteristics are also addressed in the ANSI A137.1 American National Standard Specifications for Ceramic Tile. Tile or stone which has a high resistance to thermal expansion is also a great benefit for a steam room/steam shower installation. Linear thermal expansion of tile is determined by ASTM C372 “Standard Test Method for Linear Thermal Expansion of Porcelain Enamel and Glaze Frits and Fired Ceramic Whiterware Products by the Dilatometer Method” and ISO 10545-8 “Ceramic Tiles – Determination of Linear Thermal

Classification of Ceramic Tile by Water Absorption ISO (International Standards Organization) CEN (European Norms)				
	Group I	Group II	Group III	Group IV
Absorption	≤3%	3 – ≤6%	6 – ≤10%	>10%
Group A Extrusion	Group A1	Group AIIa	Group AIIb	Group AIII
Group B Dust-Pressed	Group B1	Group BIIa	Group BIIb	Group BIII

Figure 4.1.1 Classification of ceramic tile by water absorption (ISO and EN Standards)²⁷

Tile Class and Corresponding Water Absorption (WA) Ranges ANSI 137.1 Standards				
Forming Method	Impervious (Porcelain) WA ≤0.5%	Vitreous >0.5% WA ≤3.0%	Semi-Vitreous >3.0% WA ≤7.0%	Non-Vitreous >7.0% WA ≤20.0%
Pressed	P1	P2	P3	P4
Extruded	E1	E2	E3	E4
Other	O1	O2	O3	O4

Figure 4.1.2 Classification of ceramic tile by water absorption (ANSI Standards)²⁸

Section 4: Selection Of Steam Room/Steam Shower Tile

Expansion.” The results of thermal expansion testing are expressed as the linear coefficient of thermal expansion in units of in./in./°F (mm/m/°C). Properly choosing tile or stone with acceptable thermal expansion properties is useful for minimizing stresses within the installation under conditions of changing thermal exposures. Glass tile typically has a higher rate of thermal expansion than porcelain or other suitable ceramic tile or stone.

Tile with a high coefficient of friction is an important characteristic of tile in steam rooms and wet areas to help maintain the safety and well-being of all who use these areas. Keep in mind that the 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 should be easily cleanable, maintain its color when exposed to various chemicals and stated for use in submerged and/or steam room installations by the manufacturer. Tile or stone suitable for submersion should also be acceptable for steam room/steam shower applications as long as they meet thermal expansion requirements. Choosing the wrong tile can lead to down time for the steam room/steam shower, added expense removing the old tile, reinstallation of a suitable tile, and other potential issues that can occur when a steam room is not in use.

Abrasion resistance 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 4.1.3. Testing for abrasion resistance is conducted as per ASTM C1027 “Standard Test Method for Determining Visible Abrasion Resistance of Glazed Ceramic Tile” and ISO 10545-7 “Ceramic Tiles - Determination of Resistance to Surface Abrasion for Glazed Tiles” and are for glazed tile only. In most cases, non-glazed porcelain tile is highly resistant to abrasion, but check with tile manufacturer for complete information. Tile used in residential steam rooms/steam showers

Class	Maximum Recommended Use
0	Not Recommended for Floors
1	Light Residential
2	Residential
3	Heavy Residential or Light Commercial
4	Commercial
5	Industrial

Figure 4.1.3 – Visible Abrasion Classification²⁹

areas should be PEI 4 or higher and commercial steam rooms should also have a rating of PEI 4 or higher.

Failure to properly choose and specify a tile for steam rooms/steam shower 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 4.3 while suitable setting materials are covered in Section 6.

Tile should also be chemical resistant to make sure that chemicals, often used to clean steam rooms, do not have a negative effect on the performance of the cladding material. The definition of chemical resistance is the behavior of tile to resist damage when it comes into contact with aggressive chemicals. Chemical resistance actually measures deterioration caused by two mechanisms; 1) chemical reaction resulting in alteration of tile, and, 2) penetration of a chemical or stain below the tile surface, and difficulty of removal resulting in long-term deterioration or effect on materials in contact with the surface. Chemical resistance is measured by ASTM C650 “Standard Test Method for Resistance of Ceramic Tile to Chemical

Chemical Resistance Class	Maximum Number of Affected Samples
A	0
B	1
C	2
D	3
E	4 or more

Figure 4.1.4 Chemical Resistance Classification when tested per ASTM C650³⁰

Stain Resistance Class	Maximum Number of Affected Samples
A	0
B	1
C	2
D	3
E	4 or more

Figure 4.1.5 Stain Resistance Classification when tested per ASTM C1378³¹

4.2 Placement of Tile in Steam Room/Steam Shower Installations

Tile can be installed in almost any area within a steam room/steam shower 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 internal area of the steam room/steam shower, as long as a suitable substrate is provided. Tile is often placed on the ceiling, walls, and floors of a steam room. Tile can certainly be installed on benches or seats in steam rooms, although some people find it uncomfortable to sit on tile with grout joints wider than 1/8" (3mm).

Tile is a very popular finish option for floors both inside and immediately outside of steam rooms, and choosing a tile or stone for these areas can have a significant, positive visual and safety impact. A steam room/steam shower's functional performance depends largely on the correct use of slip resistant materials in the various areas (e.g. floors, lower seats if more than one level exists, 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's slip-resistant performance is maintained.

The tile or stone finish on a steam room/steam shower floor must be slip resistant to minimize or eliminate slip fall accidents. Coefficient of friction (COF) is the measurement of a tile's frictional resistance and is closely related to traction and slipperiness. The method for measuring the COF of ceramic floor tiles changed in 2012, after years of research and with the approval of the committee responsible for ANSI A137.1 "The American National Standard Specifications for Ceramic Tile." Previously, COF was determined per the ASTM C1028 method "Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method" from a measurement of static friction, which is the frictional resistance one pushes against when starting an object in motion.

The new method measures dynamic coefficient of friction, which is the frictional resistance one pushes against when the object is already in motion. For both static coefficient of friction (SCOF) and dynamic coefficient of friction (DCOF), a slip occurs when pushing off with more force than the surface can resist.

Previously, there was no required coefficient of friction value in ANSI A137.1 for wet floors (static or dynamic), although a minimum value of 0.6 wet SCOF, when measured by ASTM C1028, was commonly specified for ceramic tile in commercial spaces for

many years. After extensive research it has been determined that a minimum wet DCOF value of 0.42 was sufficient when testing per the DCOF AcuTest method. The DCOF AcuTest method utilizes the BOT-3000 (Binary Output Tribometer-3000) and conforms to American National Standard B101.1 "Test Method for Measuring Wet SCOF of Common Hard-Surfaced Floor Materials", as well as, B101.3 "Test Method for Measuring Wet DCOF of Common Hard-Surfaced Floor Materials (Including Actual and Limit Thresholds for the Suitable Assessment of the Measured Values)." The DCOF Acutest Method is ideal for use in both laboratory and field conditions and is easy to conduct.



Figure 4.2.1 The BOT-3000 DCOF AcuTest Method apparatus³²

Not all tiles, though, with a wet DCOF value greater than 0.42 are suitable for all level interior spaces. The design professional(s) or specifier shall determine tile appropriate for specific project conditions, including, but not limited to, type of use, drainage, how tiles are profiled or structured, expected contaminants, expected maintenance, expected wear, and manufacturer's guidelines and recommendations.

There are other methods being utilized around the world and some of those test methods are;

1. The variable-angle ramp human traction test method as the primary standard for validation of portable slip-resistance methods;
2. The Tortus dynamic slip-resistance measuring instrument, with digital data acquisition, for wet testing, and the use of a trace of Triton X-100 wetting agent in distilled or deionized water as the wetting liquid. The minimum value using this test method for use in bathtubs, showers and pool decks is 0.70; and,
3. The pendulum dynamic slip-resistance measuring instrument for wet testing, and the use of the pendulum test guidelines recommended by the United Kingdom Slip Resistance Group. The minimum British Pendulum Number (BPN) on wet, clean flooring is 35 for showers.

The Tortus method and the Pendulum method are recommended for testing performed in the field and have achieved wide acceptance. These has also been significant information obtained using these test methods so as to correlate human traction test data with well-simulated mechanical analogs of human traction.³³

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 focus is on providing the best protection for all those who will be using the steam room/steam shower.

Another factor, which should be taken into consideration for steam room/steam shower tile installations, is what temperature the finish will be when exposed to steam. 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 may get extremely hot and create an uncomfortable environment for steam room/steam shower users.

4.3 Types of Tile for Steam Room/Steam Shower Applications

While the types of tile (e.g. impervious, vitreous, some stone, and glass) recommended for use in steam room/steam shower 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 3/8" x 3/8" (9.5 mm x 9.5 mm) to as large as 4' x 4' (1.2 m x 1.2 m) or larger, and stone can come in any size, shape or thickness.

As stated earlier in this section, tile used in steam room/steam shower installations should have a very low absorption rate ($\leq 3\%$) 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 steam rooms/steam showers around the world because they are relatively inexpensive and easy to find. Glass tile, suitable for steam room/steam shower installations, is very pleasing in appearance but is typically more expensive and requires a higher degree of installation experience and expertise. Stone is also a viable 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 constant exposure to moisture and by harsh or acid based chemicals/cleaners.

Stone should be selected carefully and must be dimensionally stable in the presence of moisture, have a low absorption rate, resistant to cleaners and chemicals, and be free of minerals that may stain or discolor the stone in a steam room environment. Contact the

stone supplier or quarry to ensure that the stone is suitable for the intended purpose, or, choose stone which has a proven history in such applications. Use suitable white thin-set mortars or epoxy mortars to install light colored stone to prevent unintentional darkening of the stone's appearance.

The installation of mosaic tile in steam room/steam showers has history going back thousands of years. In fact, the Romans and Greeks may have incorporated mosaic tile in their versions of steam baths. These mosaic tiles, if used, would have been installed individually, by hand, and would have taken long periods of time to accomplish by skilled installers with artistic ability. 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.

In recent years, the tile industry has seen some issues arise with the mounting of mosaic tile when used in certain 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 the paper is peeled off to reveal the tile finish.

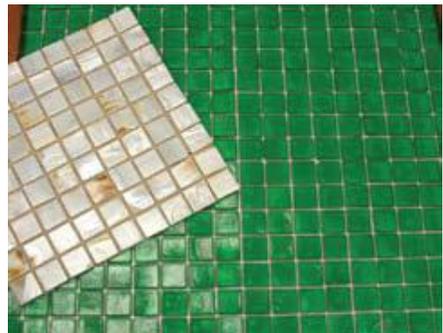


Figure 4.3.1 — Two examples of paperface mounted glass mosaic tile.

- 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 4.3.2 – 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 4.3.3.



Figure 4.3.3 – 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 amount of mesh adhesive that is used.



Figure 4.3.4 – 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 steam rooms/steam showers, swimming pools, fountains, spas, water features, or any wet area.

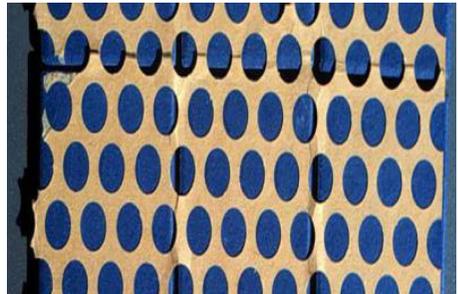


Figure 4.3.5 – An example of rear paper mesh mounted porcelain mosaic tile.

Installation of tile in steam rooms/steam showers 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 steam room installations, 95 – 100% coverage is essential to the long-term performance of the 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 . . . except on exterior or shower installations where contact area shall be 95% when no less than 3 tiles or tile assemblies are removed for inspection”.³⁴

Since maximum coverage is essential, the preferred tile mounting type for steam room/steam shower installations would be the

paper-face or plastic-face mounted mosaic sheets. This is because there are no obstacles to full adhesion (e.g. mesh and/or dot mount adhesive), so 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.

As previously stated, 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. This can result in the grout appearing to be blotchy where the dots are placed. Please note that this condition is caused by the PVC dots and is not a grout material issue.

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 and/or exposed to moisture and alkalinity 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 typically the same. Simply put, the use of back-mounted or dot-mounted sheet mosaic tiles may be precluded from use in steam room/steam shower installations if the sheet backing and/or adhesive adversely affect the development of adequate and permanent adhesion between the mosaic tile body and the bedding mortar.

Tile manufacturers must specify, in writing, whether their assemblies are suitable for installation in steam rooms/steam showers and other wet areas. Paper back-mounted mosaics are not recommended in steam room/steam showers or wet areas.

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 which 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.

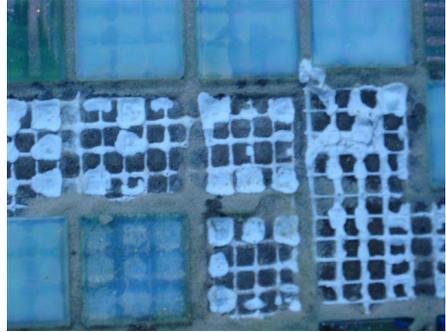


Figure 4.3.6 — A classic example of an improper adhesive used to mount the mesh for in a continually wet installation. The adhesive has changed color from clear to white and has swelled significantly, forcing delamination.

For mesh backed mosaic tile the fabric mesh and the 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. “The ceramic tile manufacturer shall be responsible for mounting the tiles so that the bond requirements of ANSI A137.1 (50 psi) according to ASTM C482-68 are met or exceeded. Tile manufacturers shall be responsible for specifying where their mounted tile assemblies shall be used.”³⁵ 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 and stone (which are suitable for the purpose), using the appropriate setting materials will save time, labor and money and keep the steam room/steam shower in continual operation for a very, very long time.

Section 5: Tile Installation Preparation and Equipment



5.1 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 steam room 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.

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. . .), presence of a curing compound or surface hardener, 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 is 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 shear 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, unsuitable and/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.

Section 6 — Tile Installation Preparation and Equipment

5.2 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 5.4 and 5.7 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. 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.

Environmental Conditions and Substrate Protection — The optimum conditions for installation of ceramic tile and stone are temperatures between 60° and 80°F (15° and 25°C), with 50% relative humidity. However, these conditions are atypical, so provisions must be made for variations in environmental conditions. Protection applies to the substrate, the installation of adhesives and joint grouts, and 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 [25–35°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. If ambient air and surface temperatures exceed 100°F (35°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. For more information, please refer to TDS 176 “Hot Weather Tiling and Grouting”

■ **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 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). For more information, please refer to TDS 175 “Cold Weather Tiling and Grouting”

As a general rule, air and 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.

NOTE: 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 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 can cause premature evaporation of water which is necessary for hydration in cementitious materials, and can 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 (30°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 - 48 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 usually only susceptible to premature drying between the spreading of adhesive

and the installation of the finish, and requires only temporary protection from dry, windy conditions 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 water exposure during the initial set period (typically 12–24 hours). Therefore, it is essential to provide protection from any significant water exposure or washing within

this period to avoid loss of strength and prevent possible fluid or latex migration staining.

5.3 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 to which it comes in contact. If that material is dirt, dust, paint, or any other impediment that is lying on a surface, the adhesion to that substrate will 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 typically 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 typically 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 100% 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.

Contamination — Tile Installation Preparation and Equipment

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 process. Imagine all other trades have been in and finished their certain part of the construction, (i.e. sheet rock, plumbing, painting, etc. . .). There is often paint, drywall compound, oil and other materials on the substrate from prior trades that must be removed. One of the most difficult tasks for any installer is the preparation of the surface before the installation of the tile/stone 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 installed, and sometimes multiple washings will have to take place before tiling. Just sweeping the floor is not good enough!

5.4 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. As stated in ANSI A108.01 2.6.2.2 "... tiles with all edges shorter than 15" (380mm), shall have a maximum permissible variation of 1/4" (6mm) in 10' (3 m) from the required plane, and no more than 1/16" (1.5mm) in 12" (305mm) when measured from the high points in the surface. For tiles with at least one edge 15" (380mm) or longer, the substrate shall have a maximum permissible variation of 1/8" (3mm) in 10' (3 m) from the required plane, and no more than 1/16" (1.5mm) variation in 24" (610mm) when measured from the high points in the surface. . . ."

If wall levelness, pitch-to-drain or ceiling pitch tolerances have not been met, 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; or, LATICRETE Quick Cure Mortar Bed).

5.5 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. The use of a wet vacuum to remove residual water and contaminants will help ensure that the surface remains free of contaminants prior to installation of the tile/stone.

There are no exceptions 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.

5.6 Finish Material Preparation

Cleaning of the tile or stone back, as well as the 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 bonding surface of the veneer is an 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 or engobe) which prevents fusion of the tile to kiln surfaces during the firing process. The type, amount, and degree of removal of the 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. This may not apply to moisture-sensitive stones where applying moisture to one side may cause warpage of the stone.
- 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.

5.7 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, and mix continuously for approximately one minute or until mortar is wet and plastic. 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.



Figure 5.7.1 – Variety of Mixing Paddles Used for Thin-sets, Epoxy Adhesives or Grouts.³⁶

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. 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 be done 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 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 should continue unaffected if temperatures are raised.

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 5.7.2 — Rotating Blade Type Mixer.

5.8 Installation Tools 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
- Metal Applicator Gun (Silicone Sealant)
- Rubber Mallet
- Wood Beating Block
- Spacers, Shims and Wedges
- Grout Float (Cement or Epoxy)

CUTTING/FITTING OF FINISH MATERIALS

- Wet Saw (See Figure 5.8.1)
- Ceramic Tile Cutter and Accessories

MEASUREMENT

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

CLEAN-UP

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

SAFETY EQUIPMENT

- Safety Glasses
- Rubber Gloves
- Dust Mask/Respirator (if required)



Figure 5.8.1 — A commercial grade wet saw is ideal for cutting all types of tile and stone.

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 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 moisture.

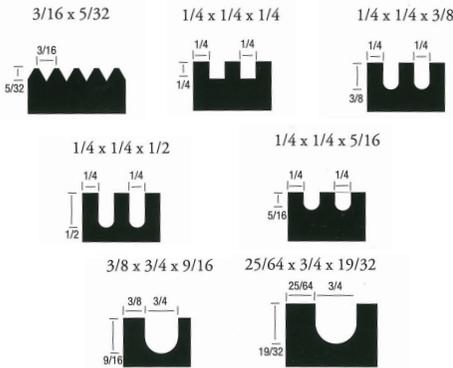


Figure 5.8.2 Notched trowel sizes for installation of adhesive mortars.

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 (or wood beating block, or hard rubber grout float for smaller tiles) 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.

THIN BED INSTALLATION PROCEDURE

The following is an abbreviated step-by-step process for the application of thin bed adhesive mortars. Follow the explicit manufacturer's installation instructions for detailed information. For access to full installation specifications for thin bed, thick bed and membrane instructions — see section 6.

1. Apply a thin skim coat ($1/16"$ [1.5 mm] thick) of thin-set 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. Ensure that mortar "ribs" are full and uniform in shape and thickness.



Figure 5.8.3 — A notched trowel has several important functions that contribute to a successful installation of ceramic tile.

3. The ribs of thin-set 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. Mortar notches running perpendicular means 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 $12" \times 12"$ (300×300 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.
5. The tile should be pressed into place, and either twisted and pressed into position, or for tile sizes $12" \times 12"$ (300×300 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 ceramic tile or stone with a rubber mallet and beating block, or, for mosaic tile the use of a hard rubber grout float to ensure thin-set or epoxy adhesive contact and make surface level with adjacent tiles.



Figure 5.8.4 — A rubber mallet is used to "beat" the tile into good contact with the mortar

5.9 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 minimize or prevent water infiltration, and compensate for varying dimensional

tolerances of the tile or stone. More importantly, though, grout or sealant locks the tile into place and provides protection against various delaminating forces. Depending on the joint material, a joint filler (e.g. LATASIL™) 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.

Minimize Water/Moisture/Steam 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 (HYDRO BAN® Sheet Membrane, HYDRO BAN, etc. . .) is strongly recommended in wet area applications. For steam room/steam shower applications, SPECTRALOCK® PRO Premium is the ideal grout due to its strength, low absorption rate and chemical resistance.

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. This ensures that the grout or sealant joint should 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 access to full grout installation specifications (see Section 7).

1. Prior to grouting, it is essential to conduct a test panel (preferably as part of the preconstruction 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 (e.g. 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 5.8.5 — Rubber 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.

5.10 Post Installation Cleaning

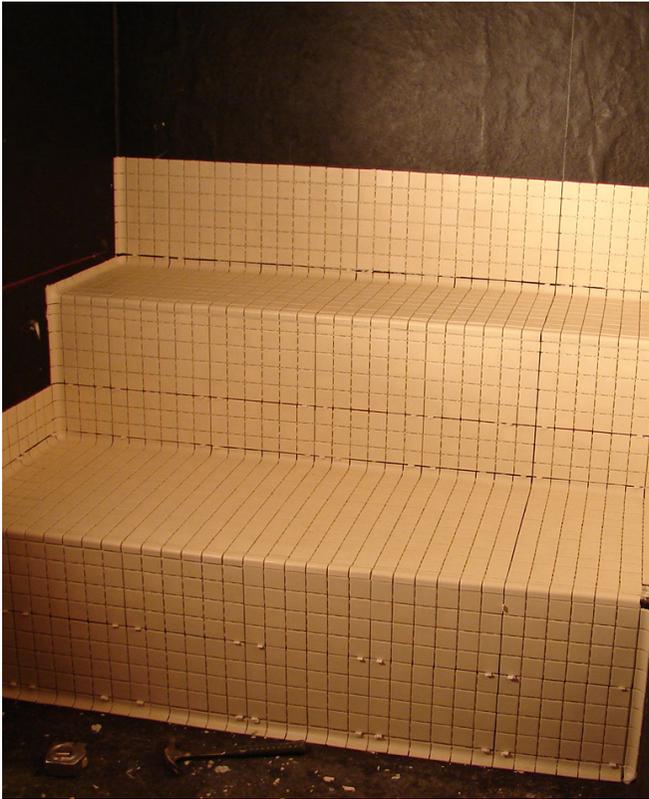
Most clean up should occur during the progress of the installation. Hardened adhesive and grout joint residue may require more aggressive mechanical or chemical removal methods than required while still relatively fresh. Water based cement and latex cement adhesives clean easily with water while fresh,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

sealants, may require more aggressive scrubbing and solvents if residue is greater than 24 hours old.

5.11 Protection of New Tilework

To avoid damage to finished tilework, schedule floor installations to begin only after all structural work, building enclosure, and overhead finishing work, such as ceilings, painting, mechanical, and electrical work are completed. Keep all traffic off finished tile floors until they have fully cured. Builder shall provide up to 3/4" thick plywood or OSB protection over non-staining kraft paper to protect floors after installation materials have cured. Covering the floor with polyethylene or plywood in direct contact with the floor may adversely affect the curing process of grout and latex/polymer modified portland cement mortar.³⁷

Section 6: Steam Room/Steam Shower Tile Installation



6.1 Tile Installation Materials Performance and Selection Criteria

The information contained in Section 6 is applicable to two types of construction methods; concrete/concrete block and wood/steel framing.

The performance and use of tile adhesives are regulated by the country, county and/or city according to prominent standards that govern the installation of ceramic tile, porcelain veneers and stone. Some of these standards are discussed in Section 3.6. Compliance may be mandatory or voluntary in the respective communities, depending upon whether the standard is incorporated into a building code.

Criteria for Selection of Adhesives and Mortars

- High Adhesive Strength (Tensile and Shear Bond Strength)
- Water Resistant
- Flexible (Differential Movement)
- Permanent Under Wet Conditions
- Temperature Resistant
- Non-toxic and User Friendly
- Good Working Properties (Open Time, Pot Life and 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.

Mortars which meet ANSI A118.3 (e.g. LATAPOXY® 300 Adhesive), ANSI A118.15 (257 Titanium™, 254 Platinum, MULTIMAX™ LITE) or ISO C2S1 (minimum) are ideal for steam room installations.

Water Resistance — For proper performance in wet area applications, including both commercial and residential steam rooms, a tile 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) — Adhesive must have a low modulus of elasticity (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 veneer, substrate or structure, or, changing live loads, which are common and expected in a steam room environment.

Permanence — This criteria may seem obvious, but even if all other performance criteria are met, beware that some adhesive mortars can become soluble in applications where moisture is prominent (e.g. steam rooms/steam showers) and may deteriorate over time. In addition, some epoxies can become brittle with age, and some urethanes can undergo a phenomenon known as “reversion”, where the adhesive may soften and revert to its original viscous state. Certain polymeric modifications of cement work only to enhance the workability and curing process to improve the physical characteristics of cement, but may 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, fire or from absorption of heat under normal service.

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 measures. Good initial adhesive grab to the substrate and the finish material, long pot life, long open time, vertical sag resistance and temperature insensitivity are all recommended working properties.

Non-Toxic and User Friendly — The adhesive should be non-hazardous during storage, installation, disposal, and use. This includes other materials, which may be necessary for preparation of 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 content and low VOC emissions compliance by obtaining third party certification of the installation materials (e.g. UL GREENGUARD Gold). For example, LATICRETE International, Inc. manufactures a variety of setting materials for steam room/steam shower applications (and otherwise) which are UL GREENGUARD Gold certified. For more information, please click this link.

Transparent — The products used should have publicly available Health Product Declarations (HPD) to disclose any associated hazards of raw materials used to make the installation materials. LATICRETE provides HPDs to the 100 ppm disclosure threshold. LATICRETE also provides Product Specific (Type III) Environmental Product Declarations (EPD) for cement based adhesive mortars, cement based grouts and cement based self-leveling underlayments. The LATICRETE EPDs are created and verified according to ISO 14025, and are based on a life cycle assessment according to ISO

14040 and ISO 14044. LATICRETE EPDs are third party verified by the Program Operator, UL Environment. LATICRETE HPDs and EPDs are available by clicking this link.

6.2 Methods of Installation

Bedding of Tiles — Solidly bedding tile is one of the most important steps to achieving a permanent and trouble free installation. Back-buttering tile and ensuring complete coverage without air pockets or voids is a key process to meeting this all important end. The project design professional can specify this procedure in the installation specification to ensure that this step is part of the construction process. Tile installers or inspectors should periodically remove some tile to verify that suitable coverage is being attained. For wet areas, American National Standards Institute (ANSI) A108.5 2.0 and 3.0 require a minimum of 95% coverage. Ensuring that no voids exist under the tile will minimize or inhibit water penetration into the adhesive and into the pore structure of the tile or stone, as well as fully support the tile and prevent damage. See Section 5.8 for more information on the application of adhesives, and on how to achieve maximum coverage.

Tile and stone for steam rooms can be installed by utilizing thin bed, medium bed and thick bed methods. The installation of thick bed mortar on steam room floors is suitable but appropriate precautions must be followed, including expansion joint placement, proper slope to drain of 1/4" per ft (6mm per 300mm) and a waterproofing membrane. There are two basic methods for installation of tile or stone in a steam room/steam shower. Refer to Section 7 for in depth information on the following application method types:

- Thick Bed (LATICRETE Method ES-SR613 or TCNA Method SR613)
- Thin Bed Method or Medium Bed Method (LATICRETE Method ES-SR614 or TCNA Method SR614)
- Thick Bed Method with HYDRANO[®] Sheet Membrane (LATICRETE Method ES-SR613S or TCNA Method SR613)
- Thin Bed Method or Medium Bed Method with HYDRANO Sheet Membrane (LATICRETE Method ES-SR614S or TCNA Method SR614)

6.3 Water and Water Vapor Diffusion Control

Importance — It is widely understood and accepted that water or moisture in areas where it cannot be seen or controlled in a building's structure will inevitably lead to damage. Ensuring that the water and water vapor are controlled as designed by the design and structure of an assembly will minimize or eliminate costly remediation and repair of the source of the moisture, and of the structure itself. Assuring that a suitable, properly installed vapor

diffusion retarder (vapor barrier) and waterproofing membrane will help to extend the long-term performance of a steam room/steam shower and protect the structure of the steam room/steam shower and the surrounding building.

Vapor Diffusion Retarder / Vapor Barrier - As discussed in Section 3.5, a vapor diffusion retarder (vapor barrier) is a material that reduces the rate at which water vapor can move through the material. Using the term vapor barrier can be misleading since the phrase implies that no vapor will be able to pass through a barrier. Since everything allows some water vapor to diffuse through it to some degree, the term "vapor diffusion retarder" is more accurate, and for the purposes of this manual will be used as such. Diffusion is defined as the movement of atoms or molecules from an area of higher concentration and/or pressure to an area of lower concentration and/or pressure. For example, moisture vapor under concentration/pressure in a steam room will be driven by diffusion through the vapor diffusion retarder to the area of lower concentration/pressure (wall cavity).

Material Selection - The ability of a material to retard the diffusion of water vapor is measured by units known as "Perms" or permeability. A perm at 73.4°F (23°C) is a measure of the number of grains of water vapor passing through a square foot (0.093 m²) of material per hour at a differential pressure equal to one inch of mercury (25.4 mmHg). One (1) perm equals one grain of water vapor/hour or 5.72 x 10⁻⁸ (0.000000572) g/Pa•s•m².

Vapor diffusion retarders (vapor barriers) are classified using ASTM E96 — Desiccant Method @ 73.4°F (23°C) and are based on the following requirements:

- Class I (*Vapor impermeable*): 0.1 perms or less (Sheet polyethylene, Non-perforated aluminum foil)
- Class II: (*Vapor semi-impermeable*) >0.1 to ≤ 1.0 perms (Kraft-faced fiberglass batt insulation)
- Class III: (*Vapor semi-permeable*) >1.0 to ≤ 10.0 perms (Latex or enamel paint)³⁸

Why is a vapor diffusion retarder (vapor barrier) important in a steam room? Let's look at some steam room facts;

1. Water, in the form of moisture vapor is forced into the room via a steam generator unit.
2. As water vapor enters the steam room at high temperature, typically between 105°F (41°C) and 120°F (48.9°C) and at a pressure higher than the ambient air outside of the steam room. This pressure will range from approximately 2.24 inches of mercury (Hg) to 3.43 inches of Hg (56.8 to 87.2 mmHg). (See Figure 6.3.1 for more information)

Saturated Vapor Pressure Table (Hg = Mercury)

°F (°C)	1" Hg (mmHg)	°F (°C)	1" Hg (mmHg)	°F (°C)	1" Hg (mmHg)
32 (0.0)	0.18 (4.6)	70 (21.1)	0.74 (18.8)	100 (37.8)	1.93 (48.9)
41 (5.0)	0.26 (6.5)	75 (23.9)	0.87 (22.2)	105 (41.0)	2.24 (56.8)
50 (10.0)	0.36 (9.2)	80 (26.7)	1.03 (26.2)	110 (43.3)	2.59 (65.7)
55 (12.5)	0.44 (11.1)	85 (29.4)	1.21 (30.7)	115 (46.1)	2.98 (75.8)
60 (15.5)	0.52 (13.2)	90 (32.2)	1.42 (36.0)	120 (48.9)	3.43 (87.2)
65 (18.3)	0.62 (15.8)	95 (35.0)	1.66 (42.1)	212 (100.0)	30.01 (762.2)

6.3.1 – Water Vapor Pressure Table, which can be used to help determine the amount of water vapor that can pass through materials³⁹

3. The relative humidity in a steam room is usually 98% to 100%.
4. According to Figure 6.3.2, at 122°F (50°C), 1 ft³ of air space in a steam room holds about 0.0052 lb/ft³ of water vapor. In a steam room which is 8' x 8' x 7' (2.4 x 2.4 x 2.1 m) this means that 2.33 lbs. of water is present in the air. This water vapor is being pushed out through the walls, floor and ceiling as more water vapor is being forced into the room.

$P_{W_1} - P_{W_2}$ = Difference of vapor pressure between ends of the flow path, in Hg⁴¹

As an example — a vapor diffusion retarder (vapor barrier) with a perm rating of 1.0 is installed in the walls and ceiling of a steam room. The vapor pressure in the steam room is 3.07 in. Hg and the pressure in the wall cavity is 1.0 in. Hg. Using the formula (assuming 115°F (46.1°C) temperature);

$$W = 1.0 \times (2.98 - 1.0) = 1.98 \text{ grains water vapor/hr-sq ft} \\ (1.38 \text{ g/h} \bullet \text{m}^2)$$

For an assembly utilizing a vapor diffusion retarder (vapor barrier) with a perm rating of 0.1 the equation would be as follows;

$$W = 0.1 \times (2.98 - 1.0) = 0.198 \text{ grains water vapor/hr-sq ft} \\ (0.138 \text{ g/h} \bullet \text{m}^2)$$

$$* 437.5 \text{ grains} = 1 \text{ oz. (29.6 mL)}$$

In an 8' x 8' x 7' (2.4 x 2.4 x 2.1 m) steam room, there are approximately 260 ft² (24.1 m²) of wall and ceiling space (not counting the door). Using a vapor diffusion retarder (vapor barrier) with a perm rating of 1.0, the amount of water vapor getting through the vapor diffusion retarder equates to 1.18 oz/hr (34.9 mL), while the vapor diffusion retarder (vapor barrier) with a perm rating of 0.1 allows only 0.118 oz/hr (3.49 mL) through. If 15-mil reinforced polyolefin with a perm rating of 0.025 is used, the water vapor transmission rate would be approximately 0.029 oz/hr (0.858 mL).

Since interior wall cavities are typically not vented or pressurized, any moisture vapor that transpires through the vapor diffusion retarder will condense and can accumulate over time. Making sure that the moisture does not escape through the vapor diffusion retarder (vapor barrier) is one of the most important design considerations for steam room/steam shower applications.

Proper Placement - It is very important to make sure that the vapor diffusion retarder (vapor barrier) is installed on all of the walls

Water Vapor Density Table

°F (°C)	lb/ft ³ (kg/m ³)
32 (0)	0.0003 (0.0048)
50 (10)	0.00059 (0.0095)
68 (20)	0.0011 (0.0176)
86 (30)	0.0019 (0.0304)
104 (40)	0.0032 (0.0513)
122 (50)	0.0052 (0.083)

Figure 6.3.2 – Water Vapor Density Table showing the density of water vapor at various temperatures.⁴⁰

The amount of moisture vapor that can move through a vapor diffusion retarder (vapor barrier) can be calculated using the following equation;

$$W = M \times (P_{W_1} - P_{W_2})$$

M = Overall coefficient of vapor transmission or overall Perm value (some references also use M to designate the Perm value for individual materials), grains water vapor/hr-sq ft

W = Total mass of water vapor transmission per unit area in unit time, grains water vapor/hr-sq ft

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and the ceiling, and is one continuous piece of material (if at all possible), and that the vapor diffusion retarder (vapor barrier) laps into the shower pan liner. The moisture vapor will move from areas of higher concentration to areas of lower concentration (diffusion), as well as, areas of higher pressure to areas of lower pressure. The pressure in a steam room, as determined earlier, is greater than the ambient air outside of the steam room, and, the humidity in the steam room is between 98 and 100% while the humidity in conditioned air space outside of the steam room is between 40 – 55%. Higher moisture concentration and pressure in the steam room means the physics is forcing the moisture vapor to leave the room and equalize with the ambient air.

For best performance the vapor diffusion retarder (vapor barrier) should have a Perm rating of ≤ 0.5 less to keep the moisture vapor (which can permeate the material) to an absolute minimum. The vapor diffusion retarder (vapor barrier) must also be installed to drain into the shower pan liner to make sure that any water that condenses on the material will flow by gravity into the shower pan and eventually down the weep holes of the drain. If the vapor diffusion retarder (vapor barrier) is not placed so that it drains into the shower pan, any water that condenses and reaches the bottom of the vapor diffusion retarder (vapor barrier) will end up in wall spaces of adjacent areas where damage can occur.

Typical Vapor Retarder Materials Used In Steam Rooms		
Material	Thickness in Inches (mm)	Average Perm Rating
4-mil Polyethylene	0.004 (0.102)	0.08
6-mil Polyethylene	0.006 (0.152)	0.06
HYDRO BAN® Sheet Membrane	0.006 (0.152)	0.06
10-mil Polyethylene	0.010 (0.254)	0.035
15-mil Reinforced Polyolefin	0.015 (0.381)	0.025

Figure 6.3.3 – Typical perm ratings of commonly used vapor diffusion retarders/vapor barriers.

It is the responsibility of the project design professionals to determine how waterproofing, insulation, air barrier (if required), vapor diffusion retarder (vapor barrier), penetrations, door/window(s), and any other component integration is to be accomplished. All of these design components must be properly tied together to prevent moisture from accumulating in places where it is not intended to be present.

Low Perm Waterproof Membranes – A new category of waterproof membrane for steam rooms and steam showers was

introduced in the 2013 TCNA Handbook for Ceramic, Stone and Glass Tile Installation which would allow for the installation of one product to act as both waterproofing and vapor diffusion retarder (vapor barrier).

A membrane must have a perm rating of 0.5 perms or less when tested per ASTM E96 “Standard Test Methods for Water Vapor Transmission of Materials” Procedure E in order to qualify as “low perm”. ASTM E96 Procedure E – Dessicant Method testing is performed at 100°F (38°C) and 90% relative humidity to better reflect the actual conditions found in a steam room.

Any waterproofing membrane, which does not have a perm rating of 0.5 perms or less, must have a vapor diffusion retarder (vapor barrier) installed behind the wall assembly, and the vapor diffusion retarder (vapor barrier) must have a water vapor permeance rating of 0.1 perm or less when tested per ASTM E96 Procedure A.

Waterproofing/Anti-Fracture Membranes - Many anti-fracture and/or waterproofing membranes can be applied over concrete, mortar beds, and cement backer board. Some membranes serve as both waterproofing and anti-fracture membranes (e.g. HYDRO BAN® or 9235 Waterproofing Membrane) and are ideal for use in locker rooms, showers, steam rooms/steam showers and other wet areas.

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 for Thin-set Ceramic Tile and Dimension Stone”. The product standards for waterproofing can be found under ANSI A118.10 “Standard Specification for Load Bearing, Bonded, Waterproof Membranes for Thin-set Ceramic Tile and Dimension Stone Installation” and the product standards for crack isolation membranes can be found under ANSI A118.12 “Standard Specification for Crack Isolation Membranes for Thin-set Ceramic Tile and Dimension Stone Installation”.

Types of membranes that may be suitable for a steam room/steam shower application include;

Sheet membranes - Sheet membranes (e.g. HYDRO BAN Sheet Membrane) are typically made from chlorinated polyethylene, polyvinyl chloride, and 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 scrim or fiberglass mesh adhered to or incorporated in both sides of the membrane sheet that allows it to be bonded to the substrate, and subsequently, tile or stone to

bond directly to the sheet membrane. The polyester scrim in HYDRO BAN® Sheet Membrane is infused into the chlorinated polyethylene membrane to minimize the chances of the scrim losing adhesion to the membrane. HYDRO BAN Sheet Membrane is ideal for use in a steam room, but, if another manufacturer's sheet membrane will be used then check with the sheet membrane manufacturer for suitability in these applications.

HYDRO BAN Sheet Membrane has a perm rating of 0.06, so it is ideal for use as a vapor diffusion retarder/vapor barrier and as a waterproofing membrane in a steam room/steam shower application. Please note that some sheet type membranes may not act as both vapor diffusion retarder (due to high permeance properties) and as a waterproofing membrane, so check with the membrane manufacturer prior to specifying.

Typically, a latex portland cement mortar, meeting ANSI A118.4 or ANSI A118.15 (e.g. 254 Platinum, 257 Titanium™), is used to bond the membrane to the substrate and to bond tile or stone to the membrane. If time is a limiting factor, some membrane manufacturers allow the use of a special quick setting adhesive to adhere the sheet membrane to the substrate, which in turn allows the installation of tile to take place sooner without the loss of bond of the membrane to the substrate.

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 in a concrete or mortar bed substrate, 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 or other method to eliminate air bubbles. 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. If the surface is not smooth and flat enough for tile, then it is not smooth and flat enough for a sheet membrane. Flatten or repair the substrate prior to installation of HYDRO BAN Sheet Membrane or other sheet membrane product.

The family of HYDRO BAN Sheet Membrane products includes sealing tape and pre-formed inside and outside corners to facilitate installation in critical areas such as corners and coves, as well as collars that should permanently seal pipe penetrations, shower diverters and other penetrations. (See Figure 6.3.4)

Precautions and concerns with sheet type membranes are as follows:

1. Trapping air below the sheet membrane may cause air pockets to form and radically diminish the compressive strength of the installation.
2. Overlapping and sealing the seams. The seams can be treated with a suitable sealant, thin-set or solvent. Follow the specific installation instructions for the sheet membrane being installed. For HYDRO BAN Sheet Membrane please click this link for the installation instructions.
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. The use of a pre-formed corner or collar will minimize thickness and allow for easier installation of the finish veneer. Follow the instructions to keep the total thickness of the membrane to a minimum.
4. High alkalinity can attack and adversely affect certain adhesives used to bond the sheet membrane to the substrate.
5. High MVER — generally in excess of 5 lbs./1,000 ft²/24 hours (283 mg/s m²) may have a negative impact on the adhesion of sheet type membranes (follow membrane manufacturer's guidelines for areas with excessive MVER).
6. Sheet membranes may or may not meet ANSI A118.12 standards for crack suppression/anti-fracture. Check with membrane manufacturer for more information.



Figure 6.3.4 — The family of HYDRO BAN Sheet Membrane components

HYDRO BAN Board - HYDRO BAN Board is a proprietary board with a sheet membrane adhered to the surface of the foam material. This means that the surface of HYDRO BAN Board is already waterproofed with a low perm (Class 1) membrane, and only requires the seams, corners, coves, fasteners, and penetrations be

waterproofed with HYDRO BAN® Sheet Membrane.

Another great feature of HYDRO BAN Board is, because the core is made from extruded polystyrene, provides an R-value of 2.23 per ½" (12.7mm). Depending upon the size of the steam room and the output of the steam generator, the 2" (50.8mm) thick HYDRO BAN Board may be sufficient for attaining the required insulation value needed to control dew point within the wall assembly. Please note that it is the responsibility of the project design team to determine the insulation requirements within the wall assembly and to design the steam room and specify materials accordingly.

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 separate adhesive mortar 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 peel and stick membrane and/or 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 backside of the membrane and rolled onto the primed substrate.

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 areas outside the steam room/steam shower and other intermittent wet areas. These membranes should not be used in steam room/steam shower applications, but check with the membrane manufacturer to verify suitability for intended use.

NOTE: FRACTURE BAN™ is not intended for use in steam room/steam shower applications and should never be used for this purpose.

Trowel Applied Membranes - Trowel applied membranes come in various forms, including latex fortified cement based types (e.g. HYDRO BAN Cementitious Waterproofing), epoxy resin types (e.g. LATAPOXY® Waterproof Flashing Mortar) 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. It may be necessary to check with the manufacturer of the trowel-applied membrane to see if it acts as an anti-fracture membrane as well.

Latex Cement Based, Trowel Applied 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 (e.g. high perm rating) of these types of products generally minimize their use in demanding steam room/steam shower applications.

NOTE: HYDRO BAN Cementitious Waterproofing is not intended for use in steam room/steam shower applications and should never be used for this purpose.

Epoxy Based, Trowel Applied 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 steam room/steam shower applications. While epoxy membrane types are not typically used as the primary means of waterproofing in a steam room/steam shower, they are used to complement and tie into liquid applied waterproofing membranes as a flashing mortar (please refer to Figure 6.3.5).

Some other advantages to this category type of waterproofing are as follows:

- Flood testing can be performed in as little as 24 hours at 70° F (21°C).

Section 6: Steam Room/Steam Shower Tile Installation

- 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 6.3.5 — 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 steam room/steam shower 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
- UL GREENGUARD Gold certified for low VOC emissions
- Thin — load bearing
- Shock resistant
- Fully compatible with a wide range of ceramic tile or stone installation materials which are recommended for steam room/steam shower 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) or above. See TDS 169 “Flood Testing Procedures” for more information on performing flood tests.
- Some liquid applied waterproofing membranes (e.g. HYDRO BAN®) may be spray applied with a commercial, airless sprayer.



Figure 6.3.6 — 9235 Waterproofing Membrane applied to concrete substrate.

Examples of this category type include 9235 Waterproofing Membrane and HYDRO BAN®. Waterproofing Membrane is a liquid applied, fabric reinforced membrane that is thin, load bearing and completely compatible with LATICRETE Latex Thin-set Mortars. HYDRO BAN is a liquid applied membrane that is thin, load bearing and completely compatible with LATICRETE Latex Thin-set Mortars and may be ready for flood testing in as little as 2 hours (see HYDRO BAN Installation Instructions, DS 663.5 for more information).

NOTE: HYDRO BAN Quick Cure is not intended for use in steam room/steam shower applications and should never be used for this purpose. For products in this category, please use HYDRO BAN or 9235 Waterproofing Membrane for steam rooms and steam showers.

Detailing of Penetrations/Seats/Door — Proper detailing of penetrations through a waterproofing membrane, vapor diffusion retarder (vapor barrier), insulation, and tile or stone is one of the most vital installation elements for the long term functioning of these materials and the steam room/steam shower in general. Typically, a flexible sealant, suitable for the intended application (e.g. LATASIL™ used with LATASIL 9118 Primer) is a critical component to treating penetrations. Penetrations can range from lights, steam pipes, railings, door hinges, windows, and more and come in a variety of shapes and sizes.

Keep in mind what should never happen in a steam room

application; steam cannot escape the steam room or condensation and possible property damage can occur. It is important that all penetrations and penetration treatments be designed, specified and constructed to prevent water and water vapor from escaping the steam room. There is a generic drawing in Section 7, that shows a possible way to detail certain pipe penetrations, but this drawing should not be relied upon to provide the perfect solution to preventing problems. It is the responsibility of the project design professional/team to design and specify the proper materials and methods to achieve viable solutions, and, it is the responsibility of the installation contractor to ensure that the penetrations are properly treated to prevent water and vapor from escaping the steam room. The fact that one (or more in large steam rooms) of the penetrations gets extremely hot must also be taken into account and detailed accordingly with materials that will be unaffected by the high temperatures.

Seats are very common in steam room applications (especially in commercial steam rooms) and in many cases are parts of the structure of the steam room. In the vast majority of steam rooms with seating, the seats are framed in, mudded and waterproofed along with the walls to make a single, cohesive installation. These installations are finished with tile or stone using suitable LATICRETE tile installation products. In pre-formed steam rooms (refer to Figure 2.4.1) the seats are formed with the unit to create a seamless, integral unit, but are rarely, if ever, tiled. Seats and all horizontal surfaces must slope towards the drain to prevent water from accumulating and allow water to vacate through the drain.

In recent years, pre-formed seats have been developed that can be used in steam rooms and installed using several methods, including installation directly on existing tile or stone. HYDRO BAN® Preformed Seat is high-density, expanded polystyrene with a waterproof finish that is 100% waterproof and ready-to-tile. HYDRO BAN Preformed Seat is 100% compatible with all LATICRETE products that are suitable for use in steam room/steam shower applications.

Flood Testing Steam Room Floors — If required by the design professional(s), general contractor or building owner, a flood test is conducted after the waterproofing membrane, and any penetrations within the depth to where the flood test will be conducted, are treated and all of the installed components reach full cure. The International Plumbing Code provides guidelines for flood testing shower pan liners as follows;

International Plumbing Code (IPC) Section 312.9 Shower Liner Test — Where shower floors and receptors are made water-tight by the application of materials required by IPC Section 417.5.2, the completed liner installation shall be tested. The pipe from the

shower drain shall be plugged water tight for the test. The floor and receptor area shall be filled with potable water to a depth of not less than 2" (51mm) measured at the threshold. Where a threshold of at least 2" (51mm) does not exist, a temporary threshold shall be constructed to retain the test water in the lined floor or receptor area to a level not less than 2" (51mm) deep measured at the threshold. The water shall be retained for a test period of not less than 15 minutes, and there shall be no evidence of leakage.

ASTM D5957 "Standard Guide for Flood Testing Horizontal Waterproofing Installations" can also serve as a basic guideline for flood testing steam room/steam shower applications. LATICRETE TDS 169 "Flood Testing Procedures", available at <https://laticrete.com>, can also provide guidance on this important step.

Generally, flood tests of shower pan liners are performed for a period of 12 – 48 hours and must be continuously monitored during the flood test period. All piping (within the flood test depth) and drains must be plugged to make sure that no water escapes through them. Failure to do so will render the results of the flood test as inaccurate. If any measurable amount of water is lost the following process will be required;

- The steam room/steam shower floor will have to be drained completely;
- Verify that no water was lost through the drain by placing water in an area large enough to cover the drain only. Watch to see if water is lost;
- Inspect for leaks;
- Repair the leak(s);
- Allow the waterproofing membrane used to affect repairs to fully cure;
- Repeat flood test procedure.

Keep in mind that if water can get out, then steam can get out!

Protection of Waterproofing Membranes - LATICRETE waterproofing membranes must be allowed to cure fully at the required temperature, as stated by the membrane manufacturer. The membrane (e.g. HYDRO BAN, HYDRO BAN Quick Cure, or 9235 Waterproofing Membrane) must be protected from UV exposure beyond the stated time period stated in the product data sheets (DS 663.0 for HYDRO BAN, DS 670.4 for HYDRO BAN Quick Cure and DS 236.0 for 9235 Waterproofing Membrane which can be found at <https://laticrete.com>) and from the elements, including rain and wind. Tenting and shading the work areas for the installation and cure periods is critical to ensuring the long-term performance of the installation system.

6.4 Tile Setting Mortars

Importance - Steam rooms/steam showers are exposed to unique factors not typically found in other installation types. The adhesive mortars must also be able to deal with moisture expansion/contraction, thermal expansion and contraction, differential movements, varying live loads, thermal cycling (more frequently in residential steam rooms/steam showers), and thermal shock. Therefore, the adhesive mortars and grouting materials must be able to withstand these demanding conditions in addition to providing all of the performance properties of the adhesive to maintain a high performance, durable tile installation. Tile, which is installed using an adhesive that is not suitable for the application may damage property or harm people who are using the steam room/steam shower facility. Proper design, specification, installation, and maintenance of the steam room/steam shower and the tile installation are critical to the long-term performance of the system. LATICRETE International manufactures a range of products that are ideal for steam room applications.

Types of Mortars — There are three categories of mortars that are ideally suited for installation of tile or stone in a steam room/steam shower: Thick Bed Mortar, Redispersible Polymer-fortified Cement Mortar, and Epoxy Resin Adhesives.

Thick Bed Mortar — For installation of tile or stone in a commercial steam room, the TCNA requires the installation of a mortar bed (e.g. 3701 Fortified Mortar Bed, or Quick Cure Mortar Bed) following TCNA SR-613 (LATICRETE ES-SR613) into metal lath (installed over a suitable vapor diffusion retarder), which has been attached to the structure using wire and pencil rods.

Redispersible Polymer Fortified Cement Mortar - The use of a high performance redispersible polymer fortified cement mortar designed for use in steam room/steam shower applications are also outstanding choices for these applications.

257 Titanium™, 254 Platinum or MULTIMAX™ LITE mixed with potable water is a perfect choice for steam room/steam shower applications. The mortars listed are formulated to have high adhesive strength while providing the flexibility, temperature resistance, moisture resistance, and other characteristics required of adhesive mortars used for ceramic tile and stone installations in steam rooms/steam showers and surrounding areas. These mortars also meet ANSI A118.15, the American National Standard Specification for Improved Modified Dry-set Cement Mortar.

Epoxy Resin Adhesives - LATAPOXY® 300 Adhesive is another great product that is perfect for steam room/steam shower

applications. LATAPOXY 300 Adhesive can not only withstand the heat, moisture and chemical attack from cleaners and sanitizers, it can also provide the highest level of adhesion and strength to tile and stone which may not be attained when using polymer-fortified mortars. LATAPOXY 300 Adhesive is also capable of bonding tile or stone directly on a difficult to bond to substrate (e.g. stainless steel, fiberglass, etc. . .). LATAPOXY 300 Adhesive is a perfect choice when bond tile and stone that may be moisture sensitive, resin backed, or a resin agglomerate stone. Check with the tile manufacturer or stone supplier to make sure that the tile or stone is suitable for steam room/steam shower use.

6.5 Grout

Importance - As is the case of any tile or stone installation, the grout is the most visible and most scrutinized part of the installation system. The grout in steam room/steam shower applications is subject to varying and extreme conditions. In addition, the grouting materials must also be able to remain colorfast and maintain its performance integrity when subjected to high temperatures, high humidity and the thermal forces found in steam room/steam shower applications. The grout should also be able to handle a suitable, well planned and consistently implemented cleaning and sanitizing regimen designed for steam room systems. If possible, use neutral pH, low VOC cleaners that can be used in high temperature and high humidity applications.

Epoxy Grout - SPECTRALOCK® PRO Premium Grout† is an ideal choice for steam room/steam shower applications. 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 may face in these harsh conditions. Therefore, the life cycle cost for these materials is much lower than traditional latex cement based grouts that may require periodic re-grouting due to erosion caused by the extreme conditions in this environment.

Polymer Fortified and Latex Cement Grout — PERMACOLOR® Grout or PERMACOLOR Select are very good choices for grouting in steam room/steam shower applications. It is important to note that these products have limited chemical resistance, and are typically only used where no exposure to aggressive or corrosive chemicals will occur. If cement-based grout is selected for a steam room/steam shower, careful detail to the maintenance regimen is required. At times, the extra cost associated with additional maintenance of a cement-based grout used in steam rooms can be offset with the selection and use of an epoxy grout (e.g. SPECTRALOCK PRO Premium Grout) that will greatly reduce the maintenance required.

6.6 Sealants

Importance - Sealants used in steam rooms/steam showers are subjected to a host of movement related issues including, but not limited to, thermal movement (e.g. thermal expansion/contraction, thermal shock), moisture expansion/contraction, live loads, and differential movement. Refer to Section 7 for information on the proper specification of sealants in steam room/steam shower applications.

Movement Joints — Movement joint materials (e.g. 100% silicone or urethane), specifically designed for the purpose, are typically used as fillers only at movement joints, changes in plane, where dissimilar materials meet, and at any penetrations (such as pipe penetrations, light, doors, etc. . .). These are places where a high degree of adhesion is required, as well as resistance to differential movement, tensile stress, and other forces while maintaining its performance characteristics in the high temperature and humidity of a steam room. Movement joints are intended for relief of significant stress build-up that may be transmitted over a larger area. Movement joints are filled with a flexible material to resist much greater elongation or compression than more rigid materials like cement. These flexible materials should also have the ability to adhere to structural or design elements (e.g. lights, pipes, tile, stone, etc. . .) to not only maintain a water barrier where a more rigid material may fail, but also to accommodate the potentially significant different thermal movement characteristics of some dissimilar materials.

LATASIL™ along with LATASIL 9118 Primer (required for steam room applications) is an ideal combination for steam room/steam showers. 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. Please note that the TCNA Handbook for Ceramic, Glass and Stone Tile Installation Method EJ-171 provides a generic guide for the installation of movement joints. However, it is the responsibility of the project design professionals to provide the design, location, and construction of movement joints and it is the responsibility of the contractor to make sure that they are properly installed. Always check with the sealant manufacturer to determine if a particular product is suitable for the intended application and whether, or not, that application would require a primer for the sealant product.

6.7 Post Installation

Cure Time - Cure completed tile work in steam room/steam showers for 10 days when using an epoxy based grout at 70°F (21°C) and

14 days when using a latex portland cement based grout at 70°F (21°C) before activating steam unit. Extend period of protection and cure at temperatures below 60°F (16°C), and at high relative humidity (>70 RH) due to retarded set times of mortars, adhesives and grouts.

Inspection — The tile or stone installation in a steam room/steam shower should be inspected prior to testing the steam generation system, and then again prior to full steam activation to look for any non-conformities in the tile installation. Final grouting and sealant touch-ups should be performed during this phase and before the steam room goes into full use. Critical areas include the sealant treatment at all penetrations, movement joints and drains. The sealant should be in place and fully cured prior to turning the steam on for normal operation to prevent any steam or moisture from escaping the room. Make sure that all grout joints are full, that exposed edges of seats are rounded (to prevent discomfort or injury on sharp edges), that there is no condensation on the outside of any exposed wall of the steam room/steam shower, and that water is not dripping from the ceiling.

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. To avoid damage to tile work, schedule floor installations to begin only after all structural work, building enclosures, and overhead finishing work, such as ceilings, mechanical and electrical work are completed.

Keep all traffic off finished tile floors until they have fully cured. Builder shall provide up to ¾" (19mm) thick plywood or OSB protection over non-staining Kraft paper to protect floors after installation materials have cured. Covering the floor with polyethylene or plywood in direct contact with the floor may adversely affect the curing process of grout and latex/polymer modified portland cement mortar.⁴²

6.8 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), available at <https://laticrete.com> for more information.

Section 7: Specifications For Steam Room/ Steam Shower Installation



Since steam room/steam shower applications are reasonably complex in design and in application, they require intelligent design, superior materials, an experienced contractor, and a tile installer who has skill sets and necessary experience to assure a fully functional, problem free steam room. The importance of all of these elements cannot be overstated. The contractor(s) chosen should be required to provide a portfolio and references reflecting the installer's/contractor's experience, along with a bid or estimate, which is a good way to ensure work of similar size, scope and complexity has been completed. Matching installer ability to the project at hand requires close evaluation of their experience, training, licensing, certifications and/or credentials. Because tile is a permanent finish, the lowest bid should not be the driving factor, but rather who is the most qualified to perform the scope of the work specified.

There are essentially two types of jobsite constructed steam room/steam showers; wood or steel framed, and, concrete or concrete masonry construction;

- I. The first design incorporates steel or wood framing and a concrete, slab-on-grade sub-floor. The ceiling framing should be sloped at least 2" minimum per foot (50mm per 300mm) to prevent water from dripping on steam room occupants (per Tile Council of North America recommendations) and the slope must be maintained throughout substrate and veneer installation. The floor should be pre-pitched (prior to the installation of the shower pan liner) at the rate of ¼" per foot (6mm per 300mm), per International Residential Code (IRC) P2709.1 stated as "1/4 unit vertical in 12 units horizontal (2% slope) nor more than ½ unit vertical in 12 units horizontal (4% slope) and floor drains shall be flanged to provide a water-tight joint in the floor"⁴³, to make sure that water flows toward the drain. Keep in mind that a shower pan is required in all site constructed steam room/steam shower installations unless otherwise stated in local building code!

Typically, the installation begins with the proper choice and placement of a two-part clamping ring style drain with weepers as per ASME A112.6.3. Place tile spacers or gravel around weep holes, as detailed by the design professional, to prevent mortar from clogging the weep holes and should be installed by a qualified plumber in accord with International Residential Code (IRC) P2709.4. The pipes and drain should be properly supported to prevent problems in the future. Unless specified otherwise, a suitable primary shower pan liner, complying with ASTM D4068 "Standard

Specification for Chlorinated Polyethylene (CPE) Sheeting for Concealed Water Containment Membrane", D4551 "Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water Containment Membrane" or other approved material would be installed to tie into the bottom flange of the drain (without blocking the weep holes). Turn shower pan membrane up walls a minimum of 3" (75mm) above the top of steam rooms/steam showers with a curb or 6" [150mm]) above floors in steam rooms or steam showers without curbs.⁴⁴

The shower pan must be properly formed and fastened to prevent problems. Check with local building code to help determine what shower pan liner is acceptable in your area. Curbs must be sloped to drain back into the steam room for condensation runoff and any horizontal surfaces within the steam room should be pitched to the drain to prevent pooling of water. Slope curbs at the rate of ¼" per foot (6mm per 300mm). Perform a flood test to determine integrity of the pan liner and make repairs as necessary before proceeding (see Section 6.3 for more information on flood testing).

After the shower pan liner is in place, install the vapor diffusion retarder directly onto the side of the framing that will be exposed to the steam room. The vapor diffusion retarder should be 4 – 6 mil thick polyethylene (cross-laminated virgin polyethylene is excellent) and, if possible, should be one piece that can fit into the entire area (please refer to Sections 3.5 and 6.3 for more information). Fasten the vapor diffusion retarder to the studs with corrosion resistant fasteners. A spot of LATASIL™ (100% silicone) onto the fasteners will help prevent moisture penetration through the fastener holes. Make sure that the vapor diffusion retarder (vapor barrier) is properly formed and is tight to the studs of the walls and ceiling. Yes – the vapor diffusion retarder (vapor barrier) must be installed onto the ceiling as well as the walls, as steam will certainly escape through the ceiling. If possible, the vapor diffusion retarder (vapor barrier) should be one piece to prevent moisture escape through any seams. It is imperative that this vapor diffusion retarder (vapor barrier) be placed so that it laps into the shower pan liner! This way any moisture that comes in contact with the vapor diffusion retarder (vapor barrier) will drain into the shower pan and exit through the weep holes of the drain.

Next, install a 2" (50mm) thick minimum, wire-reinforced mortar bed of 3701 Fortified Mortar, or, LATICRETE Quick

Cure Mortar Bed onto the shower pan liner. The wire-reinforcement should be 2" x 2" (50mm x 50mm), 16 gauge, galvanized, welded wire mesh (or other as noted in ANSI A108.02 3.7) and should be placed at half the depth of the mortar bed. Make sure that the mortar bed maintains the 1/4" per foot (6mm per 300mm) slope to drain which was established by the pre-pitch in the sub-floor. After the mortar bed has cured, the installation of the insulation and specified backer board on the walls and ceiling can begin.

The addition of a suitable insulation material between the joists should be done before installation of the specified non-insulated backer board. Walls utilizing a foam-cored board (e.g. HYDRO BAN® Board) may provide enough thermal resistance (R value) to act as the insulation. The Project design team will have to determine the R value and determine suitability of board to act as insulation.

Insulation will help keep the heat in the steam room and helps to control the dew point (the temperature where condensation takes place) within the wall. The backer board must be acceptable for steam room use and installed per board manufacturer's written installation instructions; this includes taping of all board joints as required by the board manufacturer. Use 254 Platinum or 257 Titanium and 2" (50mm) wide, alkali-resistant fiberglass mesh tape to treat the board joints. Be sure to allow space at the ceiling/wall transition for the insertion of a slip joint to allow expansion/contraction to take place (Please refer to Section 3.4 for more information on slip joints).

Pipes and penetrations through board should be accounted for and space between board and penetration should be kept to a minimum. Allow the mortar used to tape the board joints to harden and then commence with waterproofing the entire inside area of the steam room with HYDRO BAN or 9235 Waterproofing Membrane. The entire steam room should be waterproofed, including the ceiling, walls, floor, seat(s), penetrations, and any other exposed areas; this will help improve the functionality of the vapor diffusion retarder and inhibit the passage of much of the moisture through the system. Loop the HYDRO BAN (must be used in conjunction with Waterproofing/Anti-Fracture Fabric when installing slip joints) or 9235 Waterproofing Membrane to loop into the slip joints to allow for excessive movement in these areas. Any vapor transpiring through the HYDRO BAN or 9235 Waterproofing Membrane should easily be handled by the vapor diffusion retarder. Make sure that ALL penetrations are

properly waterproofed! (Please refer to Section 6.3 for more information on treating pipes and penetrations).

Tile can be installed directly onto the HYDRO BAN or 9235 Waterproofing Membrane as soon as it is dry to the touch. 254 Platinum or 257 Titanium are the thin-sets of choice for steam room/steam shower installations. For installation of large format tile or stone in a steam room, we would recommend the use of MULTIMAX™ LITE. Check with the manufacturer of the tile to make sure that it is compatible for steam room applications.

Once the tile or stone installation has set firm, grout the installation with SPECTRALOCK® PRO Premium Grout† for best performance. Alternative grouting choices would be either PERMACOLOR® Grout; or, PERMACOLOR Select. Use LATASIL™, with LATASIL 9118 Primer, for treating the sides of tile or stone at movement joints, slip joints, around the drain, to seal lighting fixtures, access panels (if present), or at any change of plane. Please note that LATASIL 9118 Primer should not contact the LATICRETE waterproofing membrane. The use of SPECTRALOCK PRO Premium Grout will add to the performance of the tile installation because it has an absorption rate of <0.5%. It will be necessary to wait for 14 days for the cementitious grout, and 10 days for SPECTRALOCK PRO Premium Grout to cure at 70° F (21°C) before turning on the steam generation unit.

- II. Unless specified otherwise, a suitable primary shower pan liner, complying with ASTM D4068 "Standard Specification for Chlorinated Polyethylene (CPE) Sheeting for Concealed Water Containment Membrane", D4551 "Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water Containment Membrane" or other approved material would be installed to tie into the bottom flange of the drain (without blocking the weep holes). Turn shower pan membrane up walls a minimum of 3" (75mm) above the top of steam rooms/steam showers with a curb or 6" [150mm] above floors in steam rooms or steam showers without curbs. No matter which of the approved materials is used as the shower pan liner, it must be properly tied into the bottom flange of the drain. The liner is applied directly onto the concrete or masonry walls and concrete floor. Turn shower pan membrane up walls a minimum of 3" (75mm) above the top of the curb (6" [150mm] above floors in steam rooms or steam showers without curbs.

The shower pan must be properly formed and fastened to prevent problems. Check with local building code to help determine what type of shower pan liner is acceptable in your area. Slope curbs at the rate of $\frac{1}{4}$ " per foot (6mm per 300mm). Perform a flood test to determine integrity of the pan liner and make repairs as necessary before proceeding (see Section 6.3 for more information on flood testing).

After the shower pan liner is in place, install the vapor diffusion retarder (vapor barrier) directly onto the side of the framing that will be exposed to the steam room. The vapor diffusion retarder (vapor barrier) should be 4 – 6 mil thick polyethylene (cross-laminated virgin polyethylene is excellent) and, if possible, should be one piece that can fit into the entire area (please refer to Sections 3.5 and 6.3 for more information). Fasten the vapor diffusion retarder (vapor barrier) to the studs with corrosion resistant fasteners. A spot of LATASIL™ (100% silicone) onto the fasteners will help prevent moisture penetration through the fastener holes. Make sure that the vapor diffusion retarder (vapor barrier) is properly formed and is tight to the studs of the walls and ceiling. Yes — the vapor diffusion retarder (vapor barrier) must be installed onto the ceiling as well as the walls, as steam will certainly try to escape through the ceiling. If possible, the vapor diffusion retarder (vapor barrier) should be one piece to prevent moisture escape through any seams. It is imperative that this vapor diffusion retarder (vapor barrier) be placed so that it laps into the shower pan liner! This way any moisture that comes in contact with the vapor diffusion retarder (vapor barrier) will drain into the shower pan and through the weep holes of the drain.

The addition of a suitable insulation material between the joists should be done before installation of the specified non-insulated backer board. Walls utilizing a foam-cored board (e.g. HYDRO BAN® Board) may provide enough thermal resistance (R value) to act as the insulation. The Project design team will have to determine the R value and determine suitability of board to act as insulation.

Once the vapor diffusion retarder (vapor barrier) has been properly installed, application of the insulation panels or HYDRO BAN Board can commence. These panels are typically fastened mechanically through to the substrate through the vapor diffusion retarder (vapor barrier); check with the insulation manufacturer for proper installation instructions for their product in this application. A dab of LATASIL™ can

help prevent moisture from getting through the fastener holes. Install galvanized diamond metal lath, complying with ASTM C847 "Standard Specification for Metal Lath", according to the current revision of ANSI A108.02 3.6 and ANSI A108.1A. Make sure that no fasteners penetrate the shower pan liner. Pencil rods and tie wires should be used to secure the metal lath in place. As stated in the TCNA Handbook for Ceramic, Glass and Stone Tile Installation, "Attach four equally spaced tie wires through the insulation. Attach $\frac{1}{4}$ " (6mm) diameter steel pencil rods vertically over the insulation. Attach metal lath to pencil rods on walls and ceilings."⁴⁵

Apply a mortar bed consisting of 3701 Fortified Mortar; or, Quick Cure Mortar Bed as scratch and leveling coats, in compliance with ANSI A108.02 4.0 and A108.1 5.0 over the wire lath on the walls and ceiling. The scratch and float coats can be installed in lifts up to $\frac{1}{2}$ " (12mm) thick and should be floated plumb and true.

Next, install a 2" (50mm) thick minimum, wire-reinforced mortar bed of 3701 Fortified Mortar, or, Quick Cure Mortar Bed onto the shower pan liner. The wire-reinforcement should be 2" x 2" (50mm x 50mm), 16 gauge, galvanized, welded wire mesh (or other as noted in ANSI A108.02 3.7) and should be placed at half the depth of the mortar bed. Make sure that the mortar bed maintains the $\frac{1}{4}$ " per foot (6mm per 300mm) slope to drain which was established by the pre-pitch in the sub-floor.

Allow the mortar bed on the floor to set until firm and then commence with waterproofing the inside area of the steam room with HYDRO BAN® or 9235 Waterproofing Membrane. The entire steam room should be waterproofed, including the ceiling, walls, floor, seat, and any other exposed area; this will help improve the functionality of the vapor diffusion retarder (vapor barrier) and inhibit the passage of much of the moisture through the system. Any vapor transpiring through the HYDRO BAN or 9235 Waterproofing Membrane should easily be handled by the vapor diffusion retarder (vapor barrier). Loop the HYDRO BAN (must be used in conjunction with LATICRETE Waterproofing/Anti-Fracture Fabric when installing slip joints) or 9235 Waterproofing Membrane to loop into the slip joints to allow for excessive movement in these areas. Make sure that any and all penetrations and fixtures are properly waterproofed! (Please refer to Section 6.3 for more information on treating pipes and penetrations).

Tile can be installed directly onto the HYDRO BAN®, HYDRO BAN Quick Cure, or 9235 Waterproofing Membrane as soon as it is dry to the touch. 254 Platinum is the thin-set of choice for steam room/steam shower installations. Check with the manufacturer of the tile to make sure that it is compatible in steam room applications.

Once the tile or stone installation has set firm, grout the installation with SPECTRALOCK® PRO Premium Grout† for best performance. Alternative grouting choices would be either PERMACOLOR® Grout; or, PERMACOLOR Select. Use LATASIL™, with LATASIL 9118 Primer, for treating the sides of tile or stone at movement joints, slip joints, around the drain, to seal lighting fixtures, access panels (if present), or at any change of plane. Please note that LATASIL 9118 Primer should not be used in slip joints and should not contact the LATICRETE waterproofing membrane. The use of SPECTRALOCK PRO Premium Grout will add to the performance of the tile installation because it has an absorption rate of <0.5%. It will be necessary to wait for 14 days for the cementitious grout, and 10 days for SPECTRALOCK PRO Premium Grout to cure at 70° F (21°C) before turning on the steam generation unit.

Expansion joints are generally placed at the wall/floor and wall/ceiling transitions. Larger steam rooms may require additional expansion joints to allow for movement. The project design professional should indicate where these expansion joints are placed. Refer to the Tile Council of North America Handbook for Ceramic Tile Installation – current year EJ-171 for more information and details. (Please refer to Section 3.4 for more information on movement joints).

Once the steam room is ready . . . ENJOY!!

Please refer to the proper execution statement located at in Section 7.2 for more detailed instructions and Section 8 for details on steam room/steam shower installations.

Please keep in mind that it would be beneficial for all concerned to make sure that the steam room construction and installation are done properly the first time. Any mistake can lead to structural damage, mold, water infiltration issues, and more . . . Repairs can be extensive; and the steam room would be far more costly to repair than to do it right the first time!!

SPECIFICATIONS

Method SR613 – Masonry or Concrete Walls with Mortar Bed

Method SR613 Sheet Membrane - Masonry or Concrete Walls with Mortar Bed with HYDRO BAN Sheet Membrane

Method SR613 Sheet Membrane Linear Drain - Masonry or Concrete Walls with Mortar Bed, HYDRO BAN Sheet Membrane and HYDRO BAN Linear Drain

Method SR613 Sheet Membrane BFD - Masonry or Concrete Walls with Mortar Bed, HYDRO BAN Sheet Membrane and HYDRO BAN Bonding Flange Drain

Method SR614 – Framed Construction with Cement Backer Board

Method SR614 HYDRO BAN Board - Framed Construction with HYDRO BAN Board

Method SR614 Sheet Membrane - Framed Construction with Cement Backer Board and HYDRO BAN Sheet Membrane

Method SR614 Bonding Flange Drain - Framed Construction with HYDRO BAN Sheet Membrane and HYDRO BAN Bonding Flange Drain

Method SR614 HYDRO BAN Board BFD – Framed Construction with HYDRO BAN Board and HYDRO BAN Bonding Flange Drain

Method SR614 HYDRO BAN Board Linear Drain – Framed Construction with HYDRO BAN Board and HYDRO BAN Linear Drain

Method SR614 HYDRO BAN Sheet Membrane Linear Drain - Framed Construction with Cement Backer Board, HYDRO BAN Sheet Membrane and HYDRO BAN Linear Drain

Method S313 Stainless Steel Direct Bond – Stainless Steel Construction with Direct Adhered Tile

Method S314 Stainless Steel Mortar Bed – Stainless Steel Construction with Mortar Bed and Tile

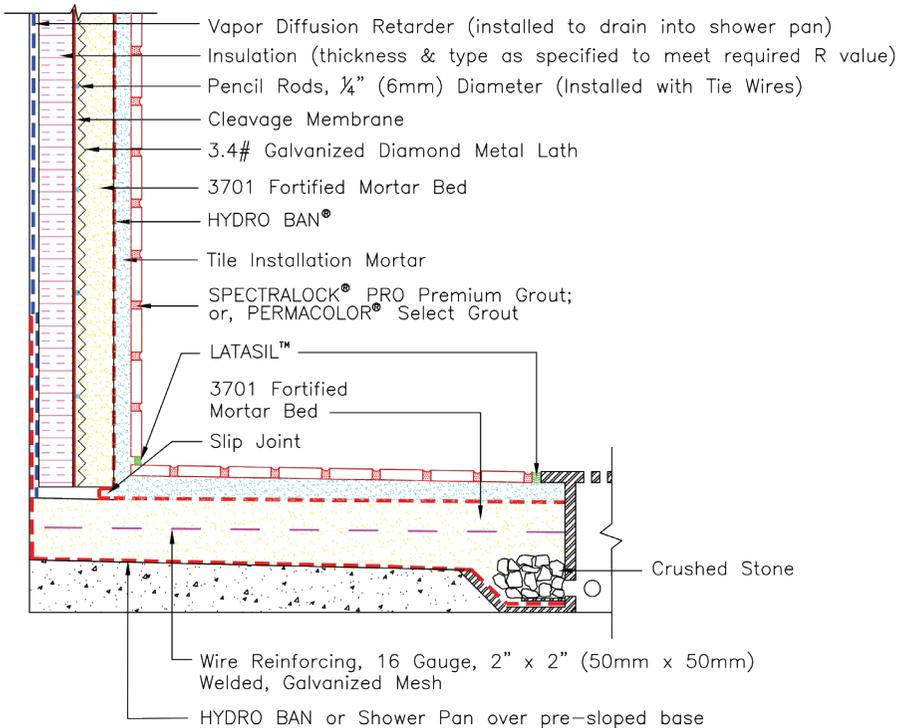
Section 8: Steam Room/Steam Shower Detail Drawings



8.1 Masonry or Concrete Walls with Mortar Bed



Drawing No. ES-SR613



NOTE: Vapor diffusion retarder (vapor barrier) to drape into primary shower pan liner. This detail is intended to show installation of LATICRETE products and is not to be used to show steam room construction, placement of insulation, type of finish, structural considerations, or other design features. Insulation must be of proper type and thickness to ensure that dew point temperature occurs within the insulation and prevent condensation within the concrete or concrete masonry wall. Insulation to be continuous on walls and ceiling except at slip joints. * Tile installation mortar to be either 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE

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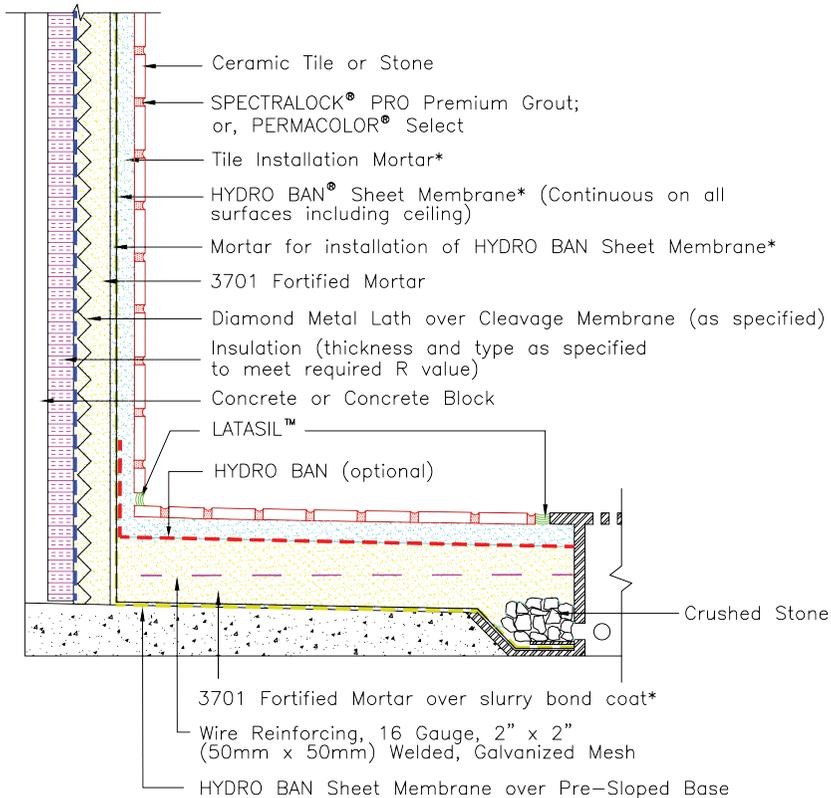
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Section 8: Steam Room/Steam Shower Detail Drawings

8.2 Masonry or Concrete Walls with Mortar Bed with HYDRO BAN® Sheet Membrane



Drawing No. ES-SR613S



NOTE: HYDRO BAN Sheet Membrane Sealing Tape is used to treat board joints, corners and coves. HYDRO BAN Collar is used to treat pipe penetrations. See DS 040.0 for more complete installation instructions. This detail is intended to show steam room construction, placement of insulation, type of finish, structural considerations, or other design features. * Slurry bond coat, tile installation mortar and mortar for installation of HYDRO BAN Sheet Membrane to be either 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE.

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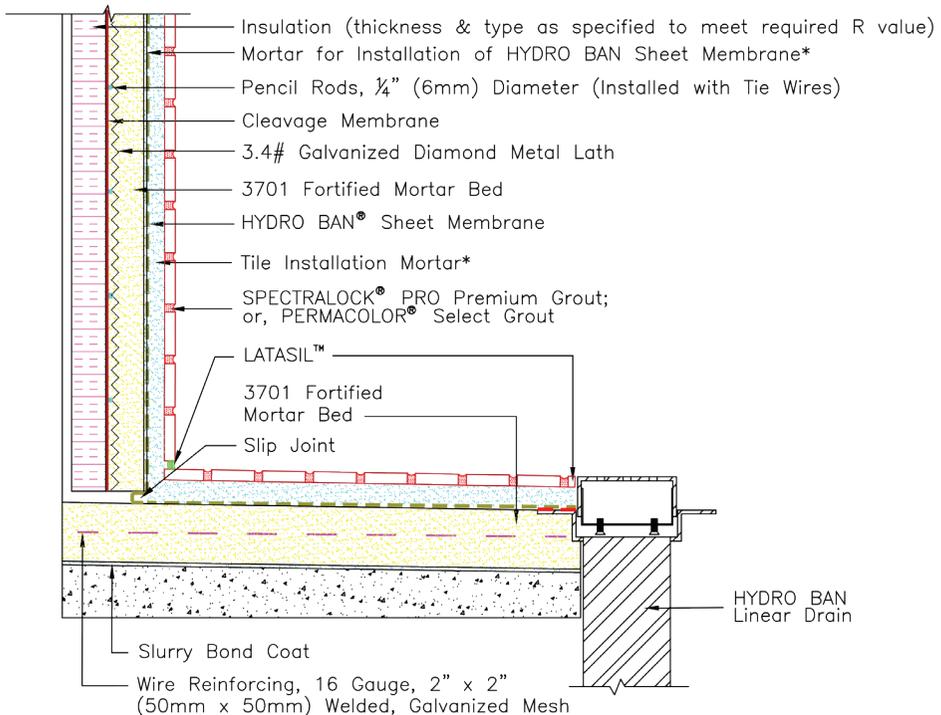
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8.3 Masonry or Concrete Walls with Mortar Bed, HYDRO BAN® Sheet Membrane and HYDRO BAN Linear Drain



Drawing No. ES-SR613LD



NOTE: This detail is intended to show installation of LATICRETE products and is not to be used to show steam room construction, placement of insulation, type of finish, structural considerations, or other design features. Insulation must be of proper type and thickness to ensure that dew point temperature occurs within the insulation and prevent condensation within the concrete or concrete masonry wall. Insulation to be continuous on walls and ceiling except at slip joints. * Slurry bond coat, tile installation mortar and mortar for installation of HYDRO BAN Sheet Membrane to be either 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE

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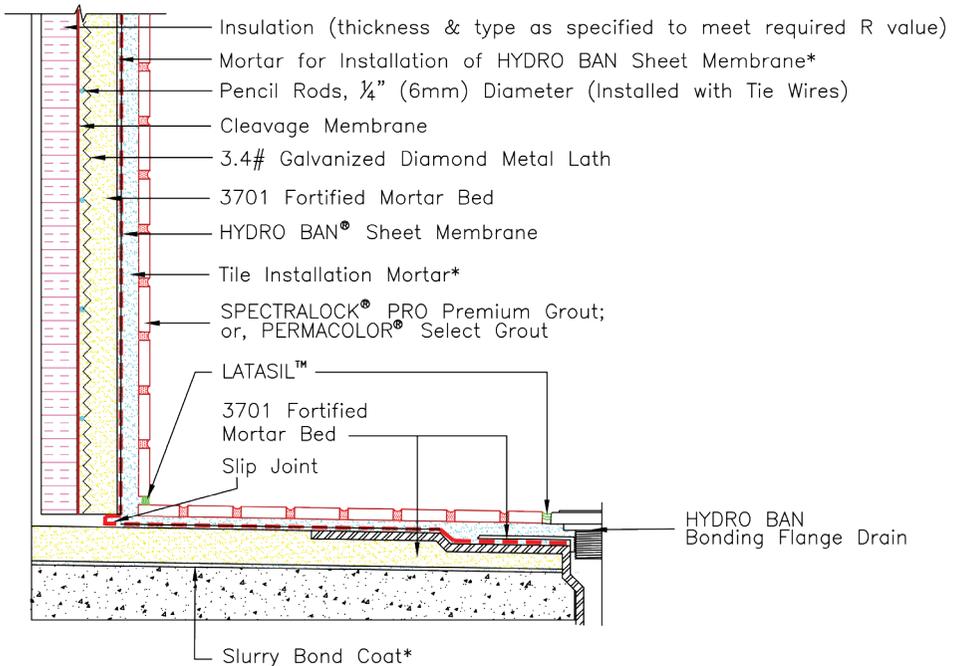
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8.4 Masonry or Concrete Walls with Mortar Bed, HYDRO BAN® Sheet Membrane and
HYDRO BAN Bonding Flange Drain



Drawing No. ES-SR613BFD



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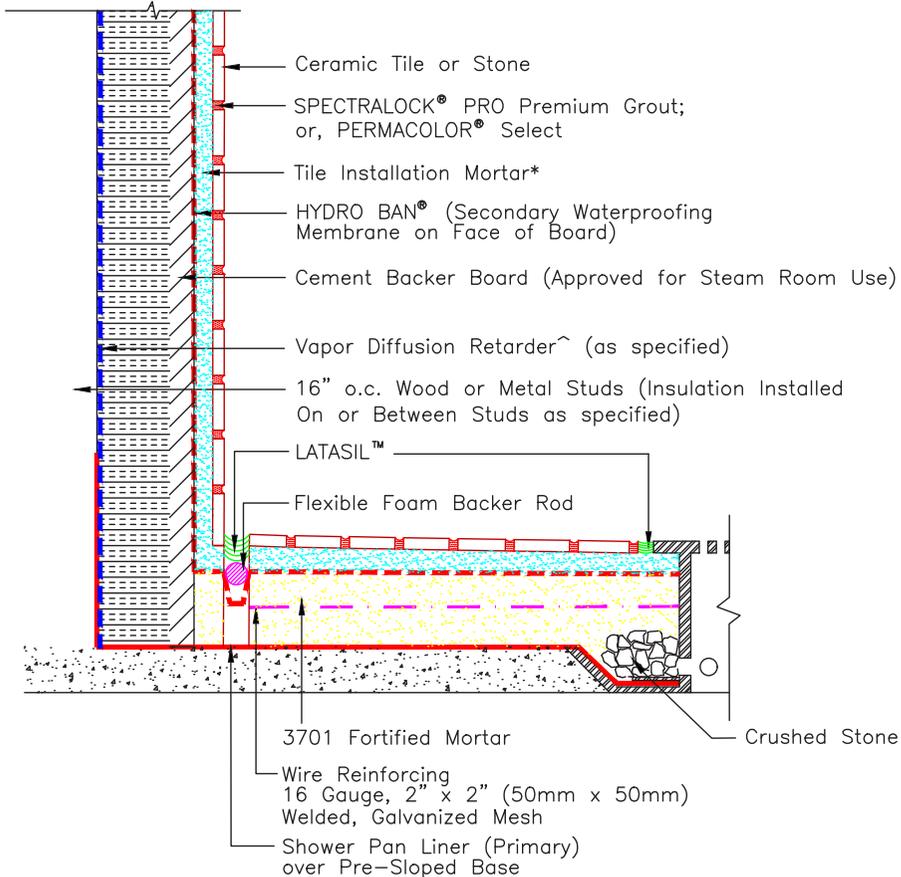
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8.5 Framed Construction with Cement Backer Board



Drawing No. ES-SR614



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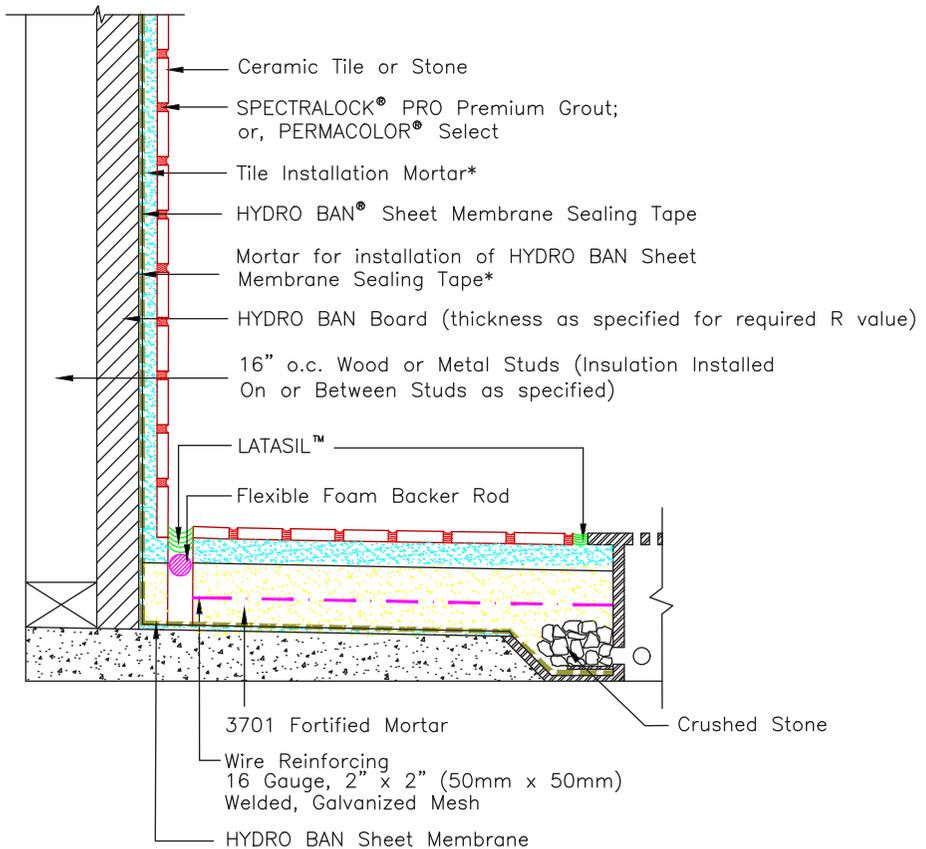
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8.6 Framed Construction with HYDRO BAN® Board SR614 with HYDRO BAN Board with HYDRO BAN Board



Drawing No. ES-SR614HBB



NOTE: * HYDRO BAN Sheet Membrane installation mortar, HYDRO BAN Sheet Membrane Sealing Tape installation mortar and tile installation mortar to be either 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE. ^ HYDRO BAN Board Sealing Tape and Pre-Formed Corners to be used at all board joints, fastener penetrations and corners. This detail is intended to show installation of LATICRETE products and is not to be used to show steam room construction, placement of insulation, type of finish, structural considerations, or other design features.

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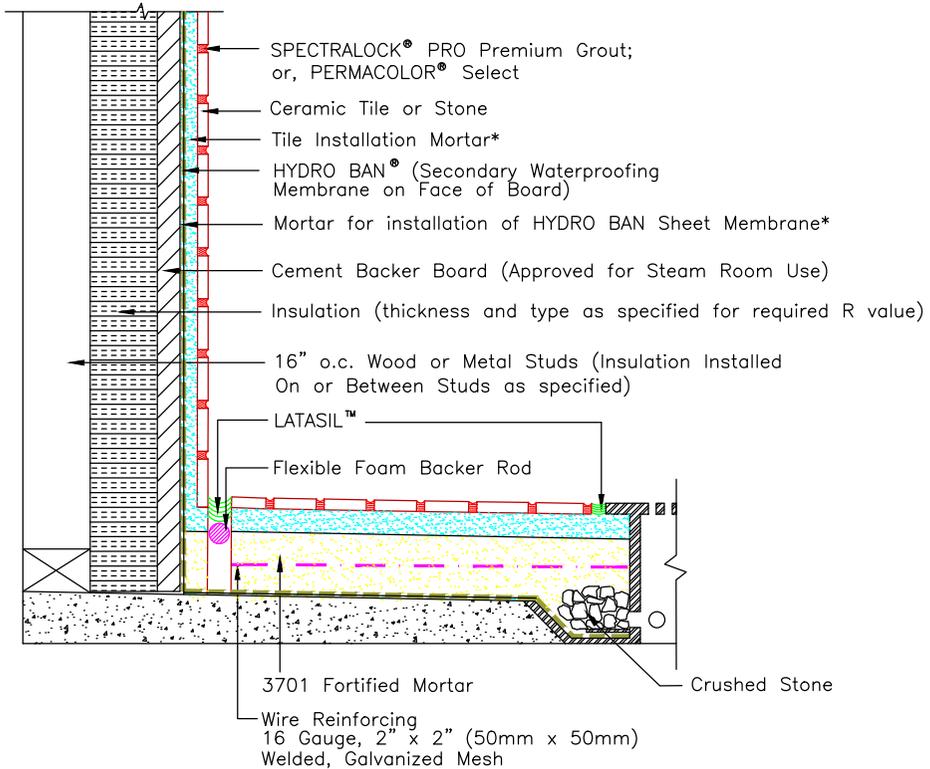
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8.7 Framed Construction with Cement Backer Board and HYDRO BAN Sheet Membrane



Drawing No. ES-SR614S



NOTE: * HYDRO BAN Sheet Membrane and tile installation mortar to be either 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE. This detail is intended to show installation of LATICRETE products and is not to be used to show steam room construction, placement of insulation, type of finish, structural considerations, or other design features. Insulation must be of proper type and thickness to ensure that dew point temperature occurs within the insulation and prevent condensation within the concrete or concrete masonry wall. Insulation to be continuous on walls and ceiling.

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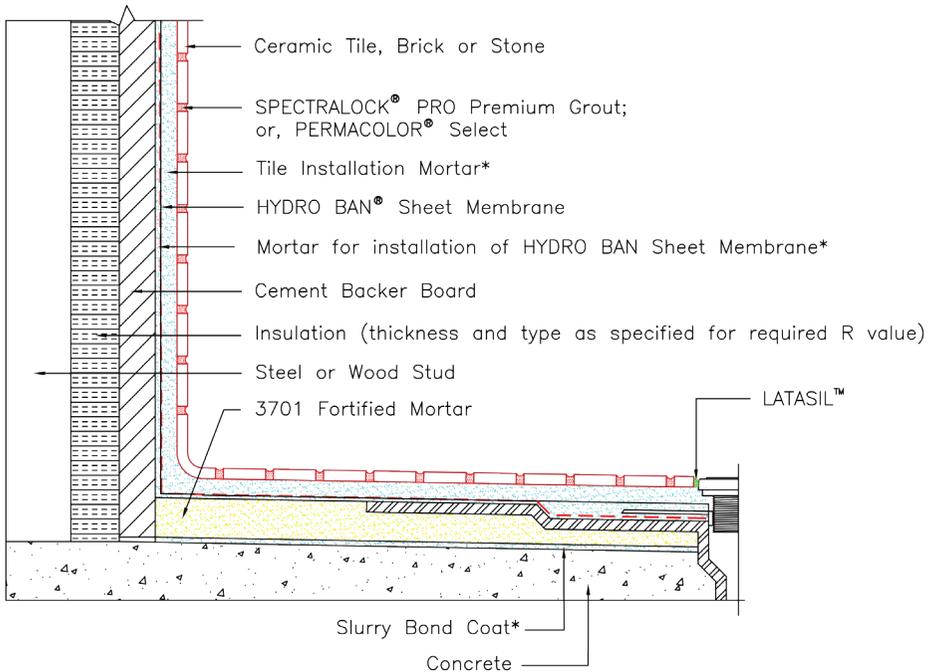
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8.8 Framed Construction with HYDRO BAN® Sheet Membrane and HYDRO BAN Bonding Flange Drain ES-SR614 with Sheet Membrane and Bonding Flange Drain



Drawing No. ES-SR614BFD



NOTE: Cement Backer Board to be installed per board manufacturer’s written installation instructions, including taping of joints. All fastener penetrations to be treated with HYDRO BAN Board Sealing Tape or HYDRO BAN Sheet Membrane Pipe Collar as stated in D.S. 040.0. This detail is intended to show installation of LATICRETE products and is not to be used to show steam room construction, placement of insulation, type of finish, structural considerations, or other design features. Insulation must be of proper type and thickness to ensure that dew point temperature occurs within the insulation and prevent condensation within the concrete or concrete masonry wall. Insulation to be continuous on walls and ceiling except at slip joints. * Slurry bond coat, tile installation mortar and mortar for installation of HYDRO BAN Sheet Membrane to be either 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE.

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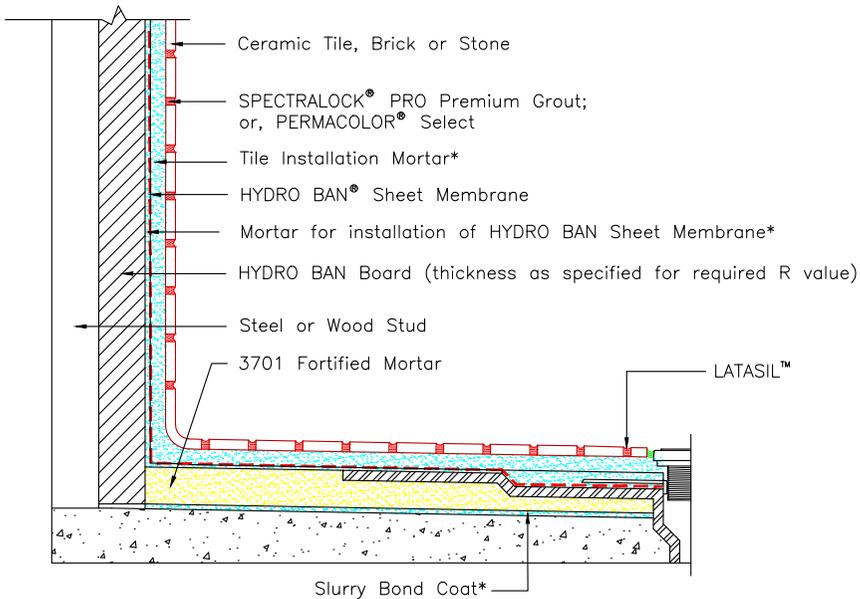
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8.9 Framed Construction with HYDRO BAN® Board and HYDRO BAN Bonding Flange Drain



Drawing No. ES-SR614HBB-BFD



NOTE: HYDRO BAN Board to be installed as state in DS 040.0 including treatment of joints, corners, coves, and penetrations. All fastener penetrations to be treated with HYDRO BAN Board Sealing Tape and all pipe penetrations to be treated with HYDRO BAN Sheet Membrane Pipe Collar as stated in D.S. 040.0. This detail is intended to show installation of LATICRETE products and is not to be used to show steam room construction, placement of insulation, type of finish, structural considerations, or other design features. Insulation must be of proper type and thickness to ensure that dew point temperature occurs within the insulation and prevent condensation within the concrete or concrete masonry wall. Slurry bond coat, tile installation mortar and mortar for installation of HYDRO BAN Sheet Membrane to be either 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE.

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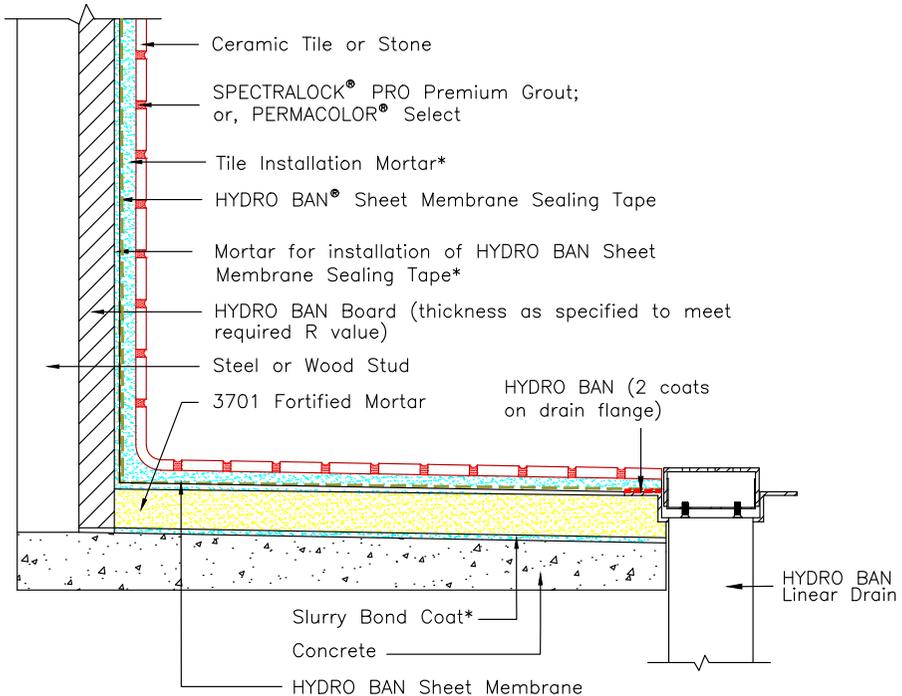
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8.10 Framed Construction with HYDRO BAN® Board and HYDRO BAN Linear Drain



Drawing No. ES-SR614HBB-LD



NOTE: * HYDRO BAN Sheet Membrane, HYDRO BAN Sheet Membrane Sealing Tape, slurry board coat and tile installation mortar to be either 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE. ^ HYDRO BAN Board Sealing Tape and Pre-Formed Corners to be used at all board joints, fastener penetrations and corners. Pipe penetrations to be treated with HYDRO BAN Sheet Membrane Pipe Collar as stated in D.S. 040.0. This detail is intended to show installation of LATICRETE products and is not to be used to show steam room construction, placement of insulation, type of finish, structural considerations, or other design features.

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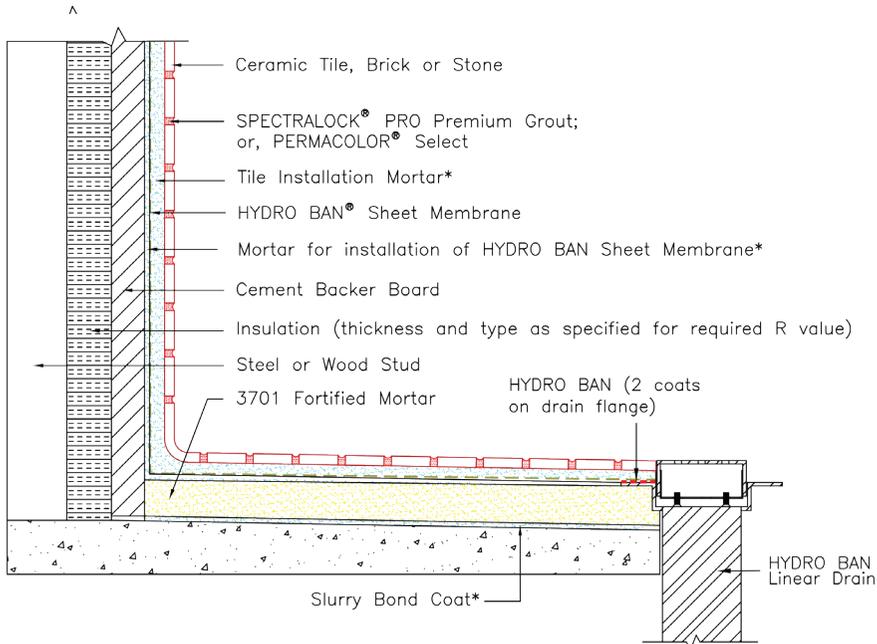
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8.11 Framed Construction with Cement Backer Board, HYDRO BAN® Sheet Membrane and HYDRO BAN Linear Drain



Drawing No. ES-SR614S-LD



NOTE: Cement Backer Board to be installed per board manufacturer's written installation instructions, including taping of joints. All fastener penetrations to be treated with HYDRO BAN Board Sealing Tape or HYDRO BAN Sheet Membrane Pipe Collar as stated in D.S. 040.0. This detail is intended to show installation of LATICRETE products and is not to be used to show steam room construction, placement of insulation, type of finish, structural considerations, or other design features. Insulation must be of proper type and thickness to ensure that dew point temperature occurs within the insulation and prevent condensation within the concrete or concrete masonry wall. Insulation to be continuous on walls and ceiling. * Slurry bond coat, tile installation mortar and mortar for installation of HYDRO BAN Sheet Membrane to be either 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE.

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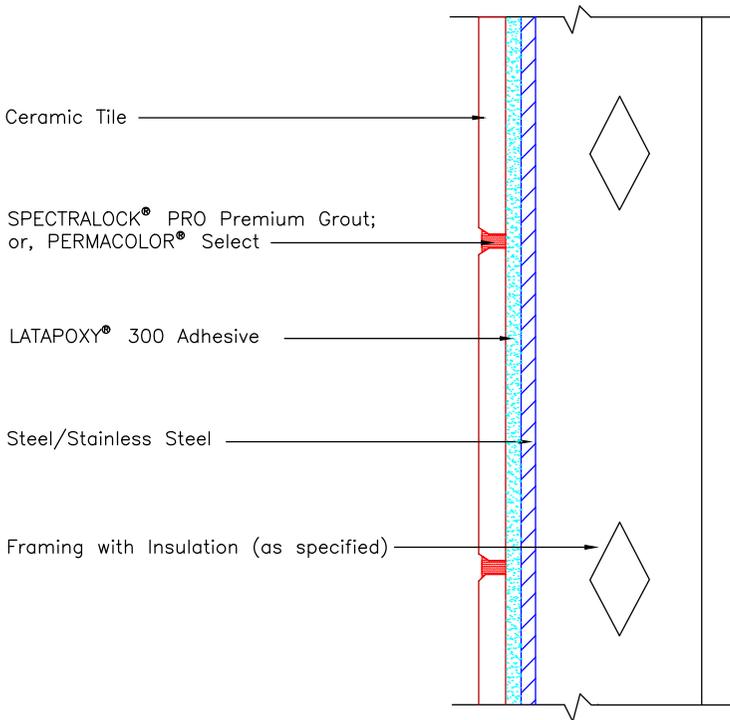
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8.12 Stainless Steel Construction with Direct Adhered Tile



Drawing No. ES S313



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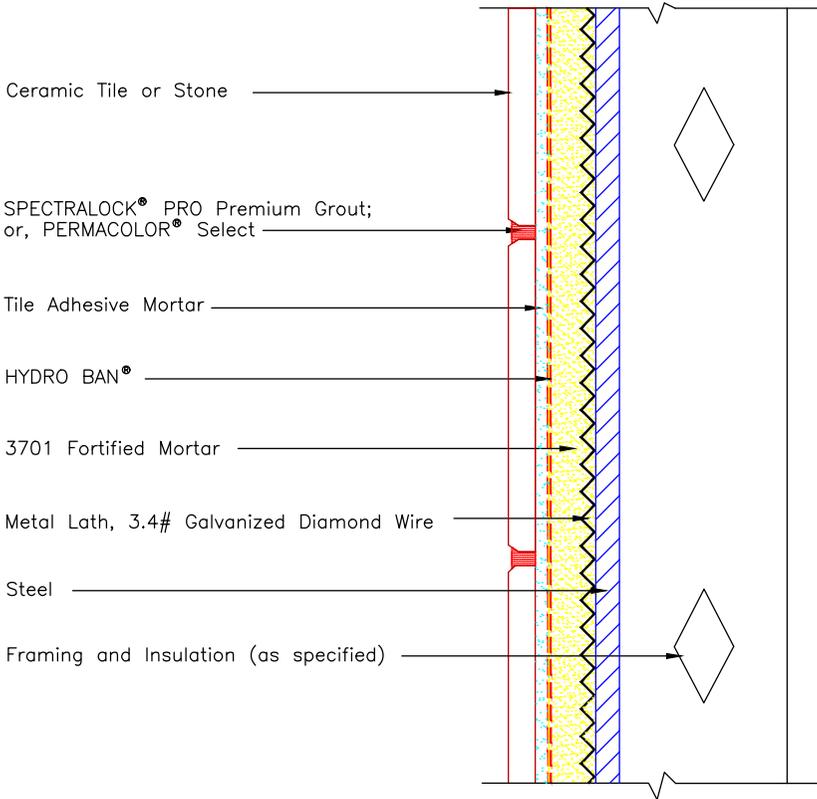
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8.13 Stainless Steel Construction with Mortar Bed and Tile



Drawing No. ES S314



Note: Slurry bond coat, tile installation mortar and mortar for installation of HYDRO BAN Sheet Membrane to be either 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE.

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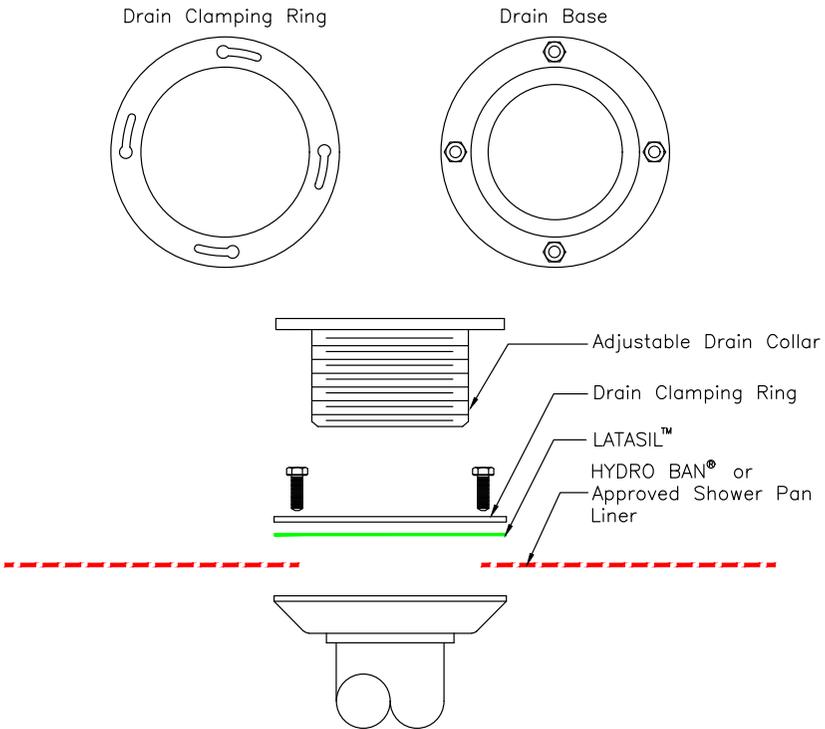
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8.14 Waterproofing Connection to a Clamping Ring Drain – Liquid Applied Waterproofing



Drawing No. ES–WP302



NOTE: It is important to ensure that drain weep holes are not blocked and are functioning fully.

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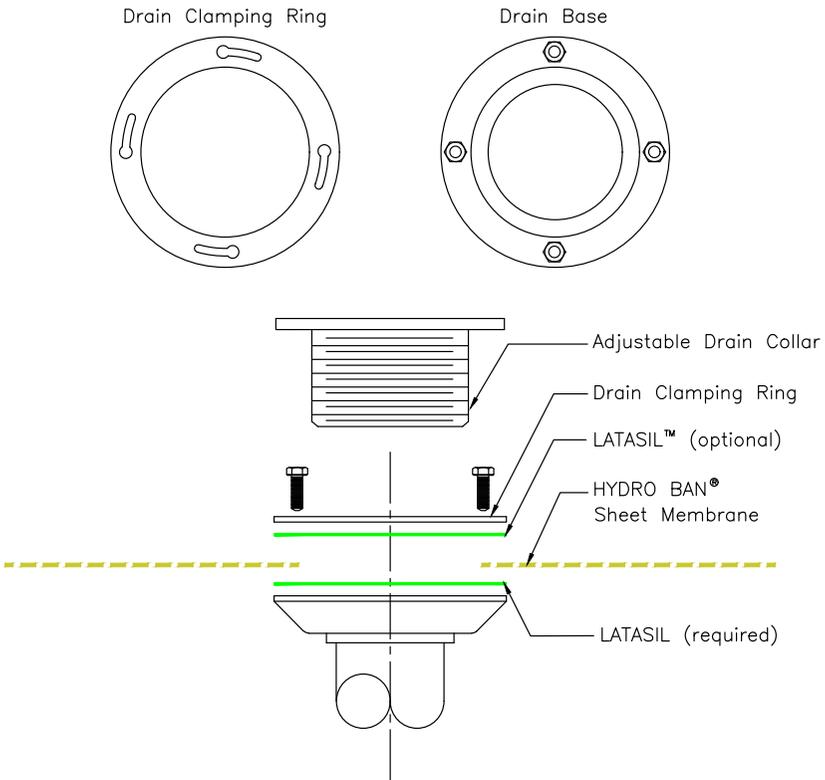
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8.15 Waterproofing Connection to a Clamping Ring Drain – Sheet Membrane



Drawing No. ES WP302
HYDRO BAN Sheet Membrane



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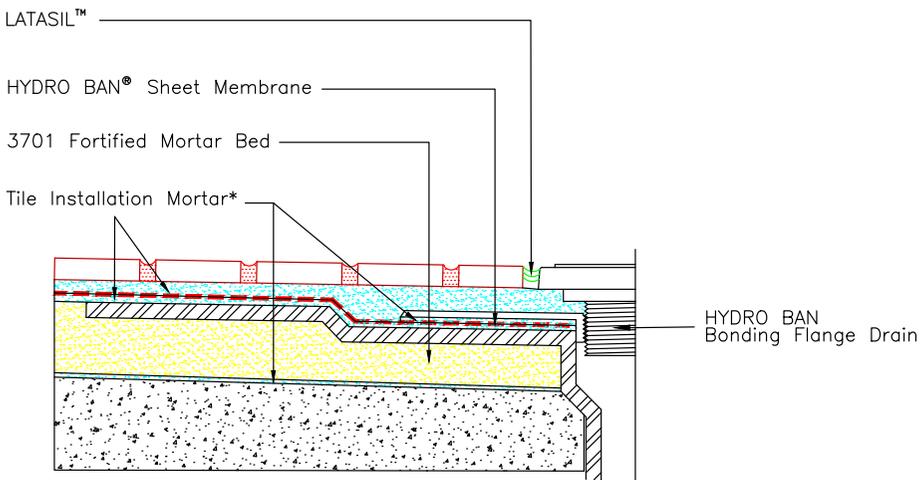
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8.16 Waterproofing Connection to a Bonding Flange Drain – Sheet Membrane



Drawing No. ES WP305



NOTE: This detail is intended to show installation of LATICRETE products and is not to be used to show steam room construction, placement of insulation, type of finish, structural considerations, or other design features. *Slurry bond coat, tile installation mortar and mortar for installation of HYDRO BAN Sheet Membrane to be either 257 TITANIUM™, 254 Platinum or MULTIMAX™ LITE

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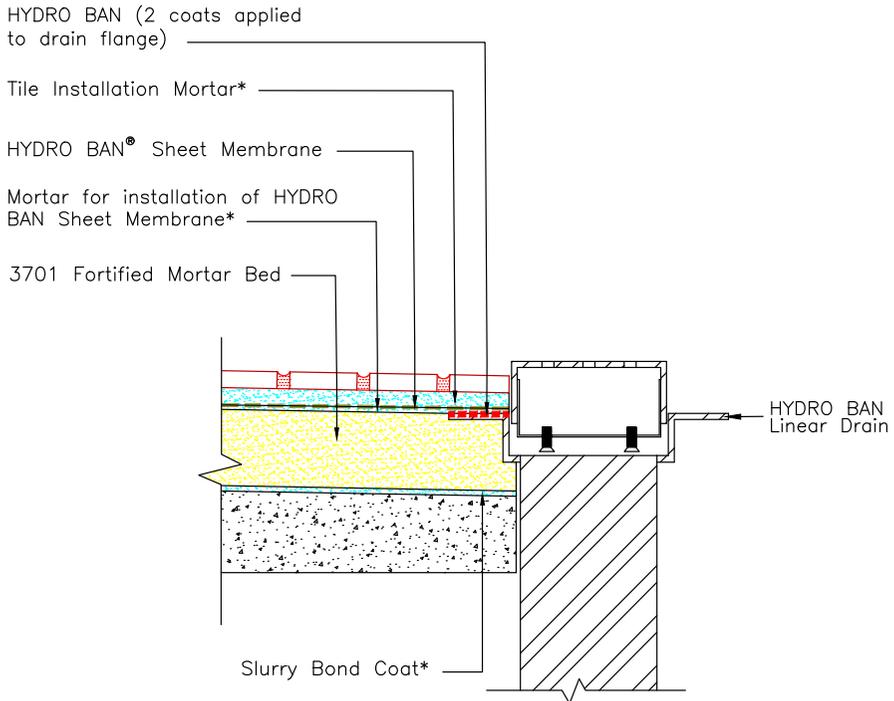
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8.17 Waterproofing Connection to a Linear Drain – Sheet Membrane



Drawing No. ES-WP306



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Section 9: Steam Room/Steam Shower Quality Assurance



9.1 Quality Assurance

The success of a steam room/steam shower project depends entirely on a good quality assurance program implemented at all levels of the project. Unfortunately, comprehensive quality assurance programs remain the most overlooked and ignored process in the design and construction of steam rooms and steam showers. There are important distinctions between the terms “quality assurance” and “quality control”. The distinction is that quality assurance is preventative in nature and encompasses all the procedures necessary to insure quality, from design through implementation. Quality control is corrective in nature, typically implemented during or after a procedure, and is only one component of a more comprehensive and planned quality assurance program. A quality assurance program should include quality checks during the design, specification and bidding phases as well as during and after construction. One factor of tile installations in steam room/steam shower applications is the quality of the installation is only as good as each component, and its’ installation, of the system. Choosing the proper products and installing them correctly is critical to the long-term performance of the steam room.

A comprehensive quality program for the design and construction of steam rooms and steam showers should involve the following:

Owner

- Define Scope of Work
- Organizational Requirements
- Quality Objectives

Design Professional

- Wall System, Shower Pan/Floor System and Ceiling System Product Component Design, Specification, Installation, and Inspection Procedure Training
- Pre-Installation Conference Materials and Methods
- Identification of Construction Progress and Post Installation Inspection, Testing and Evaluation Requirements; Identify Resolution Methods for Non-Compliant Conditions
- Develop and Specify Post Installation Preventative Maintenance Programs

Construction Professional

- Substrate Preparation
- Control of Materials (Evaluation of Contract Document Performance Requirements, Material Suppliers, Delivery, Handling, and Records)

- Product Use Monitoring and Documentation (Pot Life, Curing, Protection and Batch Mixing)
- Setting or Fixing of Tile or Stone — Adhesion Monitoring (Spreading, Thickness, Open Time, Tackiness, Beat-In, Coverage)
- Clean-Up and Protection

9.2 Inspection and Maintenance

Inspection - As with any type of tile or stone installation, a systematic post-installation inspection and maintenance plan should be developed (and implemented) by the facility maintenance engineer and/or owner. Whether defects develop from exposure to normal service conditions, or exist from defective installation, they often are hidden from view and do not manifest as problems until an advanced stage of deterioration or failure. Therefore, it is essential to develop, as a minimum, a systematic plan of visual inspections including pre-construction material and sample evaluations, during construction, and upon completion. The inspections should be conducted on a regular and continual basis, with immediate inspection and maintenance after periods of long steam room operation. Visual comparisons with reference samples, and observation for obvious signs of distress, such as cracked cladding/jointing material or signs of water leakage, should be followed by extensive inspection and testing.

A well performed visual inspection record (including pictures) of steam room conditions can serve as an excellent reference point for performance of the steam room and its components in the future. In addition to inspection of the performance and adhesion of the cladding material, other critical components of the wall system, such as movement joints and penetrations, should be inspected and assessed.

Maintenance - A systematic maintenance plan is a critical required final step in steam room/steam showers that is often overlooked. A steam room is exposed to harsh, deteriorating conditions and without regular maintenance, the normal deterioration process will be accelerated. The result is a loss of performance and shortening of expected service life.

Maintenance of steam rooms is categorized according to how and when maintenance actions are taken. Preventative maintenance is planned and that represents a proactive approach that maintains specified performance and prevents potential defects or failures. Preventative maintenance includes anticipated routine actions and repairs, such as application of protective sealers or deteriorated sealant replacement, as well as unexpected repairs such as replacement of cracked tile or stone, or correcting water leaks that

may manifest into structural problems later.

The benefits of preventative maintenance are well documented; prevention has been proven to increase expected service life, and, cost a fraction of more extensive remedial action (corrective maintenance) typically required once a problem occurs. Corrective maintenance is a remedial action, which repairs a problem after occurrence. Corrective maintenance is necessary to prevent further deterioration or total failure of a steam room system. Corrective maintenance may involve evaluation with either a non-destructive or destructive test procedure.

The use of an epoxy grout (e.g. SPECTRALOCK®[†] PRO Premium Grout) aids in the maintenance of the installation. These epoxy grouts reduce the amount of time needed to clean, seal and provide general upkeep typically required with traditional cement based products.

9.3 Protection and Sealing - Water Repellent Sealers and Coatings

The purpose and performance of water repellent sealers and coatings is widely misunderstood by design and construction professionals. Generally, clear water repellent coatings aid in retarding surface water absorption of porous materials, thereby reducing adhesion of atmospheric pollution and other stains to the surface. However, these materials often provide a false sense of security due to the lack of understanding of their suitability, compatibility, and performance. Water repellents can reduce water leakage and deterioration through normally porous tile, stone or grout materials, but they are not a cure to abnormal leakage caused by fundamental defects in detailing and construction.

There are several general principles for use and application of sealers. Water repellent sealers are not waterproof, and generally cannot bridge gaps or hairline cracks in grout joints or the cladding material, so these materials are useless when used over cracks or very porous materials. Sealers suitable for steam rooms must be vapor permeable, and allow the wall materials to “breathe” vapor, but stop water penetration. Sealers can also create functional or aesthetic defects that are intended to be prevented or corrected by their application. Sealers can have a negative effect on a steam room system if water infiltrates behind the tile/stone through hairline cracks/gaps, or, through poorly designed or constructed wall interfaces. Sealers can trap moisture within a wall, and cause efflorescence, spalling/exfoliation of the cladding material, or structural damage.

As sealers age and weather, several other problems can occur. Effectiveness is typically reduced over time, so periodic

reapplication (depending on the manufacturer’s formulation and recommendations) is necessary; effective service life ranges from 2–5 years. Sealers may also allow variable wetting of the grout, tile or stone from poor application or from weathering; this can produce a blotchy appearance. In some cases, the sealer can be reapplied; in other cases it may be necessary to allow the sealer to completely “weather off”, or be removed chemically to restore a uniform appearance. Please check with sealer manufacturer for complete information on their products.

Compatibility of sealers is also important, with the materials to be sealed, as well as adjacent and underlying components of the steam room system. The appearance of certain tile, stone or grout materials can be affected by sealers. Poor application or poor quality products can darken or change appearance. Silicone based sealer formulations cause discoloration on high lime surfaces such as limestone or marble. Application (or overspray) of sealers to non-porous tile such as porcelain will result in visible residue or a dripping, wet appearance from sealers that do not absorb (e.g. acrylics and urethanes). Sealant joints, waterproofing membranes, and metal are some of the system components that could be affected by solvents in some formulations.

Prior to application of water repellents, all joint sealant work should cure a minimum of 72 hours; the solvents in these materials can affect the cure of sealants. Protection should also be provided for other solvent-sensitive material, such as waterproofing membranes, rubber, glass, and metal frames, by saturating with dish washing soap and water prior to application. Most water-based formulations are non-reactive with solvent sensitive materials.

As an Alternative to Using Sealers or Coatings

Use LATICRETE SPECTRALOCK®[†] PRO Premium Grout in conjunction with a porcelain bodied tile. SPECTRALOCK PRO Premium Grout never needs sealing. The grout becomes just as dense and durable as the porcelain tile.

9.4 Steam (Heat and Moisture) – Effects On A Tile Installation

All building materials expand and contract when exposed to changes in temperature. There are two factors to consider in analyzing thermal movement:

- the rates of expansion of different materials (also known as the linear coefficient of thermal expansion)
- the anticipated temperature range exposure

The primary goal in analyzing thermal movement is to determine both the cumulative and individual differential movement that

Linear Thermal Movement of Different Porcelain Ceramic Tile Sizes		
Tile Size	Thermal Coefficient x Temp. Range x Tile Length (using $8 \times 10^{-6} \text{mm}/^{\circ}\text{C}/\text{mm}$)	Linear Movement per Tile in mm
24" x 24" (600 x 600 mm)	$(8 \times 10^{-6}) (50^{\circ} \text{C}) (600 \text{ mm})$	0.24 mm
16" x 16" (400 x 400 mm)	$(8 \times 10^{-6}) (50^{\circ} \text{C}) (400 \text{ mm})$	0.16 mm
12" x 12" (300 x 300 mm)	$(8 \times 10^{-6}) (50^{\circ} \text{C}) (300 \text{ mm})$	0.12 mm
8" x 8" (200 x 200 mm)	$(8 \times 10^{-6}) (50^{\circ} \text{C}) (200 \text{ mm})$	0.08 mm
6" x 6" (150 x 150 mm)	$(8 \times 10^{-6}) (50^{\circ} \text{C}) (150 \text{ mm})$	0.06 mm
4" x 4" (100 x 100 mm)	$(8 \times 10^{-6}) (50^{\circ} \text{C}) (100 \text{ mm})$	0.04 mm

Figure 9.4.1 Linear thermal movement of different porcelain ceramic tile sizes at normal steam room maximum temperature 122°F (50°C).

occurs within and between components of the facade wall assembly. For example, a porcelain tile has an average coefficient of linear expansion of between $4 - 8 \times 10^{-6} \text{mm}/^{\circ}\text{C}/\text{mm}$ of length. The chart above takes into account only the porcelain tile. Other tile or stone types have varying coefficient of thermal expansion values, as do grouts, sealants, setting materials, and other components of the steam room assembly. These must all be taken into account when determining the selection of materials as well as movement joint size, spacing and construction. Figure 9.4.1 shows that each porcelain tile is expanding the stated measurement in each direction. In a steam room measuring $10' \times 10' \times 8'$ ($3\text{m} \times 3\text{m} \times 2.4\text{m}$) where $12" \times 12"$ ($300\text{mm} \times 300\text{mm}$) tile is used the movement caused by thermal expansion is 4mm (0.16") horizontally and 3.2mm (0.125") vertically. The above stated calculations are just for thermal expansion of the tile only and must be added to the calculations for the other factors that will have an effect on movement (e.g. thermal induced structural deflection, moisture expansion, linear expansion between adhesive and substrate, etc...). The general rule for determining the width of a movement joint is 2–3 times the anticipated movement. The minimum recommended width of any individual joint is $3/8"$ (10mm). Therefore, the calculations must include this fact as well. There is also potential differential movement between the veneer and underlying substrate that must be accommodated by the flexibility of the adhesive and sealant.

Please note that glass tile or glass mosaics may have an even greater degree of thermal expansion than porcelain tile. Check with the glass manufacturer to determine the coefficient of thermal expansion for the particular glass tile being used to help determine the required movement for allowance of thermal expansion.

Thermal Induced Structural Deflection - Thermal induced

structural deflection is a phenomenon, which can occur when there is significant temperature differential between the exterior and interior of a framed steam room structure. This can cause the framing to bend and exert force on the exterior wall assembly. For example, a 50°F (10°C) temperature differential between interior (in the steam room) and exterior wall of the steam room in an air-conditioned space can result in stress being induced on the structure. An engineering analysis to determine movement joint requirements is mandatory, because the frame transmits movement directly to the fixed, direct adhered cladding. This problem seems to be more acute in steel framed steam room structures.

The use of properly placed and installed insulation should prevent thermal induced structural deflection from occurring.

Moisture Expansion - Building materials will be affected by moisture and any subsequent moisture expansion (water absorption into the material). Some building materials (typically not used in a steam room) may be permanently affected by long-term moisture expansion. The effects of moisture expansion and contraction of building materials may also cause problems with tile installation systems. For instance, the use of a tile with low water absorption (e.g. porcelain, glass) with a high absorption, cement based grout may cause cracking within the grout joint due to compressive forces as the grout expands from the moisture. The use of a low absorption epoxy grout (e.g. SPECTRALOCK PRO® Premium Grout) can help to minimize or eliminate this particular issue.

Mold and Mildew – As with any area that has a measure of moisture and/or humidity, mold and mildew may become an issue. Steam rooms/steam showers are not exceptions.

Since steam rooms/steam showers create moist heat, they potentially could be an area where bacteria can flourish, so bacterial infection is a risk in this environment. Some bacteria, such as

methicillin-resistant staphylococcus aureus (MRSA), can thrive in a steam room, and may enter the body through any open wound or cut and cause severe infections. Mold and mildew can also flourish in a steam room/steam shower environment and cause unsightly growth and possible health issues for the steam room users.

Ceramic tile and stone represent excellent protection against mold and mildew. Ceramic tile and stone are inherently water-resistant, whereas some of the other finish types can absorb moisture and degrade over time, further adding to the mold issue. A building owner certainly would rather have finishes in their structures that are resistant to the threat of mold and mildew. Therefore, ceramic tile and stone is the natural choice to be used as a finish material that can provide long lasting benefits. These benefits include a long in-service life cycle, no negative contribution to indoor air quality and are very easy to maintain. When compared to other finish materials, the clear choice is to use ceramic tile and stone as a finish material in today's healthy building environments.

The use of LATICRETE products that incorporate anti-microbial protection can help to eliminate the growth of unsightly mold and mildew into the grout or sealant joints. Mold and mildew may still appear on the surface of the grout or sealant due to the presence of organic material (e.g. hair, dead skin, towel fibers, etc. . .), it should not cause permanent discoloration of the material. However, the presence of the anti-microbial does not mean that the grout or sealant is maintenance free. Please refer to Section 9.5 for Maintenance recommendations.

9.5 Maintenance and Repair of Tile or Stone - Steam Rooms

It may be necessary, from time to time, to make repairs to the steam room/steam shower in areas where plumbing, lighting fixtures, tile or stone, fittings, steam generator, steam vent, and other components of the steam room system show signs of disrepair.

Maintenance - A suitable maintenance regimen, using STONETECH® products, should be established for all types of steam rooms, including both residential, low use types and large commercial steam rooms, which are in constant operation.

Cleaners and sanitizers, capable of eliminating mold and mildew (e.g. STONETECH Mold & Mildew Stain Remover) should be used on a consistent basis to prevent issues associated with mold or mildew. Some cleaners and sanitizers may have a deleterious effect on the grout, sealant and tile. Acid based cleaners can have an effect on not only grout, sealant and tile but may also have on any exposed metal surfaces in the steam room/steam shower.

Make sure that any cleaners, sanitizers, water/steam treatment, or other maintenance products used in a steam room environment are safe for tile and stone, as well as safe for the people who use the steam room/steam shower. If possible, the use of non-pigmented, neutral pH cleaners and sanitizers (STONETECH® Stone & Tile Cleaner) is recommended. Aromatherapy oils/additive manufacturers should certify that their product(s) is safe for steam room use.

Repairing Tile or Stone - Replacing tile, stone, grout, and sealant should only be attempted when the steam generator has been turned off and the tile or stone installation and the substrate have had sufficient time to dry. There should be no repairs or replacement attempted while the steam generator is still in operation. To replace any tile, stone, grout or sealant in a steam room/steam shower application, the LATICRETE materials listed in Sections 6 & 7 can be utilized for each type of application (e.g. ES-SR613, ES-SR614, etc. . .).

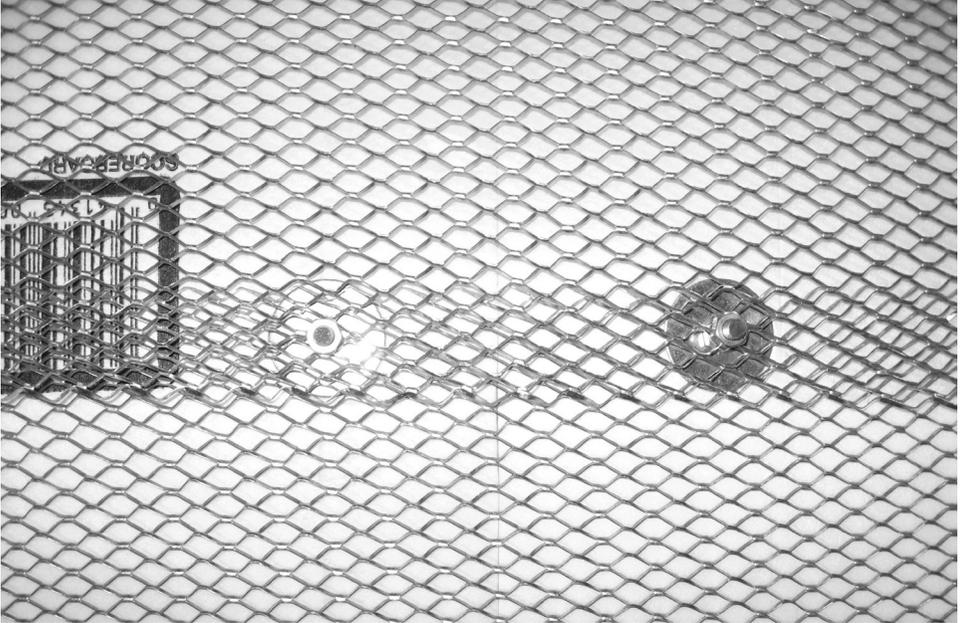
If tile or stone ever becomes damaged, for any reason, it is typically possible to make repairs, but great care must be taken. Damage to any of the key, functional components (e.g. vapor diffusion retarder, waterproofing membrane, movement joints, etc. . .) of the steam rooms' installation system may require more elaborate repairs. This includes possible removal and replacement of the entire steam room system.

The removal of tile without damaging the waterproofing membrane is critical to being able to make the repair easier. If the waterproofing membrane is damaged during repair work it will be required to repair the membrane. If the tile is small in size or the area of membrane damage is extensive this can be very, very difficult to perform. The reason is that either HYDRO BAN® or 9235 Waterproofing Membrane must overlap 2" (50mm) onto undamaged membrane. This may mean having to remove tiles that are not damaged in any way to ensure that the LATICRETE membrane will perform as required. Removal of the tile should not be performed using sharp tools or instruments, which may corrupt the membrane. Great care should also be used when pry bars and levers (including screwdrivers twisted) are used as they can damage the membrane.

Section 10: Appendix



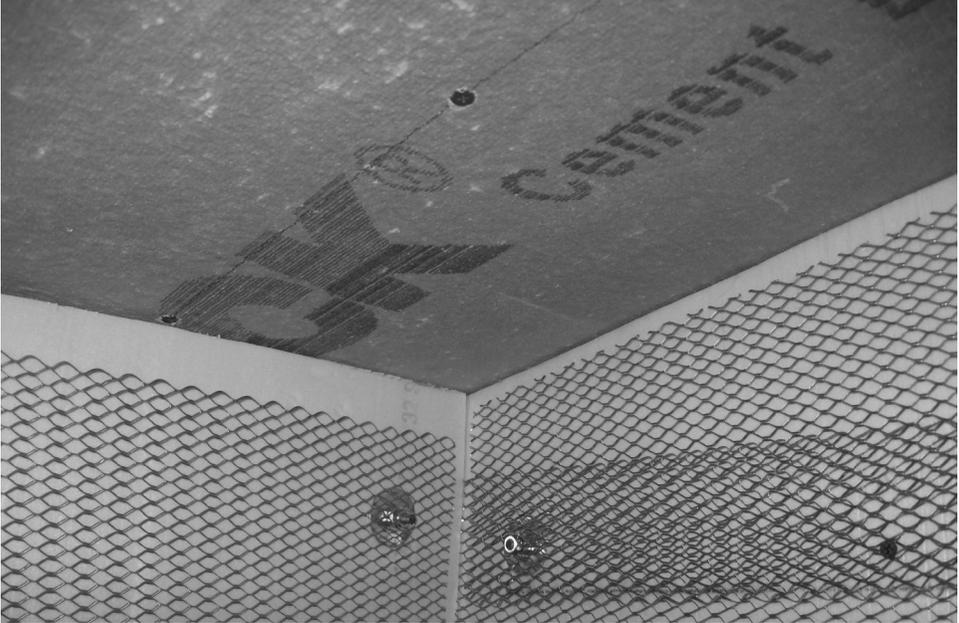
10.1 Case Study



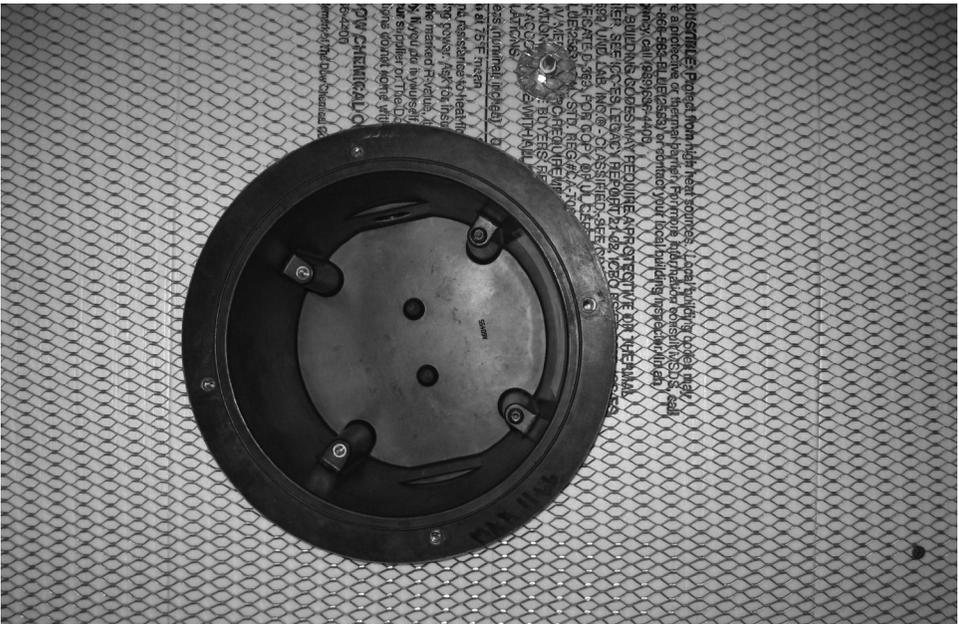
3.2# expandable diamond metal lath fastened through the rigid foam insulation board that has been installed over a vapor diffusion retarder (vapor barrier).



Bench/wall transition and proper placement of 3.2# expandable diamond metal lath.



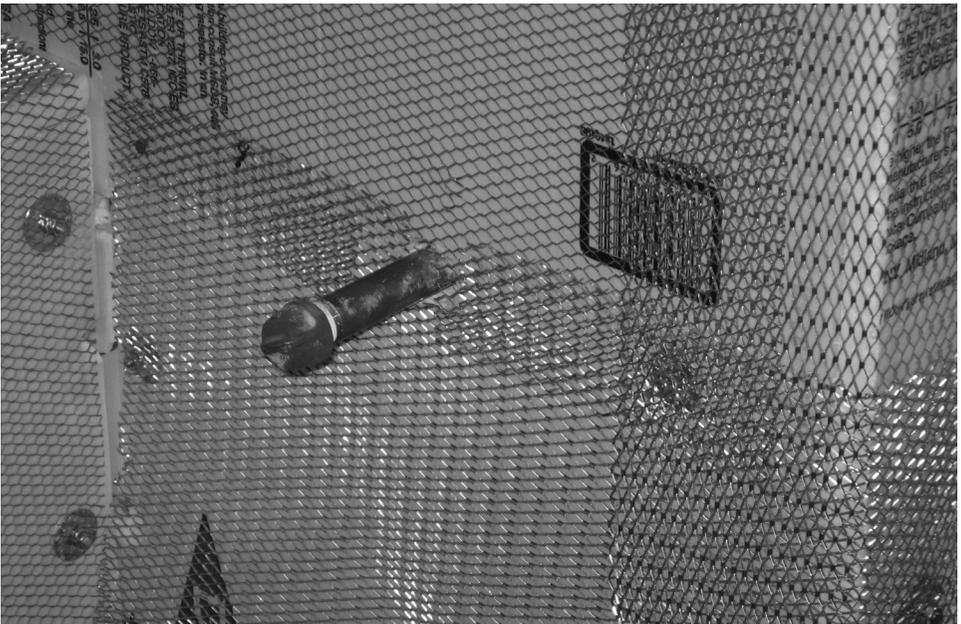
Transition of walls to ceiling prior to installation of 3701 Fortified Mortar Bed.



Tie-in of 3.2# expandable diamond metal lath to steam room light fixture.



Ceiling (with fire sprinkler head) showing Tile Council of North America (TCNA) recommended pitch of 2" per foot (50mm per 300mm).



Pipe penetration for steam generation unit and tie-in of 3.2# expandable diamond metal lath.



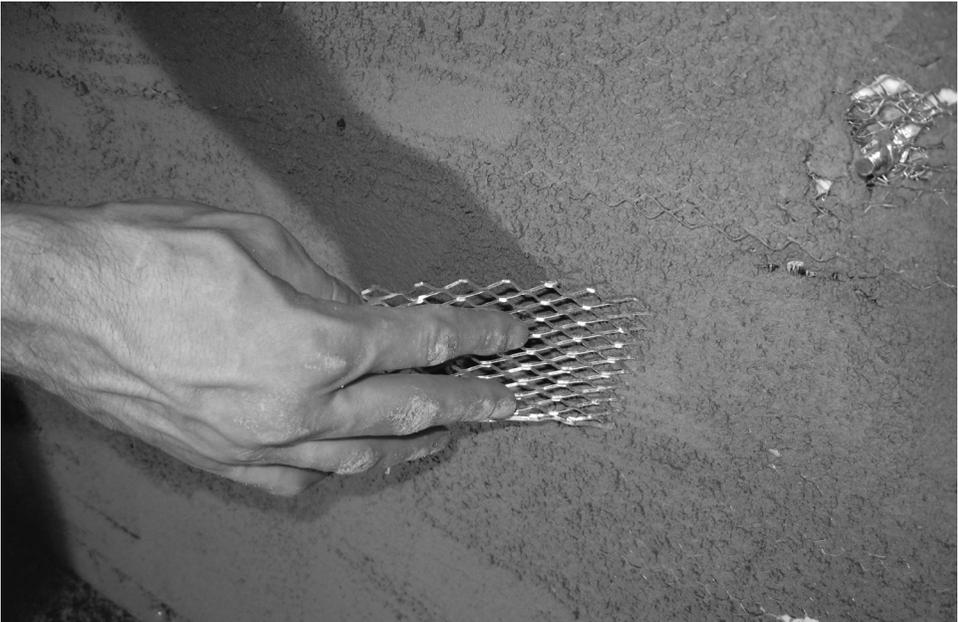
Installation of 3.2# expandable diamond metal lath to stainless steel door frame and flashing.



Wall partially finished with scratch coat of 3701 Fortified Mortar Bed.



Finishing the application of the 3701 Fortified Mortar Bed scratch coat.



Scratching the 3701 Fortified Mortar Bed with a piece of metal lath.



A finished scratch coat wall that is now ready for the float coat.



The steam room seats after the installation of the 3701 Fortified Mortar Bed.



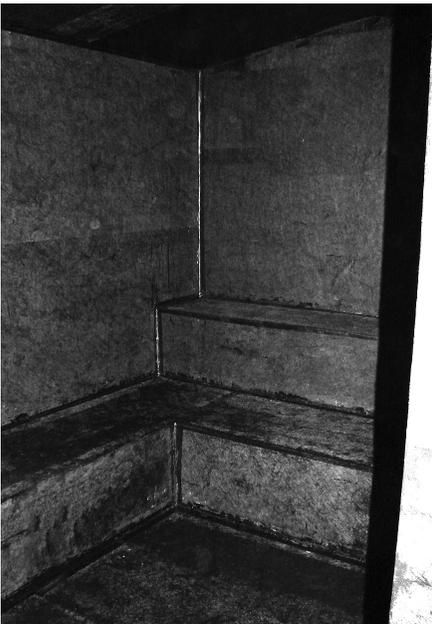
Finishing the application of the 3701 Fortified Mortar Bed scratch coat.



Scratching the 3701 Fortified Mortar Bed with a piece of metal lath.



A finished scratch coat wall that is now ready for the float coat.



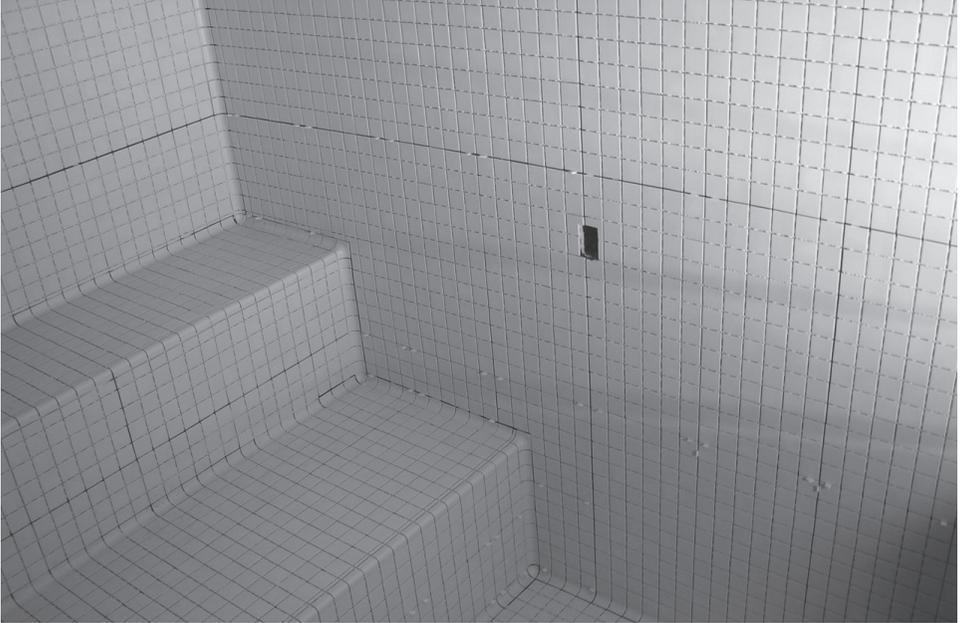
The steam room seats after the installation of the 3701 Fortified Mortar Bed.



Installation of tile onto 9235 Waterproofing Membrane using 254 Platinum.



Continuing tile installation onto all surfaces using 254 Platinum.



Finished installation of 2" x 2" (50mm x 50mm) vitreous tile using 254 Platinum. Notice the cut-out in the wall for the emergency call switch.



Same view of finished installation after grouting with SPECTRALOCK® PRO Premium Grout and LATASIL™.



Finished floor installation of tile. Floor and seats are sloped $\frac{1}{4}$ " per foot (6mm per 300mm) to the drain.



The finished tile installation and stainless steel steam room door.

10.2 Glossary

ABSORPTION — the relationship of the weight of water absorbed to the weight of the dry specimen, expressed in percentages

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. Usually available in assorted sizes as well as large slabs

ANSI — American National Standards Institute

APA — American Plywood Association

AROMATHERAPY (Steam Room) — the use of essential oils as an additive to steam to help alter a steam room user's mood

ASME — American Society of Mechanical Engineers

ASTM — American Society for Testing and Materials

BACK-BUTTER — the spreading of a bond coat to the back of ceramic tile and stone just before the tile is placed

BACK MOUNTED MOSAIC TILE — mosaic tile which may have perforated paper, fiber mesh, resin or other suitable material bonded to the back of each tile which becomes an integral part of the tile installation

BICOTTURA — method for producing tile by firing it twice (first fire is for body, second is to fuse glazes or patterns in glaze onto the body).

BISQUE — the refined mixture of clay, water and additives that has been shaped into the body of a tile

BODY — the structural portion of a ceramic tile

BOND COAT — a material used between the back of a tile and the substrate. Suitable bond coats for a steam room application include latex portland cement mortar and epoxy adhesive

BOND STRENGTH — a bond coat's ability to resist separating from the tile and underlayment, measured in pounds per square inch (psi)

BROWN COAT — the second coat in a three-coat render or mortar application

BULLNOSE — a trim tile with a convex radius on one edge

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 1.2°C)

CAULK — see sealant

CEILING SLOPE — steam rooms require ceilings to be pitched 2" per foot (150mm per m) to prevent condensation from dripping on steam room occupants

CEMENT — binding component of mortars and concrete (usually portland cement)

CEMENT BACKER BOARD — a backer board, usually composed of cement, fillers and fiberglass mesh, designed for use with ceramic tile in wet areas

CEMENT GROUT — a cementitious mixture of portland cement, sand or other ingredients, pigments and water, to produce a water resistant, uniformly colored material used to fill the joints between tile units

CEMENTITIOUS — having the properties of cement

CERAMIC TILE — a surfacing unit, usually relatively thin in relation to facial area, made from clay or a mixture of clay and other materials called the body of the tile, and having either a glazed or unglazed face

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. . .

CLEAVAGE MEMBRANE — a membrane that provides a separation and slip sheet between a mortar bed and the substrate

COLD JOINT — any point in concrete construction where a pour is terminated and the surface lost plasticity before work continued

COMPACTION — the process where a freshly placed mortar is reduced to the minimum practical space to form a stronger, denser mass

COMPRESSIVE STRENGTH — a material's ability to withstand a load force, measured in pounds per square inch (psi)

CONTROL JOINTS — a joint physically cut into concrete to help control cracking during the curing of the concrete

CRAZING — the cracking that occurs in fired glazes or other ceramic coatings due to critical tensile stresses

CURING — maintenance of humidity and temperature of freshly placed mortar or grout to assure satisfactory hydration of cement and proper hardening of mortar or grout

CUSHIONED EDGED TILE — tile on which the facial edges have a distinct curvature that results in a slightly recessed grout joint

DEFLECTION — a variation in the position or shape of a structure element due to the effect of loads or volume change

DEW POINT - The temperature at which the water vapor, contained in a volume of air at a given atmospheric pressure, reaches saturation and condenses to form liquid water (dew).

DIFFUSION — The process by which water vapor spreads or moves through permeable membranes caused by a difference in vapor pressure

DOT MOUNTED MOSAICS — tile packaged in sheets and held together by plastic or rubber dots between tiles

EFFLORSECENCE — the residue deposited on the surface of a material (usually cement grout) by crystallization of soluble salts

EPOXY ADHESIVE — an adhesive system that employs epoxy hardening portions

EPOXY GROUT — a mortar system that employs epoxy hardening portions

EXPANSION JOINT — a joint through tile, mortar and substrate to allow for excessive movement

FACE-MOUNTED MOSAICS — mosaic tile sheets that have paper or other suitable material applied to the face of the mosaic sheets, usually with water soluble adhesives for easy removal after installation and prior to grouting

FLOOD TEST — the intentional filling of a vessel with water to test integrity of the waterproofing membrane and/or vessel shell

GLASS MOSAIC TILE — tile made of glass, usually not over 2" x 2" (50mm x 50mm) and 1/4" (6mm) thick and mounted on sheets. Sheets are typically 12" x 12" (300mm x 300mm)

GLAZED TILE — tile with a fused impervious facial finish composed of ceramic materials fused to the body of the tile

GREENGUARD Environmental Institute — independent, third party organization which certifies products for low VOC compliance to strict standards (UL GREENGUARD Gold certification)

GROUT — a material used for filling the joints between tiles

GROUTING — the process of filling tile joints with grout

HEALTH PRODUCT DECLARATION (HPD) — a globally harmonized declaration showing any hazards associated with the raw materials of products

IAPMO — International Association of Plumbing and Mechanical Officers

IBC — International Building Code

IRC — International Residential Code

LARGE, HEAVY TILE MORTAR — a bonding mortar for tile and stone that is intended to be used as a bond coat 3/32" (2.4mm) thick (nominal) to 1/2" (12.7mm) thick after the tile is embedded.

LATEX-PORTLAND CEMENT GROUT — a mixture of portland cement grout with a latex additive or polymer

LATEX PORTLAND CEMENT MORTAR — a mixture of portland cement, sand and a latex additive

LEED — Leadership in Energy and Environmental Design

LOW PERM WATERPROOF MEMBRANE - a membrane with a water

vapor permeance rating of 0.5 perms or less when tested per ASTM A96 Procedure E, tested at 90% relative humidity.

MARBLE TILE — marble cut into tiles and available in various finishes

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

MEDIUM BED — tile setting material that has a finished thickness between 3/8" (9mm)

METAL LATH — expandable metal mesh material which is mechanically fastened to a surface and onto which a mortar bed is applied

MOISTURE EXPANSION — the tendency of materials to change in volume depending upon exposure to moisture and the absorption rate of the material

MONOCOTTURA — method of producing tile by a single firing

MORTAR BED — the final coat of mortar on a wall, floor or ceiling before the installation of tile

MOSAIC TILE — any tile (ceramic, porcelain or stone) with a facial dimension of less than 6 in2 which usually comes in sheets (paper face mounted, dot mounted, back mounted, etc...)

MUD — see mortar bed

NON-VITREOUS TILE — tile with an absorption rate greater than 7.0%

NOTCHED TROWEL — a trowel with a serrated or notched edge which is used to gauge the amount of mortar or adhesive to a specific thickness when setting tile

OPEN TIME — the period of time that a bond coat retains its ability to adhere to the tile and bond the tile to the substrate

PENCIL ROD — reinforcing rod with a diameter no greater than 1/4" (6mm)

PERM — a measure of the number of grains of water vapor which pass through a square foot (0.093 m²) of material at a differential pressure equal to 1 inch of mercury (25.4mmHg) at 73.4°F (23°C)

PERMEABILITY (VAPOR) - a material's ability to allow water vapor to pass through

PINHOLES — imperfections in the surface of tile or grout

PLASTER — a cementitious material and aggregate that, when mixed with a gauging liquid, forms a plastic mass or paste which when applied to a surface, adheres to it and subsequently hardens, preserving in a rigid state the form or texture imposed during installation

PLUMB — perpendicular to a true level

PORCELAIN TILE — a ceramic tile that is dense, impervious and has an absorption rate of <0.5%

POT LIFE — the period of time during which a material maintains its workable properties after it has been mixed

SCRATCH COAT — a mortar bed, applied as the first coat of a mortar on a wall or ceiling, whose surface is scratched or roughened so that subsequent mortar coats will bond properly

SEALANT — an elastomeric material used to fill and seal expansion and control joints, prevents the passage of moisture and does not allow horizontal and lateral movement to affect the tile installation

SELF-SPACING TILE — tile with lugs, spacers or protuberances on the sides which automatically space the tile for the grout joint

SEMI-VITREOUS TILE — tile with an absorption rate between 3.0 to 7.0%

SHELF LIFE — the maximum period of time that an item can be stored before it is used

SHOWER PAN — a waterproof shower floor membrane which is specifically recognized for use in this application — required for steam rooms as well as showers per local building code

SLAKE — the process of mixing a cementitious mortar or grout, allowing it to stand for 5–10 minutes and then remixing. This process makes sure that the moisture in the mix penetrates lumps in the dry components, making it easier to complete the mixing procedure

SLOPE TO DRAIN — a pitch placed in a floor used to evacuate water. ¼" per foot (6mm per 300mm) is the industry recognized standard for floors

SLURRY COAT — a coat of thin-set used to bond a mortar bed to a cementitious substrate

SPACERS — plastic or rubber units used to separate and provide consistent spacing between tiles

STATIC COEFFICIENT OF FRICTION (COF) — the degree of slip resistance presented in a quantitative number that expresses the degree of slip resistance on the face of tile

STEAM GENERATOR — mechanism that turns water into steam and pumps the steam into the steam room under pressure

SUBFLOOR — a rough floor, plywood or boards, laid directly on

joists and to which an underlayment or substrate is installed

SUBSTRATE — the underlying material to which a tile installation material is bonded

TCNA — Tile Council of North America

THERMAL MOVEMENT — the tendency of materials to change in volume in response to changes in temperature (Heat = expand: Cold = contract)

THERMAL SHOCK — internal stress created when a tile undergoes rapid changes in temperature within short periods of time

THICK BED MORTAR — a thick layer of mortar that is used for leveling (see mortar bed)

THIN-SET — tile-setting material that has a final thickness of no greater than 3/32" (2.4mm) after tile is fully embedded

USGBC — United States Green Building Council

VAPOR BARRIER — see Vapor Diffusion Retarder

VAPOR DIFFUSION — the movement of water vapor through vapor permeable building materials

VAPOR DIFFUSION RETARDER (VAPOR BARRIER) — a material that is placed within an assembly to control the migration of moisture due to diffusion

VAPOR PERMEANCE — a measure of the rate of water vapor diffusion through building materials (a lower perm rating indicates less vapor permeability)

VITREOUS TILE — tile with an absorption rate of between 0.5 — 3.0%

VOLATILE ORGANIC COMPOUNDS (VOC) — carbon compounds that participate in atmospheric photochemical reactions and evaporate at normal room temperature

WALL TILE — a glazed tile with a body that is suitable for interior use only and has an absorption rate of greater than 7.0%

WATERPROOFING MEMBRANE — a material applied to a substrate before tiling to protect the substrate and supporting structure from damage by water

WET AREA — surfaces that are either soaked, saturated, or regularly and frequently subjected to moisture or liquids (usually water), such as saunas, steam rooms, showers, swimming pools, and more

10.4 Resource Guide

Ceramic Tile Materials and Methods

Tile Council of North America (TCNA)

100 Clemson Research Blvd.

Anderson, SC 29625

(864) 646-8453

Terrazzo, Tile & Marble Association of Canada (TTMAC)

163 Buttermill Ave.

Unit 8

Concord, Ontario

Canada L4K 3X8

(905) 660-0513

Italian Tile Center (Italian Trade Commission)

33 East 67th St.

New York, NY 10022

(212) 980-1500

ASSOPIASTRELLE

Association of Italian Ceramic Tile and

Refractories Manufacturers (Confindustria Ceramica)

Viale Monte Santo 40

Sassuolo 41049

Italy

+39 0536 818 111

Trade Commission of Spain

2655 LeJeune Road

Suite 1114

Coral Gable, FLA 33134

(305) 446-4387

Association of Tile Manufacturers of Spain (ACER)

Ginjols 3

Castellon 12003 Spain

+34 64-22-3012

www.ascer.es

Ceramic Tile Institute of America, Inc. (CTIOA)

12061 West Jefferson

Culver City, CA 90230-6219

(310) 574-7800

Tile Contractors Association of America (TCAA)

10434 Indiana Ave.

Kansas City, MO 64137

(816) 868-9300

National Tile Contractors Association (NTCA)

626 Lakeland East Dr.

Jackson, MS 39232

(601) 939-2071

American Ceramic Society

600 North Cleveland Ave.

Westerville, OH 43082

(614) 890-4700

Ceramic Manufacturers Association

P.O. Box 2489

Zanesville, OH 43702

(740) 588.0828

www.cerma.org

Ceramic Glazed Masonry Institute

P.O. Box 35575

Canton, OH 44735

(330) 649-9551

www.cgmi.org

Natural Stone Methods and Materials

Marble Institute of America (MIA)

28901 Clemens Rd., Suite 100

Cleveland, OH 44145

(440) 250-9223

Masonry Institute of America

22815 Frampton Ave.

Torrance, CA 90501-5034

(800) 221-4000

The Masonry Society

3970 Broadway

Suite 201D

Boulder, CO 80304-1135

(303) 939-9700

www.masonrysociety.org

Building Stone Institute
5 Riverside Dr., Building 2
P.O. Box 419
Chestertown, NY 12817
(518) 803-4336
www.buildingstoneinstitute.org

Indiana Limestone Institute of America
400 Stone City Bank Building
Suite 400
Bedford, IN 47421
(812) 275-4426

National Building Granite Quarries Association, Inc.
1220 L St., NW
Suite 100-167
Washington DC 20005
(800) 557-2848

Thin Brick Masonry Materials and Methods
Brick Industry Association
1850 Centennial Park Dr.
Suite 301
Reston, VA 20191
(703) 620-0010
www.gobrick.com

International Masonry Institute (IMI)
The James Brice House
42 East St.
Annapolis, MD 21401
(410) 280-1305
www.imiweb.org

National Concrete Masonry Association
13750 Sunrise Valley Dr.
Herndon, VA 20171-4662
(703) 713-1900
www.ncma.org

Concrete, Pre-Cast Concrete
Portland Cement Association (PCA)
5420 Old Orchard Road
Skokie, IL 60077
(847) 966-6200
www.cement.org

Pre-cast/Pre-stressed Concrete Institute
200 West Adams St.
Suite 2100
Chicago, IL 60606
(312) 786-0300
www.pci.org

Wire Reinforcement Institute
942 Main St., Suite 300
Hartford, CT 06103
(800) 552-4974

American Concrete Institute (ACI)
38800 Country Club Dr.
Farmington Hills, MI 48331
(248) 848-3700
www.concrete.org

National Pre-cast Concrete Assn.
1320 City Center Dr.
Suite 200
Carmel, IN 46032
(317) 571-9500
www.pre-cast.org

Structural Engineering
Structural Engineering Institute of the American Society of Civil
Engineers (SEI/ASCE)
1801 Alexander Bell Dr.
Reston, VA 20191
(703)295-6300
www.seinstitute.org

Test Standards & Building Codes
American Society for Testing & Materials (ASTM)
100 Barr Harbor Drive
West Conshohocken, PA 19428
(610) 832-9500
www.astm.org

Materials & Methods Standards Association (MMSA)
P.O. Box 350
Grand Haven, MI 49417
(616) 842-7844

International Code Council (ICC)
4051 West Flossmoor Rd.
Country Club Hills, IL 60478
(888) 422-7233

American National Standards Institute (ANSI)
11 W 42nd St
New York, NY 10036
(212) 642-4900
www.ansi.org

International Organization for Standardization
ISO Central Secretariat
1 ch. De la Voie-Creuse, Case Postale
CH-1211 Geneva 20, Switzerland
www.iso.org

American Society for Quality
600 North Plankinton Ave.
Milwaukee, WI 53203
(414) 272-8575
www.asq.org

National Institute of Building Sciences (NIBS)
1090 Vermont Ave., NW
Suite 700
Washington, DC 20005
(202) 289-7800
www.nibs.org

American Society for Non-destructive Testing, Inc.
1711 Arlingate Lane
Columbus, OH 43228-0518
(614) 274-6003
www.asnt.org

Sealers, Waterproofing, Adhesives
Sealant, Waterproofing & Restoration Institute (SWRI)
400 Admiral Blvd.
Kansas City, MO 64106
(816) 472-7974

Adhesive & Sealant Council, Inc.
7101 Wisconsin Ave., Suite 990
Bethesda, MD 20814
(301) 986-9700

Test Equipment - Non-Destructive Ultrasonic, Tensile Pull
SDS Company
P.O. Box 844
Paso Robles, CA 93447
(805) 238-3229
www.3.tcsn.net/sdsc

Impact-Echo Instruments, LLC
P.O. Box 3871
Ithaca, NY 14852-3871
(607) 756-0808
www.impact-echo.com

Cement Plaster/Render
International Institute for Lath & Plaster
820 Transfer Road
St. Paul, MN 55114-1406
(612) 645-0208

Miscellaneous
Expansion Joint Mfrs. Assn.
25 North Broadway
Tarrytown, NY 10591
(914) 332-0040

- ¹ <http://www.apexsaunasteam.com/steam-history.aspx>
- ² http://en.wikipedia.org/wiki/Ancient_Roman_bathing
- ³ [http://en.wikipedia.org/wiki/Banya_\(sauna\)](http://en.wikipedia.org/wiki/Banya_(sauna))
- ⁴ <http://mysteamroom.com/2009/01/is/tile-steam-room>
- ⁵ TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, page 275.
- ⁶ TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, pages 274 & 276.
- ⁷ www.esteamshower.com
- ⁸ CNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, page 30.
- ⁹ 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.
- ¹⁰ TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, page 432.
- ¹¹ TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, pages 274 & 276.
- ¹² TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, page 44.
- ¹³ <https://www.westlandbath.com/steamroom-planning-guidelines/>
- ¹⁴ TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, pages 274 & 276.
- ¹⁵ TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, pages 274 & 276.
- ¹⁶ TCNA Handbook for Ceramic, Glass and Stone Tile Installation 50th Edition. Tile Council of North America, Inc. Anderson, SC, 2013, pages 200 and 202.
- ¹⁷ http://en.wikipedia.org/wiki/dew_point
- ¹⁸ www.kosterusa.com/files/6.0-Dew-point-table.pdf
- ¹⁹ Ceramic Tile Institute of America (CTIOA) Technical Committee. CTIOA Report 2008-3-27 Subject: Slope To Drain
- ²⁰ TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, pages 275 & 277.
- ²¹ <http://www.westlandbath.com/accessories1.htm>
- ²² <https://www.helocommercial.com/commercial-steam-door>
- ²³ http://www.lbds.info/building/engineering_n_development_services/building_code_requirements.asp#safety_glass
- ²⁴ <http://www.hillingdon.gov.uk/index.jsp?articleid=7278>
- ²⁵ United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) Reference for Green Building Design and Construction, LEED v4 Edition, 2013, The Case for Green Building, pg. 4.
- ²⁶ United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) Reference for Green Building Design and Construction, LEED v4 Edition, 2013, pg. 5.
- ²⁷ <https://www.stoneworld.com.au/classification-of-ceramic-tiles/>
- ²⁸ ANSI A137.1 American National Standard Specifications for Ceramic Tile, American National Standards Institute (ANSI), Anderson, SC 2011, pg. 5.
- ²⁹ ANSI A137.1 American National Standard Specifications for Ceramic Tile, American National Standards Institute (ANSI), Anderson, SC 2011, pg. 15.
- ³⁰ ANSI A137.1 American National Standard Specifications for Ceramic Tile, American National Standards Institute (ANSI), Anderson, SC 2011, pg. 16.
- ³¹ ANSI A137.1 American National Standard Specifications for Ceramic Tile, American National Standards Institute (ANSI), Anderson, SC 2011, pg. 16.
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- ³⁷ TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, page 39.

- ³⁸ International Code Council TechNote. Vapor Retarders: Reducing Moisture Risk in Frame Walls. Retrieved from https://www.iccsafe.org/wp-content/uploads/proclamations/TNO6-Vapor-Retarders_pdf.pdf on October 8, 2019.
- ³⁹ http://www.srh.noaa.gov/epz/?n=wxcalc_vaporpressure
- ⁴⁰ “Water Vapor and Saturation Pressure in Humid Air” The Engineering ToolBox www.engineeringtoolbox.com/water-vapor-saturation-pressure-air-d_689.html. Retrieved September 16, 2011.
- ⁴¹ Acker, William G. “Water Vapor Migration and Condensation Control in Buildings”. Heating/Plumbing/Air Conditioning June 1998.
- ⁴² TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, page 39.
- ⁴² TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, page 39.
- ⁴³ 2018 International Residential Code®. International Code Council. Country Club Hills, MI, 2018, P2709.1.
- ⁴⁴ TCNA Handbook for Ceramic, Glass and Stone Tile Installation 50th Edition. Tile Council of North America, Inc. Anderson, SC, 2013, page 275 & 277.
- ⁴⁵ TCNA Handbook for Ceramic, Glass and Stone Tile Installation. Tile Council of North America, Inc. Anderson, SC, 2019, page 275.

