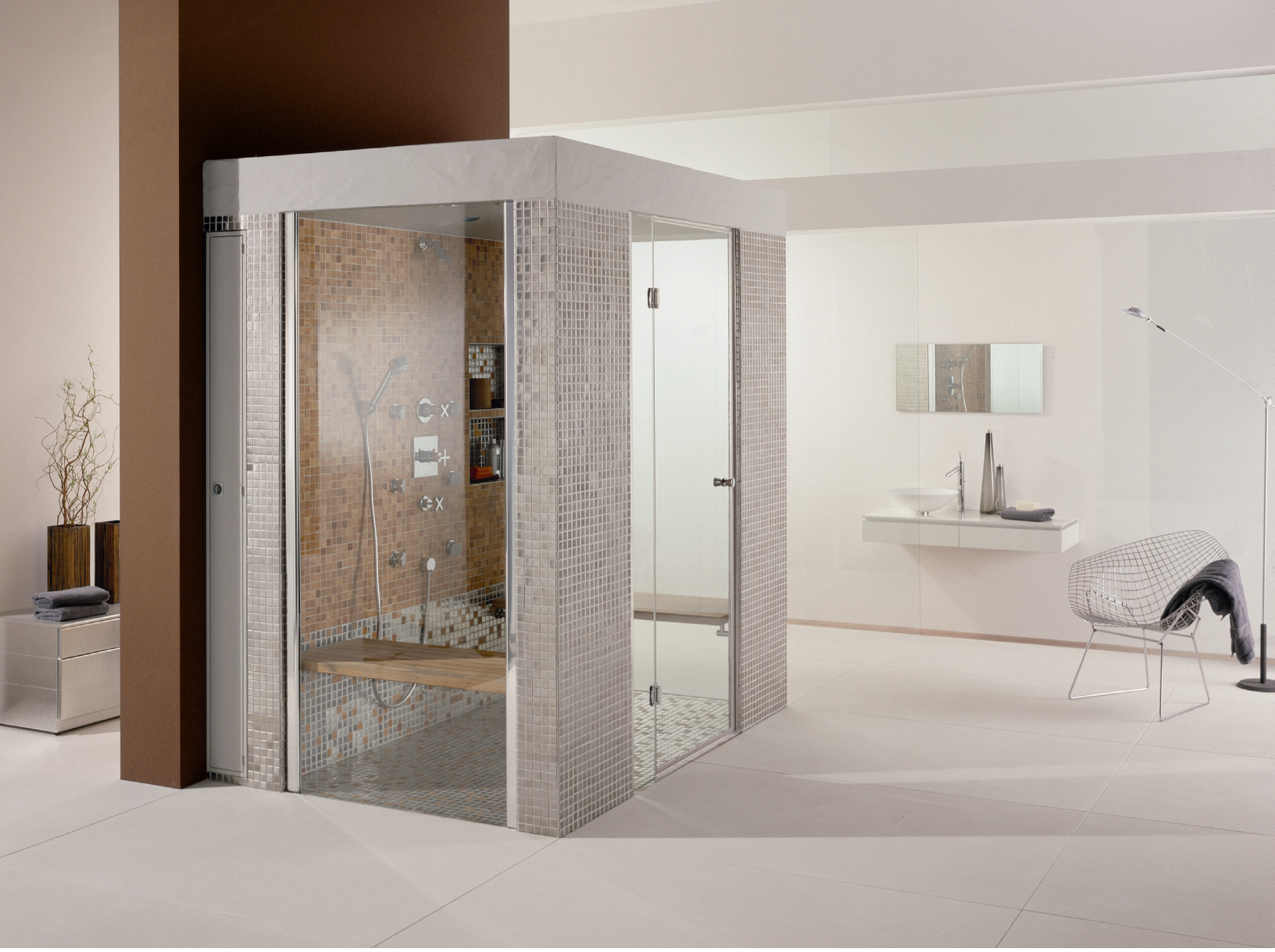


Introduction to Steam Rooms and Steam Showers

Steam Showers and Steam Rooms are not only great places to relax and be healthy. For the professional installer, they are also a special challenge and great opportunity alike.

a. Structural Design, Construction, Building Materials, Technical Equipment- Before Surface Finish Installation

Steam rooms are designed to be closed rooms within which a special environment and climate exists during operation, and it exists parallel and is different compared to the climate outside that room.

Steam rooms differentiate from steam showers mostly because the latter provide the user with both options, the use as a regular shower and the use as a steam room. Steam showers are mostly used in residential settings, while steam rooms are often larger in size, and used in commercial settings and thus used for longer periods of time. In this manual, we will refer to both applications as steam rooms. In fact, wedi applies the same installation and performance requirements to both applications to keep your installation safe under all circumstances. The same recommendations apply to residential and commercial use steam rooms, large and small in size. Naturally, we will base this manual on the assumption that tile will be used as the interior surface finish, installed over tile underlayment systems provided by wedi.

A steam room construction consists of a sloped floor structure with drainage (slope 1/4" [6.4 mm]/foot), tile load bearing wall structures, a tile load bearing ceiling structure (sloped toward wall(s) at 2" [50.8 mm]/foot), and typically seats or bench arrangements (seating area sloped in adorward direction 1/8" [3.2 mm]/foot) . While their general design reflects that of a shower in many ways, steam rooms require a completely sealed room design including the added ceiling and a sealed door and door frame arrangement. In addition to water exposure, steam rooms must be able to handle and manage water vapor and high temperature and temperature change exposure.

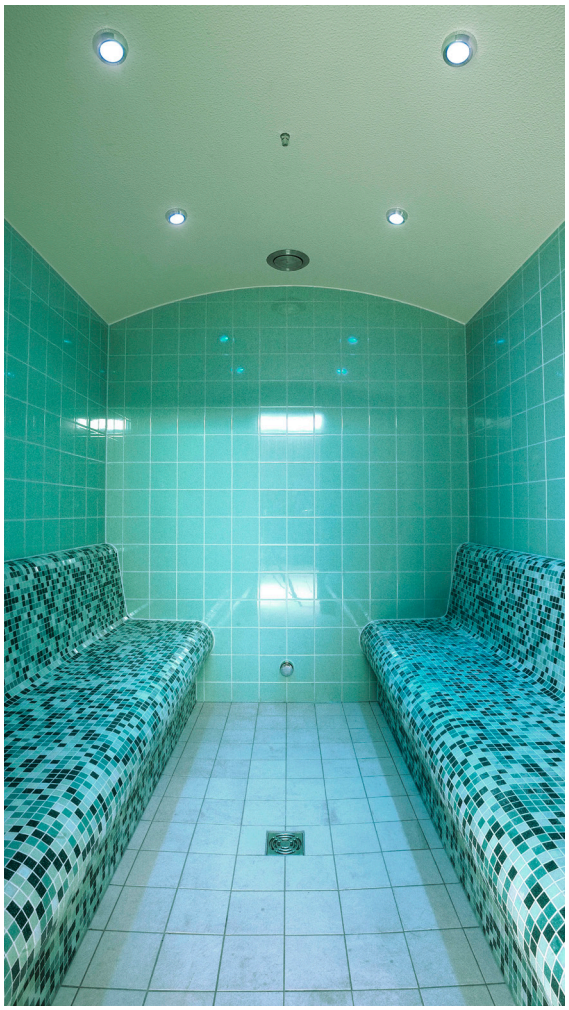
Structural walls, ceilings, benches can be constructed from wood or metal framing or may be solid brick, concrete or cinderblock. Wall and ceiling structures shall be continuously insulated even though they may entirely be interior structures with no walls being part an exterior structural wall of the building. In some areas of types of buildings, part of the wall and ceiling structures may need to be cladded with fire rated panels such as fire resistance rated cement board if on inside of a framed wall, or drywall if on safely dry exterior parts of same wall or ceiling setting. Sprinklers may also be required especially in Type I and II building commercial or occupational use buildings.

Structural subfloors may be made of concrete, screed or wood based. Door frames should be made from aluminum or stainless steel 316 when a frame is used. Glass doors shall be at minimum 3/8" (10 mm) thick reinforced safety glass and shall not be equipped with a lock and always open to the outside. Where no frame is used to tightly seal the door construction which allows for a tight seal of the glass door when closed, meticulous attention must be paid to install alternative systems in equally tight fashion. This can prove to be a challenge, as most non door frame systems are designed for use in showers and water vapor may easily escape which must not be allowed to happen. Generally, it is a good practice, however, to leave an open gap (1" [25.4 mm]) between floor surface and bottom of the glass door to guarantee access for fresh air and oxygen at all times.
All wall, ceiling, bench, floor and other structures to be finished with tile or other surface finishes require the placement of tile or other finish underlayments on the structure's interior side. The underlayments must be appropriate for attachment to the substructures, and also must be appropriate as a bond surface for the tile and environment it is placed into - such as wedi Building Panel.

Equipment for steam rooms include a steam generator, closely located to the unit. It will produce the water vapor, which is forced into the room through an insulated copper pipe led through the wall in an area no less but also no higher than 12" (304.8 mm) of the steam room floor . The copper pipe should be as short and as straight as possible for optimal performance. Condensation may collect in pipe elbows or angles. Where the copper pipe penetrates the wedi wall panel, it must still be insulated to not melt the wedi foam core. Appropriate insulation tape should be heat resistant. The vapor inlet should be equipped with a shield making direct contact between users and the ca. 200° Degree Fahrenheit hot water vapor impossible. The inlets should not be located in areas where users move or sit. The inlet should not point the vapor directly against tile and grout surfaces.

Elaborate shower equipment and plumbing installation may be present, and at least a handheld shower or a hose connection should be considered to clean surfaces in commercial use steam rooms more efficiently.

Lighting must be sufficient and guarantee safety of the users in a foggy space. Lighting may consist of LED or low voltage lights, chromatherapy lighting systems or fiber optic lighting sticking out from the ceiling where the fiber strings are bundled on top of the ceiling and connected to a light source. Audio entertainment and speaker systems may be present, as well as equipment for aromatherapy.



Heating systems, when used in steam rooms, should be hydronic systems. Caution must be applied before deciding to heat surfaces. This extra heat may interfere with temperature guided steam generator operation. In addition, when a steam room is operating at constant and high temperature levels, the water vapor will likely be less visible than would be desired. To see vapor fog, the water vapor must meet air cool enough to bring the water vapor close to its dew point (which fluctuates with density of vapor molecules in air). Cooler air is usually more prevalent in the lower areas of the steam room.

Generally, all equipment used in steam rooms must be chosen based on their suitability for steam room use. Electric equipment and fixtures must be rated for submerged use and carry an IP 67 class rating. Lighting may produce heat and such heat should always be projected away from structures. Caution is necessary when working with lighting commonly used in pools. These are often cooled by the pool water which does not occur in steam rooms. All metal based equipment and fixtures should be corrosion resistant on the level of stainless steel 316.

Please ensure the manufacturer of all materials and equipment specifically approves the installation and use in a steam room environment and is able to advise a safe and water and water vapor tight installation process.

b. The Special Challenges to Prepare the Steam Room for Water, Water Vapor and Temperature Exposure Management

During a steam room's operation, a steam generator forces water vapor into the steam room and the air is quickly saturated with moisture and up to a level of 98 % or more relative humidity. While H_2O water molecules are in a state of gas form, they also carry great energy, and move rapidly and randomly. They are not as tightly packed as the same H_2O molecules in a liquid state (plain water), in which they also move much slower.

Water vapor molecules constantly threaten to penetrate the steam room structures including walls or ceiling but also benches or similar structures, including floors. If that is allowed to happen, the water vapor and, subsequently, the condensation that it forms, may cause damage to framing, subfloors, electrical installations, the adjacent room or equipment and materials outside the steam room.

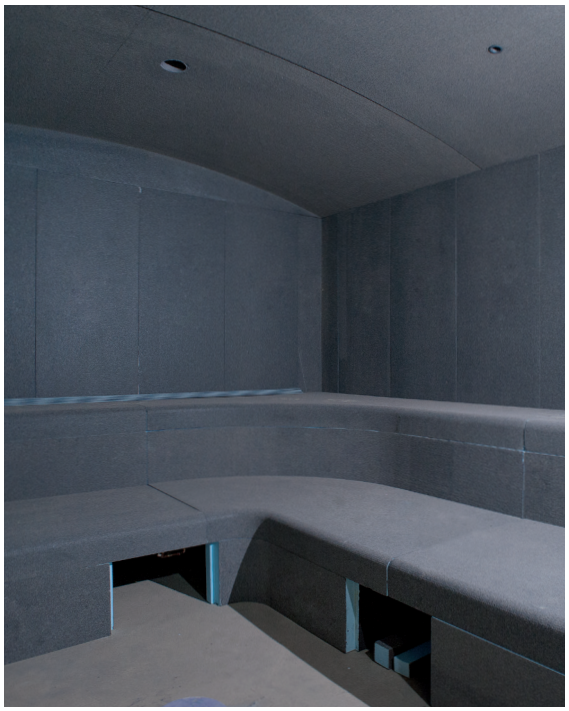
H_2O in its gaseous form (vapor) can penetrate conventional waterproofing membranes. These membranes are designed to withstand penetration of water in its liquid form. Liquid, plain water presents a larger and tighter mass of H_2O molecules and is a less energetic unit in comparison. Particularly, if the vapor molecules escape and meet their dew point inside structures, and then condensate, the condensation remains inside these structures and causes damage that may not be immediately detectable, but massively and continuously present. Wall and roof structures are typically colder, because they are in contact to the outside environment of the steam room. This attracts much condensation on the inside surfaces of the steam room, such as tile. But what is not immediately apparent is, that the water vapor also enters into the equally cold grout and thinset layers until stopped. Insulation inside a wall cavity or structure is therefore important, as it will moderate the climate variation and difference to the outside. This helps prevent excessive condensation and will allow the vapor to circulate more effectively, and it will help saving energy.

The water vapor saturation inside the steam room is maintained through the temperature in the steam room. Average temperature levels are maintained between 100 – 120 Degree Fahrenheit. When the temperature level drops, a feeler activates the steam generator to produce more hot water vapor. The warm temperature is directly caused and maintained by the hot vapor entering the steam room. There is a constant vapor pressure kept on a high level, up to saturation, which is the point at which the steam generator produces as many water vapor molecules that are separating from its water fill as there are water vapor molecules reverting back into liquid condensation inside the room. This condensation is most noticeable when it drips like warm to hot rain off the roof of the steam room. This is why it is important to design a slope of 2" (50.8 mm) per foot into ceiling structures and a recommended 1/8" (3.2 mm) of slope for bench seating areas, so most condensation is lead to the wall, over the benches and towards the slope (1/4" [6.4 mm]/foot) and drain of the steam room floor. Temperature, also in combination with moisture, prompts many materials to expand or contract and at varying degrees, which may impact the steam room functionally and cosmetically. Movement in materials of all construction layers and in between connected parts, product and equipment can cause cracks, leaks and bond issues.

To mitigate the risk from water, water vapor and temperature exposure, the waterproofing and vapor proofing or retarder is placed directly on the inside of the tile underlayment surfaces, where it will now be located directly below the tile adhesive, tile and grout material layers. Insulation is installed behind the tile underlayment.

c. How wedi Can Offer a System to Simplify Construction and Ensure Safe Operation in Consideration of a Steam Room's Special Challenges

wedi Building Panel is a tile backer board and underlayment, which offers insulation and waterproofing all in one product. wedi offers its range of pre-fabricated and pre- sloped Fundo shower floors incl. line drains or point drains for the floor. Besides wedi's regular tile backer boards in 1/2" (12.7 mm) and 5/8" (15.9 mm) thickness for use over existing wall, ceiling or bench structures, framework or solid, wedi also offers an optional 2" (50.8 mm) thick panel. When used at walls and ceilings they could replace framing or other structures and conventional insulation in one step when installed in a free standing concept. They can be used to build benches completely eliminating conventional structures. Such conventional structures can present challenges in steam rooms. Particularly wood materials move, when exposed to temperature changes, and this creates a risk for sealed seams and may cause cracks in surface finishes. When shap-



ing curvy benches or round walls, the 2" (50.8 mm) wedi Panels can complete this job much quicker than for example concrete materials, and without need for time consuming skim coating to get a structure ready for intricate mosaic tile. With our systems, you have two options to provide a strong vapor barrier on top of the wedi Building Panel basis. One option includes the use of wedi Subliner Dry over wedi Building Panel or other suitable surfaces. The other option is Vapor 85, our wedi Building Panel with Subliner Dry factory applied to one side.

Naturally, wedi's product systems are not supporting mold growth. With one system, the entire interior tileable surface is now created and sealed tight right below the level of tile and setting materials. wedi's vapor barrier successfully retards all water vapor targeting it and it is the direct bond surface for tile. It exceeds the requirements set by the Tile Council of North America as shown in the steam room details SR613 and SR614 in their Handbook for Ceramic, Glass, and Stone Tile Installation. In their details, the TCNA requires the permeability of a vapor retarder to be below .5 perms when tested using ASTM test method E96, Method E, and with test environment set at 90% R.H and 100° F temperature. The second option, our wedi Vapor 85 is a a specialized wedi Building Panel equipped and pre-laminated on the vapor exposed side with wedi Subliner Dry, a strong vapor retarder in sheet membrane form. In such assembly, seams and fastener areas are covered and sealed tight using Subliner sealing tape in combination with wedi Sealant 620. The wedi Vapor 85 Building panel will be introduced in June of 2019 and is thoroughly tested on the basis of well-known wedi product and listed under wedi's ICC PMG 1189 Certification and Quality Assurance program. In fact, wedi Subliner Dry and Vapor 85 assemblies incl. their seams were tested to ASTM E96 method E at 100*F and 90% humidity, and achieved a perm rating of 0.03 by far exceeding TCNA requirements.

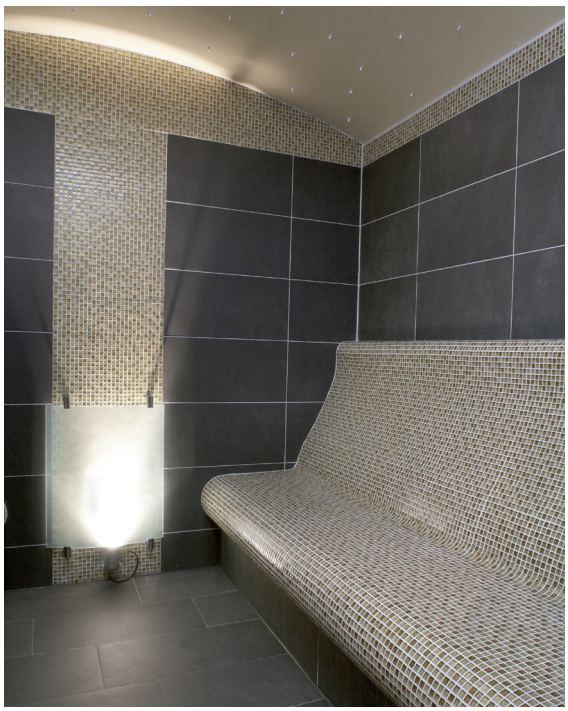
wedi Building Panels in all their sizes and thicknesses also help achieving success when working on smaller but crucial details and offer safer installation experience. They cut tight and clean around protrusions and equipment allowing for tight sealant and vapor barrier application, such as wedi's Subliner Dry membrane. They install tight at seams and are strong tile backer boards providing a gritty and very even and consistent surface you will love when tiling. Their sealed joints offer strong waterproofing but also flexibility, replacing the need for slip joints as required with conventional installation methods and materials. When working on ceilings, its lightweight nature keeps you working fast and safe. Especially when thicker wedi Building Panels are used, these may be connected in Z notch or tongue and groove fashion. This may come in handy when creating connections in ceilings and especially where walls meet sloped ceilings. Their fabrication on site is comparably quiet and causes little to no debris or dust keeping a clean environment further helping the speed of installation and allowing seals and material adhesion to proceed without risk of contamination by dust particles or debris.

d. The Surface Finish in Steam Rooms

It is important to protect the steam room structures against exposure and migration of water vapor and water into any those structures by placing waterproofing and a sufficient vapor retarder as close to the inside surface of the steam room as possible. Insulation behind these protective layers work well to mitigate issues caused by movement of many of the building materials and structures which may react to temperature and its frequent or even abrupt change.

Where steam rooms are tiled, it will come naturally that the tile, tile adhesive and grout, will be left exposed to temperature and are also subjected to water and water vapor absorption potential. This is because most tile and setting materials are, to varying extents, absorbing materials - whether due to their nature or production, or due to limitations in their installation method. Natural stones usually offer higher absorption rates than certain glass or porcelain tiles. Many natural stones are easily affected by the steam room environment and offer potential for discoloration and can also contribute to and support the process of efflorescence occurring. Bond adhesives, such as certain epoxies, may be impervious in itself, but it must be assumed that they cannot be installed providing a 100% coverage under tile and on the next layer below. Neither can grout materials offer this protection, even if they are impervious epoxy materials, and even if they fill straightest grout lines between very large, rectified and low absorbing porcelain tile. There always remains a risk that the potential seal and adhesion of grout to tile edge offers gaps. Do not rely on tile or setting material to function as a way of water or water vapor proofing. It remains, however, best practice and is important, to choose a most fitting combination of setting materials and surface finish systems that are made to endure in submerged and water vapor exposed, high temperature and abrupt temperature change environment and work with each other in this climate. A best practice for the choice of surface finish or tile includes choosing rectified, dense tile with lowest absorption rates (ANSI 137.1 rated for <.5% vol. absorption) and as large in size as possible. Rectified and large in size helps minimizing grout line exposure surface as well as it helps to align grout lines for a tightly packed fill. On the other end of the scale, Natural Stone is not recommended for use in a steam room. For safety in a wet area, the tile for the floor or stadium seating benches should provide the adequate coefficient of friction (0.42).

Adhesives and grout must also withstand the exposure the elements and climate, as well as aggressive cleaning and cleaning materials over time. They must remain unaffected in their adhesion qualities to substrate and tile, and not produce reactions such as efflorescence, which is a common side effect with cement based materials, when constantly exposed to water or water vapor pressure. Water moving through the construction layers may take on soluble salts and may deposit them when surfacing. Efflorescence is mostly known as a cosmetic issue as it causes such discolorations and deposit residues on surfaces. But it may develop into a functional issue. Trapped or continuously present sub-tile moisture expands when heated or continuously entering below the tile as vapor, applying stress to adhesive systems. Salts can also crystallize within the adhesive line, causing break down of the adhesive.



Many epoxy based bond mortars and grouts (ANSI 118.3), often also available as one product used for both setting and grouting the tile, have a good potential to help minimizing vapor migration into grout lines and between tile and setting bed surfaces over tile underlayment/vapor or waterproofing layers. They also have good potential to retain their bond strength over time but must be recommended for use in higher temperatures. They will not contribute to efflorescence and withstand aggressive cleaning better than most cement based setting materials. One disadvantage is the lack of flexibility which is natural to epoxy based materials. This might present an issue where tile is chosen that will expand and contract at higher rates in the steam room environment.

A better alternative to epoxy might be found within the range of setting mortars classified under ANSI 118.15. These thinset mortars are developed to work with tiles we particularly favor in steam rooms, including large format tile and glass tile. They are developed to endure under submerged applications and offer flexibility as most modified mortars do. They should be used in combination with solid epoxy grouts, however.

No matter the choice of tile and setting material, wedi recommends the use of expansion joints in all tile surfaces. The placement should be at perimeters and corners, where planes generally change, and every 8 ft. in either direction in large surface areas. Materials used for theses joints must be fit for use in steam rooms. Many sealants may not handle the moisture/submersion, heat well.

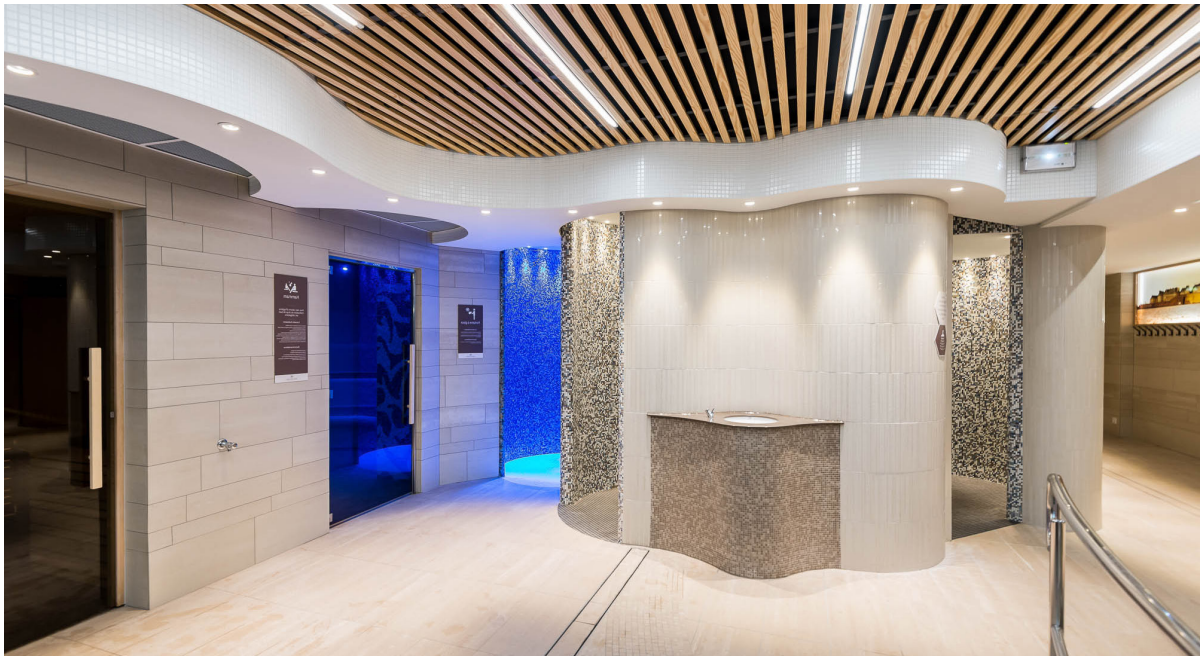
The TCNA also stresses the proper design of steam rooms including placement expansion joints in tile, see Details EJ171 (refer to exterior application type as being most close to the application of stream rooms in terms of extreme exposure levels) for more details such as width and materials recommendations.

When installing tile in steam rooms, please ensure all best practices for setting techniques and goals as outlined in the TCNA handbook are followed. The same is true with tile and setting materials' manufacturer recommendations. Of particular importance is that a coverage of between 95 and 100% of thinset and high bond strength between immediate substrate and back of the tile are achieved. This requires setting over clean, flat, even, square and plumb surfaces which are best created and secured when at the framing or subfloor preparation state. Important is good thinset mortar transfer to the tile even if mesh backed (with a mesh safe in submersed applications and unaffected by alkalis present in mortars). Grout should be tightly packed. Setting materials must be given time to fully cure before a steam room is used. Ensure the manufacturers recommendations incl. for the mixing, installation and cure times are followed to the point.

e. General Product Requirements and Recommendations

Many of the challenges to structures and product, whether to be shaped on site or installed as manufactured, are pointed to in the sections above. Many of the very relevant recommendations were provided. However, it is supremely important the installer or planner of steam rooms chooses each detail of design, installation or product only after most thorough research and investigation into the fitness of such products or work product so they may endure in steam rooms. Equally important, each product must retain their properties and remain unaffected over time as they work in their placement within a system and attached to other product which may affect them (example: they expand or contract at different rates). Ensure each product and the entire concept will be vapor proof, waterproof, and will manage within the temperature range of variations, the climate and cleaning exposure climate.

The steam room will only work if all components work as a system. It is important the fitness is verified with manufacturers and they should warrant the product's performance within the system as planned. While manufacturers will not be able to warrant a steam room system where it includes other products, they can warrant that their product will be warranted if and when installed in a certain complete design.



f. Workmanship, Knowledge and Skill Level Needed

The installer and planner of steam rooms will have to meticulously verify not only proper design and product choice. The execution of the work on such installation is equally important and requires maximum attention to detail: Most importantly, the focus is set on eliminating any possibility of breaches or pin holes which would allow vapor to escape the room or migrate deeper than planned into any product or layers. This includes that particular attention must be paid to a vapor proof installation of all protruding equipment including lighting, sprinklers, possible vents, plumbing and shower fixtures, the steam inlet, the door assembly. These installations need to be sealed in vapor tight where the seal can connect with the room's vapor barrier so the vapor barrier forms a continuous layer. Such seals may not be deferred to topical applications on the tile level such as through sealing in escutcheons. This should be done too, but the vapor will also be present below the tile and therefore, it must be addressed right there. Accidental damage to water or vapor proofing must be avoided and checked. The proper installation is also a significant part of a wholesome steam room concept to work successfully and over time.

* wedi cannot guarantee or warrant specific recommendations made here as they pertain to non wedi product. We believe the statements made here to be best practices, and we also recommend to follow manufacturers recommendations for product performance, suitability and installation process, and to ask each manufacturer for warranty coverage applicable to a specific project design.