2019 | FIELD AND INSTALLATION REQUIREMENTS

Maximum Allowable Deflection for Floor Systems and Substrates

Floor systems, whether wood framed or concrete, over which the tile will be installed using the appropriate TCNA method, according to the "Floor Tiling Installation Guide," shall be in conformance with the International Residential Code (IRC) for residential applications, the International Building Code (IBC) for commercial applications, or applicable building codes. For ceramic tile installations maximum allowable floor member live load and concentrated load deflection for framed floor systems shall not exceed L/360, where "L" is the clear span length of the supporting member per applicable building code. For natural stone tile installations, maximum allowable floor member live load and concentrated load deflection for wood framed floor systems shall not exceed L/720, where "L" is the clear span length of the supporting member, per applicable building code.

The owner should communicate in writing to the project design professional and general contractor the intended uses of the tile installation, including in-service loads or information to allow a project design professional to calculate such. Project design professional and general contractor must make necessary allowances for the expected live load, concentrated loads, impact loads, and dead loads, including maximum allowable loads during construction and maintenance. When concentrated loads such as scissor lifts, pallet jacks, automobiles, forklifts, etc., will be utilized on a tile or stone floor, the project design professional shall include their use in the determination of the appropriate substrate. For the weight of the tile and setting bed (contribution to dead load), see Typical Weight of Tile Installation in the method being specified.

The tile contractor shall not be responsible for problems resulting from any structural subfloor installation not compliant with applicable building codes, unless structural subfloor was designed and installed by tile contractor, nor for problems from overloading. As tile is a finish applied to and relying upon the underlying structure, an inadequate substructure can cause a tile failure. In many cases, problems in the substructure may not be obvious, and the tile contractor cannot be expected to discover such and 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. Consult grout, mortar, and membrane manufacturers to determine appropriate installation materials for above-ground installations. Crack isolation or uncoupling membranes and higher quality setting materials can increase the performance capabilities of above-ground applications. However, these upgraded materials cannot mitigate structural deficiencies including floors not meeting code requirements and/or overloading or other abuse of the installation in excess of design parameters.

Natural Stone Tile Installations on Post-Tensioned Concrete

Because dynamic movements of post-tensioned slabs have proven problematic for directly adhered natural stone, F111 is the only method of installing natural stone tile over post-tensioned slabs, on-ground or above-ground.

Proper Spacing for Wood Subflooring and Wood Underlayments

Plywood subflooring, OSB subflooring, and plywood underlayment shall be installed with proper spacing between the sheets (typically ⅛," except if specified otherwise by the wood manufacturer). If the subfloor or underlayment is installed without proper spacing, this condition cannot be corrected by the tile installer. It is the responsibility of the project owner (or owner's subflooring or underlayment installer) to ensure proper spacing is used as failure to do so may not be obvious, and the tile installer cannot be expected to discover such. If expansion takes place in wood subflooring or underlayment installed without proper spacing, the tile installation could fail.

Natural Stone Tile Installations Over Wood Substrates

Two layers of structural wood panels are required on floors to receive stone tile when backer board will be used as the tile substrate. The MIA prohibits installation of stone tile over single-layer wood floor systems under backer board because of the discontinuity of the system at seams between the subfloor panels. If an unbonded mortar bed will be installed as the tile substrate, a single layer of wood subflooring is permitted.

Natural Stone Tile Installation Over Frame Construction

Strongbacks, bridging, or other load-sharing members may be required within a wood framed system to reduce differential deflection between adjacent framing members; project design professional is responsible for determining the necessity of such. Without the use of such load-sharing members, deflection may differ significantly between adjoining members. Accordingly, for framed construction, an L/720 requirement has been specified (see Maximum Allowable Deflection for Floor Systems and Substrates) while an L/360 requirement can be accepted for concrete/masonry substrates.

Moisture-Affected Materials—Caution

The performance of a properly installed ceramic tile installation is dependent upon the durability and dimensional stability of the substrate. Some substrate materials used in wet areas are subject to deterioration from moisture penetration. (Reference ANSI A108.01-2.4.) Therefore, while the goal of the conference for the *TCNA Handbook* is to produce accurate guidelines, they should be used only with the independent approval of technically qualified persons.

Substrate Tolerances

To facilitate a tile installation that will meet ANSI finish flatness requirements or a stone installation that will meet MIA finish flatness requirements (see "Flatness and Lippage"), the installation substrate must meet the following flatness tolerances per ANSI A108.02 and MIA's DSDM.

Substrate Tolerances for Mortar Bed Methods and Self-Leveling Methods

For thick-bed (mortar bed) ceramic and stone tile installations and self-leveling methods: maximum allowable variation in the substrate prior to the installation of the mortar bed or self-leveling material—¼" in 10' from the required plane.

Substrate Tolerances for Thin-Bed Methods

For thin-bed ceramic tile installations when a cementitious bonding material will be used, including mortar for large and heavy tile (formerly medium bed mortar): maximum allowable variation in the tile substrate—for tiles with all edges shorter than 15," maximum allowable variation is ¼" in 10' from the required plane, with no more than 1/16" variation in 12" when measured from the high points in the surface. For tiles with at least one edge 15" in length or longer, maximum allowable variation is ⅛" in 10' from the required plane, with no more than 1/16" variation in 24" when measured from the high points in the surface. For modular substrate units, such as plywood panels or adjacent concrete masonry units, adjacent edges cannot exceed 1/32" difference in height.

For thin-bed ceramic tile installations when an organic adhesive or epoxy adhesive will be used: maximum allowable variation in the tile substrate is 1/16" in 3' from the required plane with no abrupt irregularities greater than 1/32."

Thin-bed stone tile installations: maximum allowable variation in the tile substrate—⅛" in 10' from the required plane.

Project specifications shall include a specific and separate requirement to bring the substrate into compliance if a thin-bed method is specified but substrate does not meet the flatness requirements.

See also: Disparity Between Concrete Flatness Tolerances Based on F-Numbers and the 10-Foot Straightedge Method and Substrate Tolerances and Large Tile.

Substrate Tolerances and Large Tile

As tile size increases, the negative effect of substrate irregularities is compounded. If specifying a thin-bed method, project specifications should include a separate specification and requirement (such as a pourable underlayment) to bring the substrate into compliance if the substrate does not meet the required flatness tolerance. Alternatively, when specifying tile with any edge longer than 15" consider specifying a recessed installation substrate and a mortar bed (thick-set) method to produce a tile substrate that meets the more stringent flatness requirement for large format tiles. There is no "medium bed installation method" that can be used to flatten the substrate while installing the tile, as mortar (including LHT mortar) is not intended for truing or leveling substrates or the work of others.

See also: Disparity Between Concrete Flatness Tolerances Based on F-Numbers and the 10-Foot Straightedge Method and Dry Set Mortar For Large and Heavy Tile (LHT Mortar), Formerly *Medium Bed Mortar*.

Substrate Tolerance When More Stringent Finish Tolerance is Desired

Should the architect/designer require a more stringent finish tolerance (e.g., ⅛" in 10'), the substrate specification must reflect that tolerance, or the tile specification must include a specific and separate requirement to bring the substrate into compliance with the desired tolerance.

Disparity Between Concrete Flatness Tolerances Based on F-Numbers and the 10-Foot Straightedge Method

Division 3 project specifications typically require concrete substrates to comply with floor flatness (F_F) tolerances based on the ASTM E1155 Standard Test Method to Determine Floor Flatness and Floor Levelness Numbers. A floor's F_F value reflects the aggregate of many measurements and is an indication of the overall flatness of the concrete at the time of measurement. A specified overall flatness SOF_F of 20 is considered "conventional," while an SOF_F of 35 is considered "flat." To establish if the concrete substrate meets the specified F_F the ASTM E1155 test is performed.

By contrast, Division 9 project specifications typically incorporate ANSI A108.02 criteria and as such require areas to receive tile to meet flatness tolerances based on measurements taken with a 10-foot straightedge, where the tolerance is measured as a gap between the straightedge and the floor, e.g., ¼" in 10'. Unlike an F_F number, where results are aggregated, straightedge measurements are used individually, and each area exhibiting a gap greater than the allowed tolerance is out of compliance with the required substrate flatness.

Because an F_F value is derived from many measurements, concrete that meets a specified F_F of 35 will typically have areas that do not meet the required flatness tolerance for tile. This is particularly true when larger tiles will be installed because of the tighter tolerance that applies—the maximum allowable variation for any areas where tiles with at least one edge 15" in length or longer will be installed is ⅛" in 10' from the required plane, with no more than 1/16" variation in 24" when measured from the high points in the surface. For tiles with all edges shorter than 15" the maximum allowable variation is ¼" in 10' from the required plane, with no more than 1/16" variation in 12" when measured from the high points in the surface. If these tolerances as specified in ANSI A108.02 are not met, the tile contractor cannot provide an installation that complies with tile industry tolerances for flatness and lippage without additional effort and compensation for first bringing the substrate into compliance.

In addition to the lack of correlation between the two methods for measuring concrete flatness, there are other provisions of the ASTM E1155 method that are problematic in consideration of the flatness requirements for tile. The method requires measurements be taken within 72 hours of concrete placement, before concrete curling and shrinkage resulting from the curing process has culminated. While the concrete may meet the tolerance at the time of measurement, the flatness can change significantly afterward, generally becoming less flat, not more. Additionally, no measurements are taken at construction, isolation, or control joints; at column block-outs; or within 2 feet of the perimeter of the slab; these are typically the areas with the greatest amount of variation due to curling.

Therefore, a concrete substrate that meets specified Division 3 F_F criteria will likely not be suitably flat to receive tile as defined in ANSI A108.02 and Division 9. Accordingly, a separate specification and requirement is often necessary to bring the substrate into tolerance for tile, with the amount of substrate flattening required dependent on how close the concrete is to meeting the A108.02 flatness criteria at the time of tile installation.

Including a separate requirement helps avoid change orders. If such substrate preparation is not separately and specifically required and included in bid proposals, the tile contractor assumes a suitably flat substrate will be provided. Industry standards for tile finish flatness and lippage do not apply if the project owner does not provide a substrate that meets required ANSI A108.02 substrate flatness tolerances and chooses not to correct substrate flatness issues. See also: Substrate Tolerances and Large Tile.

Substrate Flatness Tolerance and Framed Wall Construction

In framed wall construction, where framing supports or straps are needed for mounted fixtures (grab bars, mirrors, towel dispensers, etc.), such must be located between studs. When supports or straps are installed over studs, the thickness of the supports and the fasteners used to attach them will cause flatness or plumb deviations, and studs must be shimmed out by the framing contractor sufficiently to compensate for the thickness of the supports and anchors.

Alternately, project specifications can include a separate requirement for the tile contractor to bring out-of-tolerance walls into tolerance. However such is not included unless clearly and additionally specified and included in bid proposals. Industry requirements for tile finish flatness and

lippage do not apply if the project owner does not provide a substrate that meets minimum flatness requirements and chooses not to correct substrate flatness issues. See also: Substrate Tolerances and Large Tile.

Maximum Allowable Deflection for Framed Walls

Walls intended for ceramic tile and stone installations shall meet applicable building code requirements.

"Equivalent Gauge" Steel Framing for Drywall (Commonly Referred to as "EQ" Drywall Studs)

For tile and stone installations on cementitious backer board fastened to steel studs, American National Standard Specifications for the Interior Installation of Cementitious Backer Units (A108.11) call for 20 gauge structural steel studs. Similar criteria are used for gypsum board and other backer units in tile and stone applications. According to steel stud industry standards, 20 gauge structural (load-bearing) steel studs have a minimum base metal thickness of 0.0329" and 20 gauge drywall (nonstructural, non-load-bearing wall) studs have a minimum base metal thickness of 0.0296". Some gypsum board and backer board manufacturers require the use of 20 gauge structural studs for tile and stone installations as specified by ANSI A108.11, while others allow the use of 20 gauge drywall studs.

On interior walls with a tile or stone finish, gypsum board and backer board manufacturers commonly do not support the use of steel studs with less than 0.0296" base metal thickness. This includes the use of "equivalent gauge" steel drywall framing, also known as "EQ" drywall studs, typically marketed and engineered for interior drywall applications where painted drywall is the intended finished surface.

Although referred to as "equivalent," the base metal thickness for "EQ" drywall studs is 0.019" to 0.024" (approximately two-thirds the thickness of 20 gauge structural and 20 gauge drywall studs.) Use of "EQ" drywall studs in tile or stone applications can lead to problems with wall deflection and overall flatness, screw spin-out and stripping of the framing, torsional effects, stud flange bending, and stud warpage.

If considering "EQ" drywall studs for use in a tile or stone installation, work with a project engineer, structural engineer, and/or design professional to ensure that appropriate testing and engineering analysis has been performed to confirm the suitability of the "EQ" drywall studs for the specific application, and confirm with backer board manufacturer. If such an installation is pursued, consider increased stud frequency, additional bracing, lighter weight tiling products, counter balancing, and/or use of special fasteners. Additionally, consider performing a small system mockup prior to board installation to evaluate that the fastening tools are properly adjusted such that fasteners are installed in a manner to avoid fastener spin out and overdriving, yet snug enough to remove gaps between connected parts. See *Specifications for the Application and Finishing of Gypsum Panel Products*, published by the Gypsum Association, for stud thickness criteria for abuse-resistant and impact-resistant gypsum panels, as the inherent density and weight of such products present similar challenges to those of tile and stone walls.

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 cannot be expected to discover such. Accordingly, the installing tile contractor shall not be responsible for problems resulting from any structural installation not compliant with applicable building codes or not sufficient for the intended use or application.

LIGHTING AND TILE INSTALLATIONS

Use of wall-washer and cove-type lighting, where the lights are located either at the wall/ceiling interface or mounted directly on the wall, are popular techniques for producing dramatic room lighting effects. However, when proper backing surfaces, installation materials and methods, and location of light sources are not carefully coordinated these lighting techniques produce shadows and undesirable effects with ceramic tiles, particularly when light strikes the tile surface at a low or nearly flat angle (i.e., nearly parallel to the tile surface.) Similar shadows can be created from natural light from windows and doors side-lighting interior walls and floors, and when light shines at a low angle on exterior walls and floors, as commonly occurs in the early morning and evening.

Because such low angle lighting highlights and exaggerates normal and acceptable inconsistencies in tile and tilework, the shadow-producing light is often referred to as "critical light" or "critical lighting." Some of the allowable and acceptable characteristics of tile and tilework that can be highlighted or exaggerated by critical lighting include:

- Die release lines on the edges of tiles
- Difference in appearance between a factory edge of a tile versus an edge that has been field-cut by scoring, grinding, or wet cutting
- Allowable warpage in the tile (see ANSI A137.1 for definition and allowances)
- Allowable lippage (see ANSI A108.02 for definition and allowances)
- Allowable variation in height between field tile and trim pieces and/or accent tiles, whether such are or are not part of the same tile line

In addition, critical lighting can worsen the appearance of tilework that does not meet the finish flatness and lippage tolerances set forth in ANSI A108.02, which is considered acceptable tile workmanship under certain specified conditions:

- Tiled floors sloping to drains (see ANSI A108.02)
- When the project owner does not provide a substrate that meets required flatness tolerances for tile nor contract the tile contractor to correct substrate flatness defects (see ANSI A108.01 and Disparity Between Concrete Flatness Tolerances Based on F-Numbers and the 10-Foot Straightedge Method in this *Handbook*)

To minimize the undesirable effects of critical lighting:

- Place lighting such that it will decrease or eliminate the undesirable effects of critical lighting, and install permanent lights prior to tile installation to provide the installer the maximum opportunity to reduce undesirable shadows.
- Reduce the amount of inherent or allowable lippage by ensuring substrates meet required flatness tolerances for ceramic tile, for example by: specifying a mortar bed, pourable underlayment, or other tile substrate that facilitates a flat tile installation; including adequate allowance in the tile specification for substrate preparation; and specifying the trade responsible for required alterations to a substrate that does not meet flatness tolerances for tile.
- Reduce the amount of inherent or allowable lippage by specifying tile with minimal warpage, such as rectified tile per ANSI A137.1.
- Minimize the effect of lippage due to warpage by specifying wider grout joints, cushioned or beveled edge tile, and tile sizes and patterns that minimize lippage due to warpage, for example avoid offset or brick-joint patterns or specify a maximum 25% or 33% offset (see ANSI A108.02).

MORTAR APPLICATION AND COVERAGE

Mortar Coverage for Ceramic Tile

Average contact area for dry areas is 80% and for wet areas is 95%. Mortar coverage is to be evenly distributed to support edges and corners.

It is not possible or practical to achieve 100% coverage consistently and such should not be specified.

Mortar Coverage for Natural Stone Tile

Mortar coverage must be sufficient to prevent cracks in the stone resulting from voids in the setting bed. In dry and wet areas, the minimum coverage is 95% with no voids exceeding 2 square inches and no voids within 2" of tile corners. All corners and edges of the stone tiles must be fully supported, and back-parging, or back-buttering, is recommended in all areas. Coating the back of the tile, however, does not constitute coverage, which is the area where the mortar makes contact with the tile and the substrate.

It is not possible or practical to achieve 100% coverage consistently and such should not be specified.

Directional Troweling

To ensure proper coverage of the bonding surface of 8" × 8" and larger tiles and to provide full support of edges and corners, select a notched trowel sized to facilitate the proper coverage. Key the mortar into the substrate with the flat side of the trowel. Comb with the notched side of the trowel in one direction. Firmly press tiles into the mortar and move them perpendicularly across the ridges forward and back to flatten the ridges and fill the valleys. This method can produce maximum coverage, with the corners and edges fully supported, without back-buttering or beat-in. Periodically remove and check a tile to ensure proper coverage is being attained.

Excessive or Nonuniform Depth of Mortar

Many stone varieties, particularly the softer marbles, limestones, and travertines, are extremely vulnerable to nonuniform shrinkage of cement mortar. Uneven mortar shrinkage during curing can produce a fine but visible crack in the stone. This is also true for larger glass tiles. To avoid this, the mortar must be applied in uniform thickness, and within the minimum and maximum thickness allowed by the manufacturer. Substrate preparation, or flattening, is required if the substrate does not meet the substrate tolerances. Mortar bed and self-leveling methods may be a good choice when larger glass tiles or such stones have been selected.

High-Porosity Stone Tile

Installing high-porosity stones in hot, dry climates may require that the stone be presoaked prior to installation to prevent the stone from wicking excessive amounts of water out of the mortar and inhibiting hydration of the cement needed for bonding. Alternately, rapid-setting mortar can be used.

FLATNESS AND LIPPAGE

Flatness for Ceramic and Stone Tile Installations

The finish flatness requirement for ceramic tile installations is ¼" in 10' from the required plane according to ANSI A108.02. The finish flatness requirement for stone tile installations is ⅛" in 10' from the required plane according to MIA.

Lippage in Natural Stone Tile Installations

Lippage is a condition where one edge of a tile is higher than an adjacent tile, giving the finished surface an uneven appearance. Lippage in stone tile flooring is accentuated from what would be perceived in a ceramic tile installation for several reasons. First, natural stones tend to be installed with tighter joints, particularly because some stones require narrower joints to allow for the use of unsanded grout. Second, natural stones typically have slight or no chamfer at their edges. Third, many natural stones have a high-gloss, polished finish.

Industry standards limit lippage between adjacent units of smooth-finished natural stone flooring to 1/32". When this is not achieved, there is the option of grinding the stone tiles in place to eliminate the lippage. This work must be done by skilled, experienced technicians, with care taken to avoid a wavy-looking finished floor. In some cases, installing contractors plan to grind the finished floor regardless of the lippage amount, usually per the requirement of the client. Lippage should still be minimized to the extent possible during installation to avoid extremely thin stone sections after grinding.

Lippage in Ceramic Tile Installations

Lippage is a condition where one edge of a tile is higher than an adjacent tile, giving the finished surface an uneven appearance. Lippage is inherent in all ceramic installation methods and may also be unavoidable due to the tile tolerances, in accordance with ANSI A137.1.

The following is excerpted from ANSI A108.02—2017, Section 4.3.7:

> **4.3.7 Lippage—guidelines, explanation, and caution:** Lippage refers to differences in elevation between edges of adjacent tile modules. These differences or perception thereof are influenced by many factors such as:
>
> A) The allowable thickness variation of the tile modules when judged in accordance with manufacturing standards.
>
> B) The allowable warpage of the tile modules.
>
> C) The spacing or separation of each tile module, which would influence a gradual or abrupt change in elevation.
>
> D) Angle of natural or manufactured light accentuating otherwise acceptable variance in modules.
>
> E) Highly reflective surfaces of tile modules accentuating otherwise acceptable variance in modules.

The following chart is a guideline for identifying acceptable lippage—in addition to the inherent warpage of tile manufactured in accordance with ANSI A137.1—for typical installations of tile:

Tile Type	Tile Size (in.)	Joint Width (in.)	Allowable Lippage (in.)
Glazed Wall/Mosaics	1 × 1 to 6 × 6	1/16 to ⅛	1/32
Quarry	6 × 6 to 8 × 8	¼ or greater	1/16
Pressed Floor and Porcelain Tiles	All	1/16 to less than ¼	1/32
Pressed Floor and Porcelain Tiles	All	¼ or greater	1/16

CAUTION —This chart does not apply to tiled floors sloping to drains. Lippage will be present when using tiles 6 in. × 6 in. and larger over interior and exterior conical surfaces sloped to drains. The larger the tile unit surface area, the greater the lippage. Cutting the individual units can reduce the amount of lippage but may not eliminate lippage. Using smaller units in sloping areas will reduce lippage.

End of Excerpt

Minimum Grout Joint Width

The minimum required joint width for ceramic tile and natural stone tile is 1/16". Setting ceramic or stone without a grout joint of at least 1/16", often referred to as a butt joint, does not provide sufficient accommodation for dynamic building movement, differential thermal expansion, or allowable variation in fabrication or manufacturing.

ANSI Grout Joint and Offset Pattern Requirements for Ceramic Tile Installations

The following criteria are excerpted from ANSI A108.02—2017, Section 4.3.8 regarding grout joint size, particularly in relation to the tile size, dimensional precision, and offset pattern:

> **4.3.8 Grout joint size:** To accommodate the range in facial dimensions of the tile supplied for a specific project, the actual grout joint size may, of necessity, vary from the grout joint size specified. The actual grout joint size shall be at least three times the actual variation of facial dimensions of the tile supplied. Example: for tile having a total variation of 1/16 in. in facial dimensions, a minimum of 3/16 in. grout joint shall be used. Nominal centerline of all joints shall be straight with due allowances for hand-molded or rustic tiles. In no circumstance shall the grout joint be less than 1/16 in.
>
> **4.3.8.1 Running bond/brick joint patterns:** For running bond/brick joint patterns utilizing tiles (square or rectangular) with any side greater than 15 in., the grout joint shall be, on average, a minimum of 1/8 in. wide for rectified tiles and, on average, a minimum of 3/16 in. wide for calibrated (non-rectified) tiles. The grout joint width shall be increased over the minimum requirement by the amount of edge warpage on the longest edge of the actual tiles being installed. For example, for a rectified tile exhibiting 1/32 in. edge warpage on the longest edge, the minimum grout joint for a running bond/brick joint pattern will be 1/8 in. + 1/32 in. or 5/32 in., on average. Of necessity, in any installation, some grout joints will be less and some more than the average minimum dimension to accommodate the specific tiles being installed.
>
> **4.3.8.2 Running bond/brick joint and any offset pattern:** For running bond/brick joint and any offset patterns (i.e. non-continuous grout joints) utilizing tiles (square and/or rectangular) where the side being offset is greater than 15 in. (nominal dimension), the offset pattern will be a maximum of 33% unless otherwise specified by the tile manufacturer. If an offset greater than 33% is specified, specifier and owner must approve mock-up and lippage.

End of Excerpt

Tile Layout Considerations

Basic provisions for tile layout are given in ANSI A108.02 Section 4.3, however such may not be practical or applicable under the following conditions:

- The size and configuration of the room and the size of the tile make it impossible to center the layout in all aspects or avoid cut tiles less than ½ tile.
- The tile layout is continuous, flowing into multiple spaces, making it impossible to center the layout in all aspects or avoid cut tiles less than ½ tile.
- The overall layout and/or aesthetics are improved by laying out the tiles such that the layout is not centered in all aspects and/or not all cut tiles are at least ½ tile, for example to place a full tile or larger cut tile, or decorative element, in a high visibility location.
- Tile waste can be dramatically reduced using a layout that is not centered in all aspects and/or does not have any cut tiles less than ½ tile.

The layout preferences of the design professional should be well defined for each space prior to bidding. If a layout is not provided by the design professional prior to bidding, the tile contractor may, of necessity, determine the layout based on the space, tiles, and pattern specified.

System Modularity

Nominal sizes only provide a general idea of tile size (see ANSI A137.1) and cannot be relied upon as an indicator of size compatibility or pattern compatibility with other tiles having the same nominal size, including for tiles from the same tile line. Grout joint sizing for patterns can only be determined based on actual tiles ready for installation.

Per ANSI A137.1 system modularity is defined as follows: "tiles of various nominal dimensions are sized so that they may be installed together in patterns with a common specified grout joint width." System modularity is not a required or standardized tile property, although various trade names exist for common modular patterns (pinwheel, ashlar, hopscotch, etc.) While tiles manufactured to be installed in a modular pattern will have both the pattern and suggested grout joint width provided by the manufacturer, the specified grout joint width may not be appropriate for the site conditions or the size variations in the actual tiles supplied for installation. Adjusting the grout joint width may be required to accommodate the actual tiles, and, because of site conditions and size variations in the tiles, some grout joints will be wider than others. This is a necessary fact of the overall modular layout.

Similarly, when the design professional creates a modular pattern using tiles that are not specifically manufactured for a pattern, some grout joints will of necessity be wider than others. Verifying system modularity and specifying the achievable grout joint for the pattern and actual tiles to be installed is the responsibility of the design professional.

If grout joint alignment from floor to wall is desired (i.e., carrying grout joints continuously from a floor onto adjoining walls), the design professional must confirm suitability of such based on actual tiles to be installed. If grout joint alignment cannot be accommodated with the actual tiles, the tile contractor may, by necessity, reasonably adjust the pattern, for example by "breaking the joint" at the floor/wall interface. Tiles should not be field-cut to size to accomplish modular patterns or to align grout joints, as field-cut edges will be dissimilar from factory edges and cannot be held to the same squareness tolerance.

Protecting 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 ¾"-thick plywood or OSB protection over nonstaining 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.

Maintenance

All tile installations (especially exterior installations, which include the movement joint sealant) require periodic inspection and maintenance by the owner. Consult material manufacturers and maintenance product manufacturers for recommended procedures.

Visual Inspection of Tilework

All components of a tile installation, including but not limited to the substrate, the tile, the installation materials, and the workmanship have tolerances, allowances, and industry best practices that govern the determination of acceptable work and the visual and aesthetic appearance of the finished installation. All of these factors shall be taken into consideration when compiling punch lists or deficiency lists.

When visually inspecting finished ceramic, stone, and glass tile installations, do so without magnification under the permanent intended lighting (artificial and/or natural) and without the use of additional lighting such as flashlights, spot lights, or temporary lights. View the installation 36" from walls and 60" or normal standing height from floors. Recognizing the hand-built aspect of tile installations, any aesthetic concerns not visible at these distances (but apparent at closer distances) are acceptable under industry best practices.

Refer to the following industry-recognized publications and standards for details on tolerances and allowances in tile and tilework:

- **Lippage:** Allowances are provided in ANSI A108.02; see also "Substrate Requirements" and "Flatness and Lippage" in this *Handbook*.
- **Finished flatness:** Allowances are provided in ANSI A108.02; see also "Substrate Requirements" and "Flatness and Lippage" in this *Handbook*.
- **Allowable tile warpage, wedging, and facial dimensions:** Allowances are provided in ANSI A137.1 and ANSI A137.2.
- **Effects of lighting on installation appearance:** See "Lighting and Tile Installations" in this *Handbook*.
- **Workmanship, cutting, and fitting:** Allowances are provided in ANSI A108.02.
- **Tile layout, system modularity:** See "Grout Joint Size, Layouts, and Patterns" in this *Handbook*.
- **Grout joint size:** Minimum size and related allowances are provided in ANSI A108.02; see also "Grout Joint Size, Layouts, and Patterns" in this *Handbook*.
- **Shade variation in ceramic tile:** Allowances and related information are provided in ANSI A137.1; see also "Ceramic Tile Selection Guide" in this *Handbook*.
- **Shade variation in natural stone tile:** Provisions are given in the *Dimension Stone Design Manual* published by MIA; see also "Natural Stone Tile Selection and Installation Guide" in this *Handbook*.
- **Facial and structural defects in glass tile:** Allowances and related information are provided in ANSI A137.2; see also "Glass Tile Selection and Installation Guide" in this *Handbook*.
- **Mortar coverage:** Allowances are provided in ANSI A108.02; see also "Mortar Application and Coverage" in this *Handbook*.
- **Hollow-sounding tile:** See "Membrane Selection Guide" in this *Handbook*.

When ceramic tile is used as the flooring surface, design professionals should consider the following, based on ANSI A108.01 and A108.02, where accessibility is a primary consideration.

Changes in Level

Changes in level up to ¼" may be vertical and without edge treatment. Changes in level between ¼" and ½" shall be beveled with a slope no greater than 1:2. Changes in level greater than ½" shall be accomplished by means of a ramp. The maximum slope of a ramp in new construction shall be no greater than 1:12. Ramps where space limitations prohibit this may have slopes and rises as follows: a slope between 1:10 and 1:12 is allowed for a maximum rise of 6", and a slope between 1:8 and 1:10 is allowed for a maximum rise of 3". A slope steeper than 1:8 is not allowed.

Flatness and Lippage

With regard to flatness, the amount of substrate variation generally is reflected in the finished tile installation. For any application, a tiled floor should comply with the flatness requirements in ANSI A108.02: no variations exceeding ¼" in 10' from the required plane. Conformance to this standard requires that substrates conform to the following: For tiles with all edges shorter than 15", maximum allowable variation is ¼" in 10' from the required plane, with no more than 1/16" variation in 12" when measured from the high points in the surface. For tiles with at least one edge 15" in length, maximum allowable variation is ⅛" in 10' from the required plane, with no more than 1/16" variation in 24" when measured from the high points in the surface. For modular substrate units, such as plywood panels, adjacent edges cannot exceed 1/32" difference in height. Additionally, the effect from irregularities in the substrate increases as the tile size increases. A substrate tolerance of ⅛" in 10' may be required.

Because the flatness of wood and concrete substrates can change over time, it is recommended that the designer make provisions for evaluating substrate flatness just before installation of the tile. Project specifications should make clear which trade is responsible for the required alterations if the subfloor is found not to be in compliance with the flatness requirements. Alternately, the designer may choose to specify a mortar bed method or a pourable underlayment installed by the tile contractor to ensure substrate flatness sufficient to facilitate a flat tile installation.

Lippage is most significantly influenced by substrate flatness and tile warpage. Allowable lippage is calculated by adding the actual warpage of the tile supplied, plus either 1/32" or 1/16" based on tile type and size and grout joint width (see "Flatness and Lippage"). Specifying wider grout joints allows for more gradual changes. To minimize lippage due to warpage, specify tile that meets the dimensional requirements for rectified tile according to ANSI A137.1, and use a larger grout joint. Some patterns, such as a 50% offset (brick-joint) pattern, accentuate the effects of warpage and result in more lippage than other patterns would. Cushioned or beveled-edge tiles can minimize the effects of lippage.

In addition to taking measures to ensure a flat substrate, designers should consult with the tile manufacturer to discuss grout joint size and tile and pattern selections that will minimize issues relating to flatness and lippage. See also "Grout Joint Size, Layouts, and Patterns."

The installation methods in this *Handbook* are rated for water exposure suitability—these ratings are listed under the Environmental Exposure Classifications subhead within each method as well as in the Environmental Exposure Classifications chart. However, this rating system cannot predict the actual amount of water any installation will be exposed to, nor compensate for water exposure exceeding the method's rating.

The design professional must choose an installation method suitable for the amount of water the installation will be subjected to; damage can result from water exposure exceeding the method's Environmental Exposure Classifications rating. Where the use of a waterproof membrane is optional, the rating assumes the optional membrane will not be used. If use of a waterproof membrane is intended in these applications, to provide a more water-resistant installation, it must be clearly specified.

When selecting a method, in addition to the use of the tiled area, consider maintenance practices that will be employed. For example, commercial restrooms and locker rooms typically do not require waterproofing in order to be suitable for their intended uses and normal maintenance; typically these are limited water exposure (Res2/Com2) applications. However, if such areas are to be hosed down or otherwise saturated, specify a wet area (Res3/Com3) method. Wet area installation methods typically incorporate waterproofing to contain and evacuate water and to protect building materials. The two general categories of waterproof installation methods are:

- Use of an unbonded water-containment membrane (referenced in this *Handbook* as an unbonded shower pan membrane).
- Use of a bonded waterproof membrane meeting ANSI A118.10.

A shower pan membrane is a loose laid, or unbonded, liner that is placed below a mortar bed, with the mortar bed receiving the tile. Acceptable shower pan membrane materials are listed in ANSI A108.01 Section 3.6 and include plastics such as polyvinyl chloride (PVC) and chlorinated polyethylene (CPE), metals such as lead and copper, and hot-mop systems, which employ layers of asphalt or coal-tar saturated roofing felt. Shower pan membranes connect into drains at the clamping ring level. Refer to B414, B415, B420, B426, B431, and F121 for shower pan membrane assemblies.

Bonded waterproof membranes can be sheet materials, or roll-on or trowel-on materials that dry/cure to form a waterproof membrane. These membranes also connect to drains, either at the clamping ring level, or just below the tile when an integrated bonding flange is used. Because these membranes can be bonded to various substrates, and tile is bonded to the membrane, they allow for thin-bed tile installation. Refer to B421 and B422 for bonded waterproof membrane assembly specifications.

Both systems manage water. The following are the essential requirements and considerations for designing wet areas.

Incorporation of a Drain/Slope to Drain

To fully evacuate water, shower pan membranes and bonded waterproof membranes must slope to and connect with a drain. Plumbing code typically requires membranes to be sloped a minimum of ¼" per foot and extend at least 3" above the height of the curb or threshold. Account for the perimeter floor height required to form adequate slopes. Membranes must be installed over other horizontal surfaces in wet areas subject to deterioration, like shower seats. They must be sloped and configured so as to direct water to the membrane connected to the drain.

Open Weep Holes

The weep holes of clamping drains enable water to pass from the membrane into the plumbing system. Crushed stone or tile or other positive weep protectors placed around/over weep holes prevent their blockage.

Membrane Connection with Drain or Integrated Bonding Flange

To form a watertight seal, membranes must have adequate contact with the clamping ring of the drain or with the bonding area of an integrated bonding flange.

Membrane Cuts and Penetrations

Membranes must be protected to prevent punctures resulting from traffic on the membrane before the mortar bed is installed (for shower pan membranes) or before the tile is installed (for bonded waterproof membranes). For punctures that do occur, the membrane must be replaced or repaired according to the membrane manufacturer's directions for repairs. Ensure the integrity of any repairs by water testing the repaired membrane.

Backer board cannot be fastened to studs lower than 3" above the finished curb height, nor fastened to the top or the inside of a curb. Backer board on shower seats must be topically waterproofed due to the use of fasteners.

In-Corners, Out-Corners, and Seams

Shower pan membrane in-corners should be folded not cut. For out-corners, such as where the shower curb meets the jamb, membrane manufacturers typically offer preformed out-corners to better enable wrapping of the membrane at the curb/jamb interface. For sheet-type bonded waterproof membranes applied topically, pre-made in-corners and out-corners enable waterproofing of corners without excessive material thickness that would result from folding. Sheet membranes in large areas are seamed, bonded, or otherwise welded together to form a continuous membrane.

Liquid-Applied and Trowel-Applied Bonded Waterproof Membranes

These membrane types are manufactured in the field by the installer who applies the waterproofing material. These products require a minimum wet film thickness and have specified cure/dry time requirements. Many membranes of this variety incorporate a mesh that is embedded in the wet material during installation. Mesh may be required over the entire surface to be waterproofed or only in corners and/or joints.

Configuration of Shower Receptor Components

When a shower pan membrane system is employed, some backer board types must be installed with the board held out of the mortar bed due to the saturation that occurs below this level. Vapor retarder membranes fastened to studs must weather-lap the shower pan membrane or flange of the tub or prefabricated shower receptor.

Whether a shower pan membrane or a bonded waterproof membrane system is used, the membrane must completely wrap the curb, and the jamb must be waterproofed to its outside edge a minimum of 3" above the curb. Curb and jamb waterproofing must be seamed together without breach to form a continuous barrier.

Performing a Water Test

Where complete waterproofing is required such as in showers, water testing of the membrane, by the installing contractor, is recommended and may be required by applicable plumbing code.

Performance Level Requirement Guide and Selection Table

Based on results from ASTM Test Method C627 Standard Test Method for Evaluating Ceramic Floor Tile Installation Systems Using the Robinson Type Floor Tester, all methods are material dependent—performance rating should not exceed rating of weakest component—consult each material manufacturer for individual component rating. Tests to determine performance levels utilized representative products meeting recognized industry standards.

Consideration must also be given to wear properties of surface of tile selected, tile size, and coefficient of friction. Unglazed standard grade tile will give satisfactory wear or abrasion resistance in installations listed. Glazed tile or soft-body, decorative, unglazed tile should have the manufacturer's approval for intended use. Color, pattern, surface texture, and glaze hardness must be considered in determining tile acceptability on a particular floor.

Those methods also applicable to stone tile installation will carry a similar rating when stone tiles with adequate compressive strength, flexural strength, and resistance to abrasion are used.

SERVICE REQUIREMENTS	INSTALLATION SUBSTRATE	
Find required performance level and choose installation method that meets or exceeds it. Performance results are based on ceramic tile meeting ANSI A137.1 or tile designated by tile manufacturer.	**CONCRETE**	**WOOD**
EXTRA HEAVY Extra heavy and high-impact use in food plants, dairies, breweries, and kitchens. Requires quarry tile, packing house tile, or tile designated by tile manufacturer. (Passes ASTM C627 cycles 1 through 14.)	**F101, F102, F111, F112, F113, F113A, F114, F115, F115A, F116E, F128[e], F131, F132, F133, F134, F205, F205A, RH117**	
HEAVY Shopping malls, stores, commercial kitchens, work areas, laboratories, auto showrooms and service areas, shipping/receiving, and exterior decks. (Passes ASTM C627 cycles 1 through 12).	**F103, F121, F103B[f], F104**	
MODERATE Normal commercial and light institutional use in public space of restaurants and hospitals. (Passes ASTM C627 cycles 1 through 10.)	**F122, F200A, RH111, RH112A, RH116, F122A, F200, RH110, RH111A, RH110A, RH112, RH115, RH115A, RH116A**	
LIGHT Light commercial use in office space, reception areas, kitchens, and bathrooms. (Passes ASTM C627 cycles 1 through 6.)	**F128[e]**	**F105, F143[d], F150[d], F175, RH122, RH135[b,c], F141, F144[b,c], F160, F180, RH123, RH141, F145, F146, F170, F250[d], RH130[d]**
RESIDENTIAL Kitchens, bathrooms, and foyers. (Passes ASTM C627 cycles 1 through 3.)	**F116O, TR711[a], F135, F136**	**F142, F147, F150[d], F155, RH130[d], F143[d], F148, F151, F185, RH135[b,c], F144[b,c], F149, F152, F250[d], RH140**

a. Tile bonded to existing resilient flooring with epoxy adhesive.

b. Minimum $\frac{7}{16}$"-thick cement backer board or minimum ¼"-thick fiber-cement backer board tested.

c. Minimum ¼"-thick cement backer board can be used for residential applications over minimum $\frac{19}{32}$"-thick subfloor; minimum ¼"-thick cement backer board can be used for light commercial applications over minimum $\frac{23}{32}$"-thick subfloor.

d. Requires minimum $\frac{19}{32}$" exterior glue plywood underlayment for light rating; $\frac{15}{32}$" exterior glue plywood underlayment may be used for residential rating.

e. Rated light for mosaic tile and extra heavy for 12" × 12" and larger porcelain tiles.

f. Not all drainage mat systems will receive heavy rating. Consult drainage mat manufacturer.

ENVIRONMENTAL EXPOSURE CLASSIFICATIONS

The end user significantly affects the amount of water and vapor an installation will be exposed to. Examples provided below and the classifications assigned to the individual methods are guidelines only and are not meant to be all inclusive. Base installation method selection on actual exposure levels, and consult with product manufacturers and their specifications. In methods where inclusion of a waterproof membrane is optional, the design professional must clearly specify that a membrane is desired. Optional membranes are not included unless clearly specified.

Res1 (Residential Dry): Tile surfaces that will not be exposed to moisture or liquid, except for cleaning purposes. Includes areas adjacent to R2 areas. Examples: Floors in rooms with no direct access to the outdoors and no wet utility function, such as living rooms, dining rooms, and bedrooms; dry area ceilings, soffits, decorative/accent walls, fireplaces, some backsplashes and some wainscots.

Res2 (Residential Limited Water Exposure): Tile surfaces that are subjected to moisture or liquids but do not become soaked or saturated due to the system design or time exposure. If waterproofing is desired, it must be clearly specified. Includes areas adjacent to R3 areas. Examples: Floors in bathrooms, kitchens, mudrooms, laundry, and foyers, where water exposure is limited and/or water is removed; some backsplashes, some wainscots, some countertops.

Res3 (Residential Wet): Tile surfaces that are soaked, saturated, or regularly and frequently subjected to moisture or liquids. Examples: Shower floors; floors and other horizontal surfaces where water is not removed or drained, such as some countertops; tub walls, shower walls, and enclosed pool area walls.

Res4 (Residential High Humidity, Heavy Moisture Exposure): Tile surfaces that are subject to continuous high humidity or heavy moisture exposure. Examples: Intermittent-use steam shower walls, ceilings, and floors.

Res5 (Residential High Temperature ≥125˚F): Tile surfaces frequently subjected to water or vapor equal to or greater than 125˚F. Examples: Furnace and boiler areas.

Res6 (Residential Exterior): Tile surfaces exposed to exterior conditions. When designing such installations, consider local climate and conditions including temperature and temperature fluctuations, humidity and humidity fluctuations, and freeze/thaw cycling. If waterproofing is desired, it must be clearly specified. Examples: Exterior walls, balconies, decks.

Res7 (Residential Submerged): Tile surfaces exposed to continuous water submersion in interior or exterior conditions. Examples: Swimming pools, water features, and fountains.

Com1 (Commercial Dry): Tile surfaces that will not be exposed to moisture or liquid, except for cleaning purposes. Commercial cleaning and maintenance practices typically generate greater water exposure than residential practices. Includes areas adjacent to C2 areas. Examples: Floors in areas with no direct access to the outdoors and no wet utility function, such as hallways; dry area ceilings; soffits; decorative/accent walls; corridor walls.

Com2 (Commercial Limited Water Exposure): Tile surfaces that are subjected to moisture or liquids but do not become soaked or saturated due to the system design or time exposure. If waterproofing is desired, it must be clearly specified. Includes areas adjacent to C3 areas. Examples: Floors in bathrooms and locker rooms; some backsplashes and other walls, such as bathroom walls and wainscots where water exposure is limited and/or water is removed.

Com3 (Commercial Wet): Tile surfaces that are soaked, saturated, or regularly and frequently subjected to moisture or liquids. Includes areas adjacent to C4 areas. Examples: Tub walls, shower walls and floors, enclosed pool areas, natatoriums, gang showers, and some commercial kitchen floors and 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 shower/steam room walls and ceilings.

Com5 (Commercial High Temperature ≥125˚F): Tile surfaces that are frequently subjected to water or vapor equal to or greater than 125˚F. Examples: Commercial saunas, furnace and boiler areas, and some commercial kitchen floors and walls.

Com6 (Commercial Exterior): Tile surfaces exposed to exterior conditions. When designing such installations, consider local climate and conditions including temperature and temperature fluctuations, humidity and humidity fluctuations, and freeze/thaw cycling. If waterproofing is desired, it must be clearly specified. Examples: Exterior walls, balconies, decks.

Com7 (Commercial Submerged): Tile surfaces exposed to continuous water submersion in interior or exterior conditions. Examples: Swimming pools, water features, and fountains.

	Installation Method	Method Type T = Tile S = Stone	Residential (Res)							Commercial (Com)						
			1	2	3	4	5	6	7	1	2	3	4	5	6	7
FLOORS	F101	T, S						•							•	
	F102	T, S						•							•	
	F103	T, S						•							•	
	F103B	T, S						•							•	
	F104	T, S						•							•	
	F105	T, S						•							•	
	F111	T, S	•	•	•		•			•	•	•		•		
	F112	T, S	•	•	•		•			•	•	•		•		
	F113	T, S	•	•	•		•			•	•	•		•		
	F113A	T, S	•	•	•		•			•	•	•		•		
	F114	T	•	•	•	•	•			•	•	•	•	•		
	F115	T	•	•	•	•	•			•	•	•	•	•		
	F115A	T	•	•	•	•	•			•	•	•	•	•		
	F116E	T	•	•	•	•	•			•	•	•	•	•		
	F116O	T	•													
	F121	T, S	•	•	•		•			•	•	•		•		
	F122	T, S	•	•	•		•			•	•	•		•		
	F122A	T, S	•	•	•		•			•	•	•		•		
	F128	T	•	•	•	•	•			•	•	•	•	•		
	F131	T	•	•	•	•	•			•	•	•	•	•		
	F132	T	•	•	•	•	•			•	•	•	•	•		
	F133	T	•	•	•	•	•			•	•	•	•	•		
	F134	T	•	•	•	•	•			•	•	•	•	•		
	F135	T	•													
	F136	T	•													
	F141	T, S	•	•						•	•					
	F142	T	•													
	F143	T	•	•						•	•					
	F144	T	•	•						•	•					
	F145	T	•	•						•	•					
	F146	T	•	•						•	•					
	F147	T	•	•												
	F148	T	•	•												
	F149	T	•													
	F150	T	•							•						
	F151	T	•	•												
	F152	T	•	•												
	F155	T	•													
	F160	T	•							•						

	Installation Method	Method Type T = Tile S = Stone	Residential (Res)							Commercial (Com)						
			1	2	3	4	5	6	7	1	2	3	4	5	6	7
FLOORS	F170	T	•	•						•	•					
	F175	T	•	•						•	•					
	F180	T	•							•						
	F185	T	•	•												
	F200	T, S	•							•						
	F200A	T, S	•							•						
	F205	T, S	•							•						
	F205A	T, S	•							•						
	F250	S	•	•						•	•					
	RH110	T, S	•	•	•		•			•	•	•		•		
	RH110A	T, S	•	•	•		•			•	•	•		•		
	RH111	T, S	•							•						
	RH111A	T, S	•							•						
	RH112	T, S	•							•						
	RH112A	T, S	•							•						
	RH115	T	•	•						•	•					
	RH115A	T	•	•						•	•					
	RH116	T, S	•							•						
	RH116A	T, S	•							•						
	RH117	T, S	•	•	•		•			•	•	•		•		
	RH122	T	•							•						
	RH123	T	•							•						
	RH130	T	•							•						
	RH135	T	•	•						•	•					
	RH140	T	•							•						
	RH141	T, S	•	•						•	•					
WALLS	W201	T, S						•							•	
	W202E	T, S						•							•	
	W202I	T, S	•	•	•		•			•	•	•		•		
	W211	T, S	•	•	•		•			•	•	•		•		
	W215	T, S	•							•						
	W221	T, S	•	•	•		•			•	•	•		•		
	W222	T, S	•	•			•			•	•			•		
	W223	T	•	•						•	•					
	W231/W241	T, S	•	•			•			•	•			•		
	W242	T	•							•						
	W243	T, S	•							•						
	W244C	T, S	•	•			•			•	•			•		
	W244E	T, S						•							•	

	Installation Method	Method Type T = Tile S = Stone	Residential (Res)							Commercial (Com)						
			1	2	3	4	5	6	7	1	2	3	4	5	6	7
WALLS	W244F	T, S	•	•			•			•	•			•		
	W245	T, S	•	•						•	•					
	W246	T, S	•	•						•	•					
	W247	T, S	•	•						•	•					
	W248	T, S	•							•						
	W260	T, S	•							•						
BATHTUBS AND SHOWERS	B411	T, S	•	•	•		•			•	•	•		•		
	B412	T, S	•	•	•		•			•	•	•		•		
	B413	T, S	•							•						
	B414	T, S	•	•	•		•			•	•	•		•		
	B415	T, S	•	•	•		•			•	•	•		•		
	B419	T, S	•	•	•					•	•	•				
	B420	T, S	•	•	•					•	•	•				
	B421	T, S	•	•	•					•	•					
	B421C	T	•	•	•					•	•					
	B422	T, S	•	•	•					•	•					
	B422C	T	•	•	•					•	•					
	B425	T, S	•	•	•					•	•	•				
	B426	T, S	•	•	•					•	•	•				
	B430	T, S	•	•	•					•	•					
	B431	T, S	•	•	•					•	•					
	B440	T, S	•	•	•		•			•	•	•		•		
	B441	T, S	•	•	•		•			•	•	•		•		
	SR613	T				•							•			
	SR614	T				•										
CEILINGS	C311	T, S	•	•	•		•			•	•	•		•		
	C312	T, S	•							•						
	C315	T, S	•	•	•					•	•					
COUNTERTOPS	C511	T	•	•						•	•					
	C512	T	•	•						•	•					
	C513	T	•	•						•	•					
POOLS & WATER FEATURES	P601MB	T			•	•		•	•			•	•		•	•
	P601TB	T			•	•		•	•			•	•		•	•
	P602	T			•	•		•	•			•	•		•	•

USING THE *TCNA HANDBOOK* FOR SPECIFICATION WRITING

The *TCNA Handbook* is not a specification. The quick-reference details provide a means of simplifying and standardizing installation specifications for ceramic, glass, and stone tile. In addition to referencing *Handbook* methods, architects and specifiers should specify tile and installation materials, including specific locations of movement joints on drawings. Use American National Standards Institute (ANSI) standards for developing specifications. Specifications shall conform to applicable building codes, ordinances, trade standards and practices, and climatic conditions. Use of materials and methods not specifically designated by the architect, will, of necessity, be determined by the tile contractor.

General

Select an installation method for the given backing or substrate with the appropriate Environmental Exposure Classification, and for floors, having the required Service Rating.

Special installation procedures or proprietary installation methods or materials should be specified in accordance with manufacturer recommendations.

Product selection guides are provided to aid in the selection of the individual components of an installation: tile (ceramic, glass, stone), setting materials, grout, backer boards, and membranes. The "Field and Installation Requirements" section outlines many of the important conditions and considerations that must be provided for when specifying and installing tile.

Components of an Installation Method

Drawing: *Handbook* illustrations show the necessary components of the given tile installation method, including the installation substrate. Glass tile can be substituted for ceramic tile in the assembly if glass tile is listed as an option under Materials.

The illustrations are intentionally not to scale in order for each material and its location within the assembly to be clearly visible. Consult manufacturers for the actual dimensions of any material.

Recommended Uses: Provides typical areas or applications for the installation method.

Service Rating: Provided for floor methods only. Indicates the expected level of use (service rating) based on Robinson Floor Test (ASTM C627) results.

Environmental Exposure Classifications: Indicates the conditions in which the installation is generally expected to perform.

Typical Weight of Tile Installation: Provided for floor methods only. Indicates estimated weight the tile installation contributes to the dead load.

Limitations: Provides special considerations and restrictions.

Membrane Options: Lists the possible membrane types that can be optionally specified.

Note: For methods that require use of a membrane, this section lists the types of membranes that may be used when there is more than one option. For methods in which use of a membrane is optional, this section lists the possible membrane choices that could be specified, if use of a membrane is desired. In both cases, the job specification must clearly indicate which, if any, membrane is to be used. If using a membrane is optional, the contractor is not required to install a membrane unless it is clearly specified to do so. If using a membrane is required, the tile contractor may choose any listed membrane option in the absence of a clear specification.

Requirements: Lists important conditions and considerations.

Materials: Lists tile and installation material options that can be used and the minimum criteria the materials must meet such as ANSI, ISO, or ASTM specifications.

Note: This section lists minimum required criteria for the listed materials. If upgraded materials are desired, the job specification must clearly indicate such. When more than one type of material is listed, for example cementitious grout and epoxy grout, the job specification must clearly indicate which material is desired. If such an indication is not included, the tile contractor by necessity may choose any listed material option.

Preparation by Other Trades: Indicates the materials and/or preparation work required of other trades preceding the work of the tile contractor. ANSI A108.01 and A108.02 provide particular specifications for related trades regarding preparation for tilework.

Preparation by Tile Trade: Indicates the materials, preparations, or other requirements typically expected of the tile contractor.

Preparation by Backer Board Installers: Indicates the materials, preparations, or other requirements expected of the contractor that installs the backer board.

Movement Joint: Refers user to EJ171 movement joint guidelines.

Installation Specifications: Lists applicable ANSI

installation specifications.

Notes: Lists additional considerations that may be important in the specification or installation of the tile and installation materials for the given method.

Design Considerations When Specifying Tile

Numerous tile industry standards, guidelines, and best practices exist, which define parameters for acceptable tilework, many of which are impacted by the tiles and designs selected. Through familiarity with tile industry standards and best practices, building design professionals can factor such parameters into selection and design decisions to specify products, patterns, and installation details that will produce the desired end result.

When variation from existing standards and guidelines is desired, such must be clearly defined prior to bidding and installation and noted within project specifications as a variance from industry standards. Such variances are discouraged because they will not always be possible to meet, with the given materials and job conditions. In such cases, established tile industry ANSI standards and industry guidelines apply.

The following are the commonly referenced industry standards, guidelines, and best practices that pertain to finished tilework and serve as the defining criteria for evaluating quality of installation and workmanship unless project specifications define otherwise:

Base/cove alternatives: Appropriate trim shapes and details must be specified by the design professional or left to the discretion of the tile contractor. All details in this *Handbook* are stylized cross-sectional drawings of typical installations and are not intended to show specific treatments of the transition between vertical and horizontal tile surfaces.

Finished flatness: Tolerances for finish flatness are provided in ANSI A108.02; see also "Substrate Requirements" and "Flatness and Lippage" in this *Handbook*.

Grout joint size: Tolerances for grout joint size are provided in ANSI A108.02; see also "Grout Joint Size, Layouts, and Patterns" in this *Handbook*.

Tile layout: Workmanship with regard to layout is addressed in ANSI A108.02; see also "Grout Joint Size, Layouts, and Patterns" in this *Handbook*.

Tile patterns and modularity: See "Grout Joint Size, Layouts, and Patterns" in this *Handbook*.

Mortar coverage: Required mortar coverage is provided in ANSI A108.02; see also "Mortar Application and Coverage" in this *Handbook*.

Effect of lighting on tilework: Natural and artificial light can dramatically affect the appearance of a tile installation; see "Lighting and Tile Installations" in this *Handbook*.

Lippage: Allowances are provided in ANSI A108.02; see also ANSI A137.1 for allowable tile warpage.

Tile warpage, wedging, and facial dimensions: Allowances are provided in ANSI A137.1.

Shade variation in ceramic tile: Allowances and related information are provided in ANSI A137.1; see also "Ceramic Tile Selection Guide" in this *Handbook*.

Shade variation in natural stone tile: Provisions are given in the Dimension Stone Design Manual published by MIA; see also Shading and Variation section within the "Natural Stone Tile Selection and Installation Guide," in this *Handbook*.

Facial and structural defects in glass tile: Allowances and related information are provided in ANSI A137.2.

ANSI Installation Specifications

A108.01	General Requirements: Subsurfaces and Preparations by Other Trades
A108.02	General Requirements: Materials, Environmental, and Workmanship
A108.1A	Installation of Ceramic Tile in the Wet-Set Method with Portland Cement Mortar
A108.1B	Installation of Ceramic Tile on a Cured Portland Cement Mortar Setting Bed with Dry-Set or Latex-Portland Cement Mortar
A108.1C	Contractor's Option: Installation of Ceramic Tile in the Wet-Set Method with Portland Cement Mortar or Installation of Ceramic Tile on a Cured Portland Cement Mortar Setting Bed with Dry-Set or Latex-Portland Cement Mortar
A108.4	Installation of Ceramic Tile with Organic Adhesives or Water Cleanable Tile-Setting Epoxy Adhesive
A108.5	Installation of Ceramic Tile with Dry-Set Portland Cement Mortar or Latex-Portland Cement Mortar

A108.6 Installation of Ceramic Tile with Chemical Resistant, Water Cleanable Tile-Setting and -Grouting Epoxy

A108.8 Installation of Ceramic Tile with Chemical Resistant Furan Resin Mortar and Grout

A108.9 Installation of Ceramic Tile with Modified Epoxy Emulsion Mortar/Grout

A108.10 Installation of Grout in Tilework

A108.11 Interior Installation of Cementitious Backer Units

A108.12 Installation of Ceramic Tile with EGP (Exterior Glue Plywood) Latex-Portland Cement Mortar

A108.13 Installation of Load Bearing, Bonded, Waterproof Membranes for Thin-Set Ceramic Tile and Dimension Stone

A108.14 Installation of Paper-Faced Glass Mosaic Tile

A108.15 Alternative Method: Installation of Paper-Faced Mounted Glass Mosaic Tile

A108.16 Installation of Paper-Faced, Back-Mounted, or Clear Film Face-Mounted Glass Mosaic Tile

A108.17 Installation of Crack Isolation Membranes for Thin-Set Ceramic Tile and Dimension Stone

Mockups

In addition to tile industry standards and guidelines, design professionals can utilize mock ups, especially in-situ mock-ups, to see the specified products and designs executed under the given job conditions.

General

A home or any building today is one of the few things still made entirely "by hand" and every aspect of a tile installation relies on the tile contracting company and its installers. How good the finished installation looks, how well it performs, and how long it lasts are in their hands. It is for this reason that the Handbook Committee and the Tile Council of North America strongly recommend using installers who have demonstrated their commitment to their craft and taken the time to stay current with the latest materials and methods. 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.

Requiring a portfolio and references reflecting the installer's/contractor's experience, along with a bid or estimate, is a good way to ensure work of similar size, scope, and complexity has been completed. Pools, exterior facades, mortar beds, shower pans, steam showers, etc., require different skills. Matching installer ability to the project at hand requires close evaluation of their experience, training, state licensing (where applicable), and certifications/credentials (where applicable). The Ceramic Tile Education Foundation (CTEF) provides a Contractor Questionnaire that can be used to aid in evaluating and comparing contractors (www.tilecareer.com).

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

- Classroom and/or online knowledge training
- Hands-on installation skills training
- Evaluation/certification of contractor qualifications
- Evaluation/certification of knowledge
- Evaluation/certification of hands-on skills

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

The following nonprofit programs are well-established and recognized by the Handbook Committee (listed alphabetically):

Advanced Certifications for Tile Installers (ACT): ACT is an evaluation and certification program for tile installers in advanced, specific skills areas: large format tile installation and substrate preparation, mudwork for walls, mudwork for floors, shower receptor (waterproof shower pan membrane, mortar bed, mortar curb) installation, membrane applications, and grouting. To pass an ACT test module, an installer must demonstrate hands-on proficiency and specific knowledge. Only installers who have already passed the Certified Tile Installer (CTI) test or those who are recognized by the U.S. Department of Labor as Journeyman Tile Layers may register for ACT testing. ACT tests were developed collaboratively by product manufacturers and industry associations including the Ceramic Tile Education Foundation (CTEF), Tile Contractors Association of America (TCAA), International Union of Bricklayers and Allied Craftworkers (IUBAC), International Masonry Institute (IMI), National Tile Contractors Association (NTCA), and Tile Council of North America (TCNA). Certification testing is administered by CTEF and IMI. For more information see www.tilecertifications.com. See also: Sample Language for Including Installer and Contractor Qualifications in Specifications.

Ceramic Tile Education Foundation (CTEF) Certified Tile Installer Program: CTEF tests hands-on installation skills and knowledge. Installers must achieve the minimum required score on both tests to earn the "CTEF Certified Tile Installer" designation. Contractors that employ CTEF Certified Tile Installers are listed on the CTEF website. See www.tilecareer.com for more information. See also: Sample Language for Including Installer and Contractor Qualifications in Specifications.

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

Journeyman Tile Layer Apprenticeship Programs: Installers recognized by the U.S. Department of Labor (DOL) as Journeyman Tile Layers are required to fulfill and document several years of training and on-the-job experience as apprentices to become Journeymen. The majority of these setters earn their Journeyman status through registered apprenticeship programs that are jointly-trusteed by union and management trustees, although some non-union tile contractors administer their own DOL-recognized apprenticeship programs and employ journeyman tile layers. Contractors that employ union Journeyman Tile Setters can be found through the union locals that list their signatory contractors, primarily

the Bricklayer and Allied Craftworkers (BAC) and the United Brotherhood of Carpenters (UBC). See www.bacweb.org and www.carpenters.org for more information. See also: Sample Language for Including Installer and Contractor Qualifications in Specifications.

Natural Stone Institute (NSI) Accreditation for Natural Stone Tile Installation Contractors: The Natural Stone Institute is an internationally recognized trade association that operates an industry accreditation program for natural stone tile installation contractors. NSI Accredited companies are required to: have been in business for at least three years and have completed at least 200 projects in that timeframe, agree to a code of ethics, and have passed the NSI Accreditation exam. NSI Accredited companies are evaluated and tested with regard to best practices in installation and safety. Visit www.naturalstoneinstitute.org/gettheseal for more information.

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

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

Other Programs: The Handbook Committee recognizes many qualified tile installers and contractors can be found that have not participated in the programs listed above. They are encouraged to do so, in order that consumers may more easily identify them. Similarly, the Handbook Committee recognizes there are useful training and evaluation programs for contractors and installers not listed in this guide, such as consumer-review-based rating systems, programs offered by for-profit educational firms, and government-based programs. See also: Sample Language for Including Installer and Contractor Qualifications in Specifications.

Sample Language for Including Installer and Contractor Qualifications in Specifications

Where inclusion of installer and contractor qualifications in project specifications is desired, include the qualifications under a quality assurance section and require proof of qualifications under a submittals section. The language below may be used for the purpose of including such requirements.

Qualifications/Quality Assurance

Installing contractor is [a five-star member of the National Tile Contractors Association] [and] [or] [a Trowel of Excellence member of the Tile Contractors' Association of America].

Installing contractor's foreman or superintendent for the Project holds the International Masonry Institute's Foreman Certification[1].

Installing contractor employs [Ceramic Tile Education Foundation Certified Installers] [and] [or] [installers recognized by the U.S. Department of Labor as Journeyman Tile Layers].

Individual installer(s) working for installing contractor are certified through Advanced Certifications for Tile Installers (ACT) for installation of <Insert one or more ACT certification requirements>: [Large Format Tile and Substrate Preparation] [and] [or] [Membranes] [and] [or] [Mud (Mortar Bed) Floors] [and] [or] [Mud (Mortar) Walls] [and] [or] [Shower Receptors] [and] [or] [Grouts].

Installer meets the requirements of a program identified and approved by the architect with the criteria for such program similar to or exceeding [Advanced Certifications for Tile Installers (ACT) for installation of Large Format Tile and Substrate Preparation] [and] [or] [Advanced Certifications for Tile Installers (ACT) for installation of Membranes] [and] [or] [Advanced Certifications for Tile Installers (ACT) for installation of Mud (Mortar

[1] The International Masonry Institute's Foreman Certification is available only to members of the International Union of Bricklayers and Allied Craftworkers; accordingly, only IUBAC signatory contractors can meet this requirement.

Bed) Floors] [and] [or] [Advanced Certifications for Tile Installers (ACT) for installation of Mud (Mortar) Walls] [and] [or] [Advanced Certifications for Tile Installers (ACT) for installation of Shower Receptors] [and] [or] [Advanced Certifications for Tile Installers (ACT) for installation of Grout] [and] [or] [Ceramic Tile Education Foundation (CTEF) Certified Tile Installer Program] [and] [or] [International Masonry Institute (IMI) Contractor College Program] [and] [or] [Department of Labor recognized Journeyman Tile Layer Apprenticeship Programs].

Installing contractor meets the requirements of a program identified and approved by the architect with the criteria for such program similar to or exceeding [National Tile Contractors Association (NTCA) Five Star Contractor Program] [and] [or] [Tile Contractors' Association of America (TCAA) Trowel of Excellence Program].

Submittals

Submit certificates and other qualification data for Installer(s).

Submit certificates and other qualification data for Installing Contractor(s).