WHITE PAPER

Ceramic & Porcelain Tile Testing Methods and Results Explained

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If there is one thing I know after working in the tile industry for 20 years, it's that there is a LOT of confusion surrounding tile test methods and results. In this white paper I will focus on explaining the test methods and results that I feel are most important for our commercial clients to know and understand. These are also the same test methods and results listed on our website for each porcelain and ceramic collection.

Note: With the exception of DCOF (which is an American National Standards Institute standard), this white paper provides details on ASTM standards. ASTM standards are primarily followed in the United States, even though ASTM is technically an international organization. For tile that is manufactured in European countries, you may come across International Organization for Standardization (ISO) test methods and values, which are different. For this white paper, I will focus on ASTM standards.

ASTM C373 — Water Absorption

The purpose of this test is to determine how much a ceramic or porcelain tile will absorb when immersed in water. Tile samples are first weighed to calculate the mass of the sample. They are then boiled in distilled water for 5 hours (+/- 5 mins) and then soaked in the same water for another 24 hours (+/- 30 mins). After this time, they are weighed again to determine what percentage of the tile's original weight in water was absorbed during the boil and soak process. Once the weights are calculated, the tiles are categorized into one of following ratings:

- Non-vitreous (Low density) – Water absorption of tile between 7.0% to 20.0%
- Semi-vitreous (Medium density) – Water absorption of tile between 3.0% and 7.0%
- Vitreous (High Density) – Water absorption of tile between 0.5% and 3.0%
- Impervious (Extremely dense) – Water absorption of tile 0.5% or less.

The ratings above directly associate with how a tile can be used; either in interior or exterior applications. Ceramic tiles, which tend to fall in the Semi-Vitreous or Vitreous range, should not be used in exterior applications that may be subject to multiple cycles of freezing and thawing. This is because the ceramic will absorb enough water that when it freezes, the water within the body of the tile could expand and therefore crack the tile.

Porcelain tiles fall into the Impervious range, which have a very low rate of absorption. Because of this, porcelain tiles can be suitable for use in exterior applications subject to multiple freeze/thaw cycles.

ASTM C648 — Breaking Strength

The purpose of this test is to determine at what point a tile will break when a load is applied to a specific point on the tile. The tile is placed into a machine that allows for a portion of the tile to be unsupported beneath. The machine then applies pressure through a steel

rod with a ball bearing on the end on the center point of the tile. Pressure is applied until the tile breaks, at which point the measurement is obtained. Ten (10) tiles are tested and the average is taken.

The measurements are calculated in pounds-force, or Newtons. Values that are stated in inch-pounds are to be regarded as standards while the values given in parentheses are mathematical conversations to SI units that are provided for information only and are not to be considered standard.

According to ANSI A137.1, tile shall have an average breaking strength of equal to or greater than 250 lbf for pressed floor, porcelain, quarry and mosaic tiles, and 125 lbf for glazed wall tiles.

It's important to note that this test method does not measure the weight limit of foot traffic or the breaking strength of a supported tile. It's simply a test to determine at what point an unsupported tile will break. Essentially this test ensures that the tile is porcelain or ceramic according to the breaking strength and it does provide a sense of durability. However, just because a porcelain tile tests at >250 lbf, does not mean it won't break after installation. A separate test, called the Robinson Floor Test, measures this. Generally, the Robinson Floor Test will only be used for large commercial projects, such as the 2nd level of a mall where floor deflection may apply. Even if the tile is durable, it does not mean the floor won't flex. Floors flex, tiles don't - and that's how you get can get cracked and broken tiles. The Robinson Floor Test builds the actual floor, from concrete substrate and all setting materials up to the tile, then uses a revolving set of steel wheels with varying weights added at certain increments. If the floor passes the full set of rotations at maximum weight with no failure, then it is considered passing.

Abrasion Resistance

ASTM C1027 – this test is for Glazed tiles. The test requires 11 test specimens and 8 separate test specimens used for visual comparison assessment. There are 8 stages of abrasion consisting of 100, 150, 600, 750, 1500, 2100, 6000 and 12,000 rotations using an abrasive load on the surface of the glazed specimen. Each stage requires a different specimen and the tile is measured on the lowest number of rotations that show abrasive wear.

1. After each cycle of rotations, the tiles are rinsed under running water and dried in an oven.
2. For visual comparison, the abraded tile is viewed in a light box with the 8 unabraded samples.
3. For any tiles that pass 12,000 abrasions, they will be tested for stain resistance. Tiles will be rubbed 3 to 4 times with a staining agent paste and allowed to stain for 24 hours. The stain is then removed, and the tiles cleaned. If the stain can be removed, it will be classified at Class V. If the stain cannot be removed, it will be classified as Class IV, per the chart below.
4. The test specimens are classified according to the following table:

Abrasion Stage at Which the Failure is Visible	Class
100	Class 0
150	Class I
600	Class II
750	Class III
1500	Class III
2100	Class IV
6000	Class IV
12000	Class IV
>12,000 and pass staining test	Class V

It is important to note that this test needs to be done per color, as darker colors tend to wear easier than lighter colors.

Mohs Scale

There is no ASTM test method or ANSI requirement for the Mohs scale. The Mohs scale is another tool that can be used to determine the hardness of either the surface glaze, or the tile body itself. The tile glaze and surface body of one tile may have 2 different Mohs scales.

The Mohs scale was created in 1812 by geologist Friedrich Mohs who created the scale using minerals that were common at the time. The scale runs from 1 to 10 with 1 being talc and 10 being Diamond. The full scale is:

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase
7. Quartzz
8. Topaz
9. Corundum
10. Diamond

The idea of the Mohs scale is that each mineral can be scratched by the mineral above it on the scale, but not the mineral below it. So, Quartz can scratch Orthoclase but not Topaz. Through-body porcelain tile generally falls around 7 on the Mohs scale, which is one of the hardest minerals to scratch (even if there are 3 more above). This is why we use diamond blades to cut porcelain tile.

To compare to some common everyday items, your fingernail is around 2.5 on the Mohs scale, meaning that it could scratch Gypsum and Talc but not Calcite. Copper Pennies fall around 3.5. Metal knife blades fall at 5.5. Masonry drill bits that are used to cut through concrete blocks and other masonry are near 8.5.

DCOF

(I borrowed most of this description from my colleague Ken Ahn, Quality Assurance and Technical Lead here at Creative Materials. He covered DCOF in a recent Tile Talk blog post.)

Dynamic Coefficient of Friction (DCOF) is the frictional resistance one pushes against when already in motion. For DCOF, a slip occurs when pushing off with more force than the surface can resist. In North America, the tile industry uses the DCOF Acutest per ANSI A137.1 to measure the DCOF rating of tiles. According to this standard, ceramic tile selected for level interior spaces expected to be walked upon when wet must have a minimum wet DCOF Acutest value of 0.42. However, having a rating below this rating, or higher than this rating does not automatically determine suitability or appropriateness of the tile. Type of use, traffic, maintenance, and wear are important and must be considered by the specifier.

Note: Prior to 2012, the coefficient of friction (slip resistance) for ceramic tile was tested using a different test called Static Coefficient of Friction (SCOF). In this test, water was placed on the floor and a weighted plate with a sensor was placed over the water. The sensor measured the force required to set the weighted plate in motion. It was determined that this test was not appropriate for measuring the slipperiness of floors because people are generally already moving and are trying to stop slipping instead of trying to start slipping. In addition, there were variations in running the test including human error. As such, ASTM C1028 was deemed to be ineffective at measuring the slipperiness of floors. Under the old SCOF standard, commercial floors required a slip resistance of 0.60 SCOF. However, that test and value are no longer used to test the slip resistance of tile.

References:

- ASTM C-1027-19 - Standard Test Method for Determining Visible Abrasion Resistance of Glazed Ceramic Tile
- ASTM C-1027-99 - Standard Test Method for Determining Visible Abrasion Resistance of Glazed Ceramic Tile
- ASTM C-373-18 - Standard Test Methods for Determination of Water Absorption and Associated Properties by Vacuum Method for Pressed Ceramic Tiles and Glass Tiles and Boil Method for Extruded Ceramic Tiles and Non-tile Fired Ceramic Whiteware Products