TCNA
TILE INITIATIVE

2019


TCNA
Handbook for
Ceramic, Glass, and
Stone Tile Installation
2019
TCNA
ANSI
American National Standard Specifications
for the Installation of Ceramic Tile
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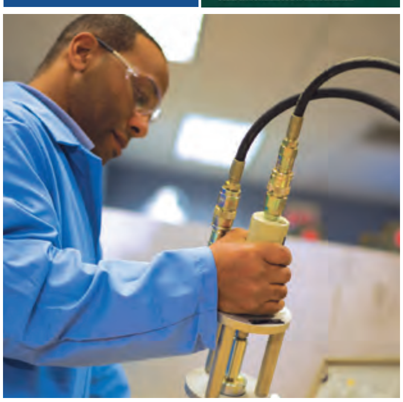
AMERICAN NATIONAL STANDARD
SPECIFICATIONS FOR SUSTAINABLE
CERAMIC TILES, GLASS TILES, AND
TILE INSTALLATION MATERIALS



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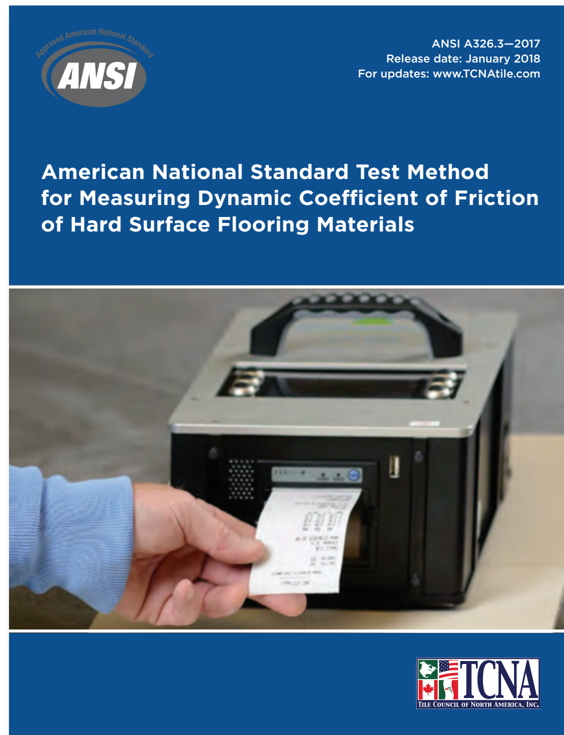
TCNA BULLETIN

ANSI A326.3 UNIFIES MEASUREMENT OF SLIP RESISTANCE FOR HARD SURFACES

A new standard for DCOF, ANSI A326.3, unifies the measurement of slip resistance for hard surface flooring materials!

Since 2012, the DCOF AcuTest® has been the ceramic tile industry standard for testing dynamic coefficient of friction (DCOF). Contained in section 9.6 of ANSI A137.1, the American National Standard Specifications for Ceramic Tile, the DCOF AcuTest® is the method used by the tile industry for assessing a floors relative "slipperiness", whether in-situ after installation or during manufacturing. Although initially developed for ceramic tile floors, the methodology was equally applicable and useful with other hard surface flooring, where its use has been "gaining traction" every year.

With facility managers, inspectors, cleaning professionals, and forensic engineers using the method increasingly in the field, ANSI A326.3, Test Method for Dynamic Coefficient of Friction of Hard Surface Flooring Materials, was developed based on the DCOF AcuTest®.



Approved in March 2017 by a broad consensus of hard surface flooring stakeholders, ANSI A326.3[1] incorporates the well-known method in ANSI A137.1 into a separate, stand-alone DCOF standard for hard surface flooring materials. Also, a new field testing section was added to provide guidance when testing in-situ. The standard includes testing an installed floor under prevailing conditions, as would be the case when evaluating cleaning/maintenance procedures. Additionally, the field testing section addresses testing after cleaning, including the use of other, stronger cleaning agents in comparison to the cleaner referenced in the laboratory method. This evaluation is useful for testing the flooring surface itself after install and use, without contaminants, to check for wear and to compare to the manufacturer's reported DCOF.

[1] As a simple mnemonic, 326.3 spells "DCOF" on a touchtone phone

Additional Guidance for the Specifier

The ANSI A137.1 specification released in 2012 included a minimum threshold of 0.42 for tiles intended to be walked upon when wet with water, and guidance to the specifier about important factors relevant to slip resistance. ANSI A326.3 has the same specification but additionally provides further guidance helpful for the specifier. Examples of the additional guidance given in A326.3 include the following:

- While specifying products with higher COF for use under contaminated conditions can be considered, higher COF can lead to maintenance/cleanliness issues and hard to remove contaminants and films, which can cause hazardous and unfavorable conditions. In addition to maintenance issues, a surface with a high COF can create a difficult walking condition for that subset of the elderly and disabled who slide their feet on the floor. For them, smooth and dry flooring is needed, specifically flooring with a low wet COF that is kept dry when in use.

- Hard surface flooring materials with a wet DCOF less than 0.42 are often used in areas such as shopping malls (outside the food court), hotel lobbies, office buildings, etc. where appearance and ease of cleaning are highly desired and measures are in place to keep the floor dry when walked upon.

- Hard surface flooring materials which have a coating applied shall only be used in areas that can be kept dry, unless otherwise specified by the coating's manufacturer. If testing data is required after a coating is applied, use the test method specified by the manufacturer, or the dry testing procedure in this standard if no test method is suggested by the manufacturer of the coating.

The new standard identifies many factors that must be taken into account when determining the suitability of a hard surface flooring material for a particular application. For example, in exterior applications, the suitability of a flooring material depends significantly on drainage of the assembly, physical structure of the flooring material, expected footwear, intended use, and the variety of contaminants present, among many

ANSI A326.3 UNIFIES MEASUREMENT OF SLIP RESISTANCE FOR HARD SURFACES

other factors. This is why a single DCOF limit value is not provided for exterior applications, interior ramps/inclines, and areas expected to be contaminated with something other than water.

Putting the Standard into Practice

Tile manufacturers already report DCOF according to A137.1/A326.3, with some including the information directly on their cartons and others providing the information in their product literature. While the ANSI specification for ceramic tile does not require a minimum or maximum DCOF value independent of how the tile is used, reporting the value per the DCOF AcuTest® is required. Other hard surface flooring industries are similarly following suit, with the Marble Institute of America specifying a similar 0.42 DCOF value for stone flooring intended to be walked on when wet.

However, it is important to understand that DCOF is only one factor in determining the suitability of a flooring material for a particular application. As the standard correctly notes, there are many factors that can affect the possibility of a slip occurring, including by way of example, but not in limitation, the following: the material of the shoe sole and the degree of its wear; the presence and nature of surface contaminants; the speed and length of stride at the time of a slip; the physical and mental condition of the individual at the time of a slip; whether the floor is flat or inclined; how the hard surface flooring material is used and maintained; and the COF of the material, how the flooring surface is structured, and how drainage takes place if liquids are involved. To specify flooring materials appropriately requires knowledge of how the space will be used and maintained; often the better the communication regarding this early on, the better the flooring selections.

Considering slip resistance is especially important at entrances and exits where flooring can become unintentionally contaminated, either from water and soil tracked inside, or from fire-fighting efforts under emergency conditions. All building chokepoints deserve extra attention, as well as spots where water and other liquids can be anticipated, such as by drinking fountains, inside and around restrooms and kitchens, etc. Also, areas where the floor may be worn or polished deserve attention and periodic monitoring. Remedial treatments are always possible when DCOF monitoring indicates the need for such.

More than anything, the easy measurement of in-situ flooring through the DCOF AcuTest® finally allows building owners/facility managers a means to monitor their spaces for essential flooring safety. Such monitoring, sometimes called DCOF auditing, can be used to keep maintenance providers accountable; after all, if a floor is not maintaining its intended DCOF value under actual use conditions, an accident can be anticipated. When floors are properly specified and maintained, safer walkways result, benefitting all.

As a public service, the Tile Council of North America, publisher of the A326.3 standard, offers the standard without charge on the TCNA website.

“Gauged porcelain tiles and gauged porcelain tile panels/slabs differ from traditional ceramic tiles in their physical characteristics and performance. … In addition to having a unique product standard (A137.3), gauged porcelain tiles and gauged porcelain tile panels/slabs require unique installation procedures and workmanship standards.”

— ANSI A137.3—2017 and A118.19—2017: American National Standard Specifications for Gauged Porcelain Tiles and Gauged Porcelain Tile Panels/Slabs

CONSIDERING THE 4T'S OF FLOORING QUALITY

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Unparalleled **design** flexibility and **style**.

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Tough
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NO.3
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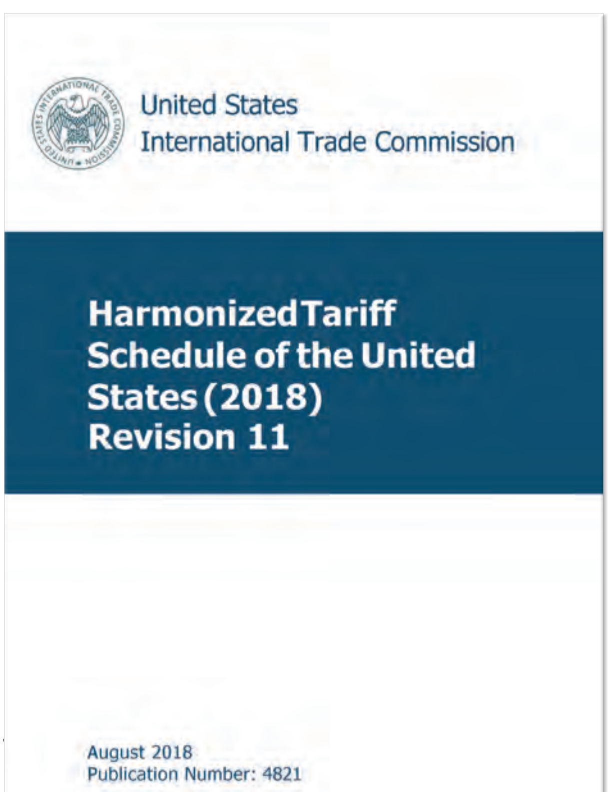
NO allergens,
NO worries.

TCNA BULLETIN

CRITICAL CHANGES TO HS AND HTS CODES FOR CERAMIC TILE IMPORTED INTO THE UNITED STATES

Ceramic tile imported into the United States is tariffed, or subject to duty, per the Harmonized Tariff Schedule (HTS) maintained by the United States International Trade Commission (USITC). This schedule provides the applicable tariff rates and statistical categories for all products imported into the United States. For ceramic tile, the HTS classifies tiles based on their water absorption, except for mosaics and finishing pieces, which are classified separately. In each category, further classification is made based on whether the tiles are glazed or unglazed, and according to certain size criteria.

Critical changes to the HTS took effect January 1, 2017 which impact all companies that import ceramic tile into the United States. These changes follow a 2014 decision of the World Customs Organization's (WCO's) Harmonized System Committee, with three years scheduled for implementation. Harmonized System (HS) codes, which are developed and administered by the WCO, are used in nearly two hundred countries by customs officials to classify and track globally traded products.



What Has Changed?

Worldwide, as of January 1, 2017, ceramic tile must be classified under HS heading 6907 as described below. Prior to this change, HS heading 6907 was used for unglazed tile, and HS heading 6908 was used for glazed tile. Under these two headings, tiles were subcategorized based on size—specifically, whether the tile was a mosaic, larger than a mosaic but smaller than a 12" x 12" tile, or larger than 12" x 12".[1]

The 6908 heading is now no longer in use, and at the six-digit, international level the revised 6907 heading classifies tiles as follows:

6907.21 Of a water absorption coefficient by weight not exceeding 0.5%

6907.22 Of a water absorption coefficient by weight exceeding 0.5% but not exceeding 10%

6907.23 Of a water absorption coefficient by weight exceeding 10%

6907.30 Mosaic cubes and the like, other than those of subheading 6907.40

6907.40 Finishing ceramics

At the national level, four additional digits are allowed (i.e., ten-digit headings) for further subdivision of the categories above.

1 For glazed tiles, there was also further subcategorization of the mosaic category.

What Are Mosaic Tiles, and Why Are They Categorized Separately?

This seemingly straightforward question is surprisingly complex. At present, the term "mosaic" is not defined by the WCO or U.S. Customs and Border Protection (CBP). Historically in HS headings, mosaic tiles were specifically defined by size requirements and limited to all tiles less than 49 cm^2. While the new heading 6907.30 does not contain size requirements, we expect CBP is interpreting the category in the same fashion.

No distinction is made at the six-digit level in category 6907.30 based on water absorption or whether the tiles are glazed or unglazed. As the quantity of mosaics moving between countries is small, and as the properties for such tiles are not internationally defined in the International Standards Organization's (ISO's) ceramic tile standard (13006), mosaics are tracked separately from tiles in categories 6907.21–6907.23, in which water absorption determines the classification.

What Are Finishing Ceramics, and Why Are They Categorized Separately?

Finishing ceramics are classified in the explanatory notes to HS heading 6907 as follows:

> Bordering, capping, skirting, frieze, angle, corner or other fitting tile pieces employed as complementary elements for finishing off the facing, paving, etc., work, with or without rounded edges, non flat or three-dimensional, which give them the character of finishing pieces; that would be the case, in particular, for bordering, skirting, frieze, corner pieces, decorative inserts and other ceramic accessories. In these cases, these pieces need to match with the other basic tiles, so their proper surface usually has the same shade or finish of the normal tiles. They are generally sold by piece or by linear metre.

These tiles sell at a volume and price very different from the field tiles they complement. As such, greater clarity is achieved in all categories by tracking finishing ceramics separately from field tiles. As with mosaics, finishing ceramics are not distinguished at the six-digit level by their water absorption or whether they are glazed or unglazed.

TCNA BULLETIN

CRITICAL CHANGES TO HS AND HTS CODES FOR CERAMIC TILE IMPORTED INTO THE UNITED STATES

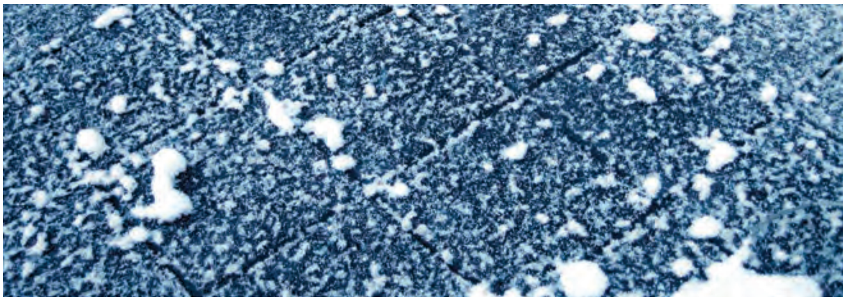
How Is Water Absorption Determined?

A tile's water absorption, or the percentage of weight it gains when water soaks into its body, is indicative of its overall connected porosity. The more water weight a tile gains, the more porous it is.

In the United States, a tile's water absorption is determined using the ASTM C373 standardized test method, which requires the use of a strong vacuum to draw water into a tile's pores. This procedure, updated in 2016 from a previous version which required a 5-hour boil and 24-hour water soak, allows for tile saturation in a much shorter timeframe than the previous boil method.

Similarly, the ISO 10545-3 water absorption test method, which is used more commonly outside the United States, was updated in 2017 to align with the new ASTM International C373 vacuum procedure.

Given that ASTM C373 and ISO 10545-3 have historically differed procedurally, this recent harmonization allows for increased consistency in water absorption testing and reporting.



Why Is Water Absorption Important?

A tile's water absorption directly affects the way it absorbs moisture, initially from the setting material and subsequently from the environment. This can affect the bond that is established where very high or low water absorption can require the use of specific bonding materials or substrate preparation.

Water absorption also affects freeze/thaw resistance, moisture expansion, breaking strength, and resistance to crazing, which can affect whether tiles are suitable for certain applications and how they should be installed. For example tiles that are highly water absorbent may not be suitable for freeze/thaw conditions, as the greater amount of water may cause the tile to crack in freezing weather.

In addition to freeze/thaw concerns, the unintended use of non-porcelain tile when porcelain tile was specified can cause greater than anticipated moisture-related expansion, possibly leading to tiles popping off the floor or wall due to the resulting compression.[2] Greater moisture absorption can also lead to crazing where the impervious glaze develops micro-cracks due to the underlying tile body expanding.

It is also true, but less well known, that a water-saturated tile has a lower breaking strength than a dry tile. This can be problematic if the tiles are exposed to a high level of point loading or are imperfectly installed.

2 As the tiles expand, they put the surrounding tiles in compression.

Historic Problem with Water Absorption Reporting and False Porcelain

Porcelain tile is defined in the U.S. ceramic tile standard, ANSI A137.1, as an impervious tile with water absorption of 0.5% or less, as measured by the ASTM C373 test method.

There is, however, a large body of foreign-made tiles not meeting this standard, many of which have been advertised and sold as porcelain. In part this has occurred due to the use of a less rigorous method internationally for determining water absorption. In other instances, some overseas manufacturers have made deliberate decisions to sell tiles as porcelain regardless of their actual water absorption value. The same has also been true of less than scrupulous importers who have marketed tiles as porcelain while knowing they did not meet the ANSI A137.1 standard.

In certain instances these products have been called "residential porcelain," but as the products didn't meet porcelain tile criteria, the term misrepresented the true nature of the tiles. Invariably these efforts to sell non-porcelain tile as porcelain were to take advantage of the popularity of the porcelain category, and because producing genuine porcelain is a more costly and higher temperature process than producing non-porcelain ceramic tiles.

Clearly the practice of selling non-porcelain tile as porcelain defrauds the consumer and creates marketplace confusion.

The Porcelain Tile Certification Agency (PTCA) was launched in 2007 to address these issues by providing a way for manufacturers to confirm their products are genuine porcelain. More information on this program can be found at www.ptcaonline.org.

New HS and HTS Codes and Revenue Neutrality

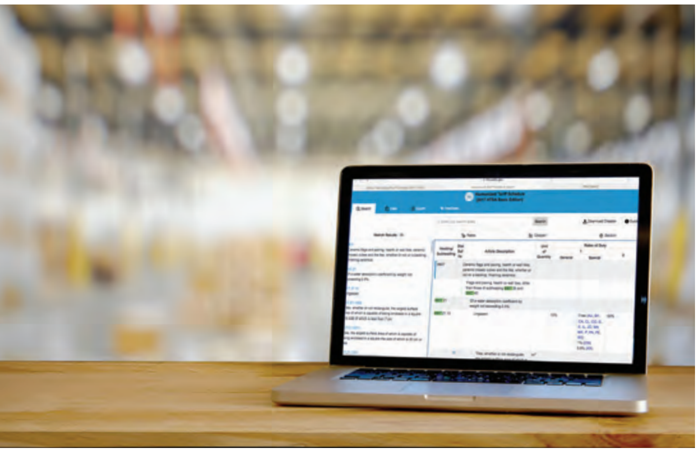
As noted previously, starting January 1, 2017, use of the 6908 heading was discontinued, and the revised 6907 heading classifies all tiles, not otherwise classified as either mosaics or finishing pieces, according to their water absorption.

For tile entering the U.S. market, the USITC further breaks the HS codes down to a ten-digit level (HTS codes) to capture more specific data. These HTS codes differ from HS codes in that they are specifically for imports into, and exports out of, the United States.

HTS codes use the same first six-digits as HS codes, but the last four digits differ. The ten-digit HTS codes for ceramic tile can be found on the USITC website, hts.usitc.gov.

TCNA BULLETIN

CRITICAL CHANGES TO HS AND HTS CODES FOR CERAMIC TILE IMPORTED INTO THE UNITED STATES



The additional four digits are used to keep the new classification revenue neutral with the old classification and to meet the following criteria:

- "The modification must be consistent with the [Harmonized System] Convention or any amendment thereto recommended for adoption, must be consistent with sound nomenclature principles, and must ensure substantial rate neutrality.
- Any change to a rate of duty must be consequent to, or necessitated by, nomenclature modifications that are recommended under this section.
- The modification must not alter existing conditions of competition for the affected United States industry, labor, or trade."

To maintain revenue neutrality, and to adhere to all existing trade agreements and rates of duty, the new codes preserve the distinction between glazed and unglazed tiles, with unglazed tiles generally at 10% duty and most glazed tiles at 8.5% duty (excepting if imported from North Korea or Cuba with much higher duties). Similarly, the new codes also preserve the size distinctions in the prior HTS codes.

In total there are 40 separate ten-digit HTS codes for ceramic tile importers and exporters under the new system, compared to the eight in the prior system.

As an example, the prior system classified glazed ceramic tiles larger than 30 cm x 30 cm (approximately 12" x 12") under heading 6908.90.00.51.

Under the new system, whether the tile is porcelain, non-porcelain floor tile, or wall tile is relevant; glazed porcelain floor tiles larger than 30 cm x 30 cm are classified under heading 6907.21.90.51, with the duty being the same in the prior system under 6908.90.00.51.

Glazed non-porcelain floor tiles larger than 30 cm x 30 cm are classified under heading 6907.22.90.51, and similar tiles for walls only (i.e., with water absorption over 10%) are classified under heading 6907.23.90.51.

A Necessary Solution

To comply with the changes from the WCO, as discussed above, USITC had no choice as a matter of law but to recommend the changes to the HTS discussed herein. It is worth clarifying that neither U.S. industry nor U.S. importers can simplify or change the tariff schedule when it affects government revenue; it literally takes an act of Congress to change the tariff system if revenue neutrality is not maintained.

Overlap in the HTS Codes

Further complicating the new HTS codes, as noted previously, the category 6907.30 for mosaics was created in the HS system by the WCO without defining the term "mosaics." This category overlaps with the mosaic sizes in HTS codes 6907.21 through 6907.23.

As an example, the pre-2017 system classified an unglazed mosaic tile under heading 6907.10.00.00 with a duty of 10% (excluding those countries with special duty provisions). Under the new system, depending on its water absorption, an unglazed mosaic tile could meet the criteria of heading 6907.21.10.05 (porcelain tile), heading 6907.22.10.05 (non-porcelain floor tile), or heading 6907.23.10.05 (wall tile), and regardless of water absorption, heading 6907.30.10.05 (mosaic cubes and the like), and if also a trim tile, heading 6907.40.10.05 (finishing ceramics). All carry the same 10% duty.

Just as the six-digit categories 6907.21 through 6907.23 in the HTS codes contain mosaic sizes, the mosaic category (6907.30) in the HTS codes contains sizes outside the mosaic range, specifically 6907.30.90.11 (30 cm x 30 cm or less) and 6907.30.90.51 (greater than 30 cm x 30 cm).

We fully expect CBP will eventually clarify which categories to use given that some size-based subdivisions within the ten-digit HTS codes conflict with the intent of the 6907.30 category. As a matter of law, CBP is the only agency that can provide legally binding advice or rulings on classification of imports. They should be contacted with any questions about how potential imports would be classified.

Impact on the U.S. Market

While PTCA has been effective as a voluntary path for porcelain tile manufacturers to demonstrate their compliance with porcelain water absorption criteria, it

does not prevent manufacturers that do not participate from false labeling. With the HTS codes in effect as of January 1, 2017 requiring water absorption to be declared, we expect importers are more careful in requiring that information from their suppliers and are more carefully reporting it. U.S. CBP can issue fines and potentially hold importers criminally liable for making false declarations. Presumably the risk of such helps reduce the amount of mislabeled tile entering the market.

Given the problems potentially occurring when non-porcelain tiles are unknowingly substituted for porcelain tiles (excessive expansion, loss of freeze/thaw resistance, moisture-related crazing, and reduced breaking strength), greater clarity in reporting water absorption will result in fewer installation failures and greater end-user satisfaction.

With the completion in 2017 of the worldwide effort to harmonize water absorption testing methods and federal laws now in force as described, we fully expect consumers to benefit and the playing field to be more level for all porcelain producers abiding by accepted water absorption criteria.

That's a win-win for consumers and manufacturers alike!

PORCELAIN TILE CERTIFICATION
AND THE PORCELAIN TILE CERTIFICATION AGENCY (PTCA)

In 2007 Tile Council of North America (TCNA) partnered with the Ceramic Tile Distributors Association (CTDA) to create the Porcelain Tile Certification Agency (PTCA) to certify porcelain tile. This program was formed at the initiative of distributors and manufacturers who were concerned with the amount of tile being sold in the United States that was marked as porcelain but which was in fact not porcelain.

CERTIFIED PORCELAIN® TILE
0.5% or less water absorption

What is porcelain tile, and why does it matter whether a tile is porcelain?

As defined by the ANSI A137.1 ceramic tile standard, porcelain tile is a ceramic tile with a very low water absorption (0.5% or less), as tested per ASTM C373. Porcelain tile is denser and has a lower water absorption than other types of ceramic tile. When non-porcelain tiles are unknowingly substituted, freeze/thaw and expansion failures can result from unexpected moisture absorption.

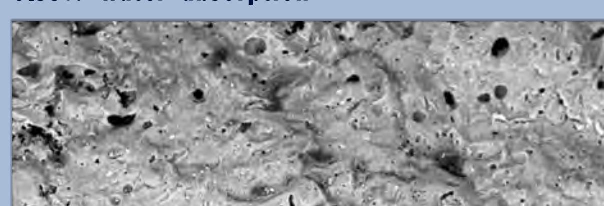
Why was this porcelain tile certification program created?

It is well known that some non-porcelain tiles made overseas are knowingly mislabeled as porcelain, with exporters and importers choosing to ignore the relevant North American standard (ANSI A137.1). While the criteria for porcelain tiles have been well-defined for several decades in North America, this practice of mislabeling tiles began when the term porcelain was undefined in international standards.

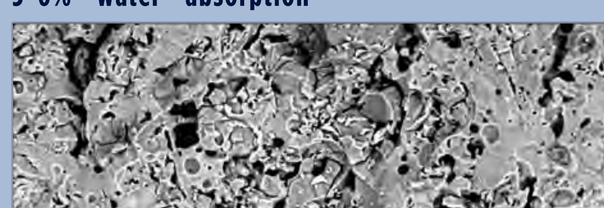
Today the term is well defined and the ISO and ASTM water absorption methods are harmonized, but historically the method used internationally for measuring water absorption (ISO) was less rigorous than the ASTM C373 method used in North America.

Simply stated, this means that some tiles classified as

0.39% water absorption



5-6% water absorption



porcelain overseas haven't met the stricter and more demanding water absorption criteria used in North America. In freeze/thaw and wet environments, that can be important. Given that approximately 70% of the tiles sold in the United States are imported, PTCA certification was developed to protect the consumer from tiles either intentionally mislabeled or mislabeled due to differences in testing.

Through the PTCA program the need for porcelain certification has become even more evident, as 348 tile series out of 1,703 (20%) failed as of third quarter 2018.

Can only manufacturers sign up for PTCA certification?

No. The program is open to both manufacturers and sellers of porcelain tiles. Either can be a program participant.

PTCA certification: What does it mean?

Recognizing that the extent of this false labeling issue only applies to whether or not tiles meet the water absorption criteria of the ANSI A137.1 standard, PTCA certification was developed only to independently evaluate if the program participant understands North American water absorption criteria and can meet such. Tiles are not checked to see whether or not they meet all the other relevant properties for porcelain tiles in the ANSI A137.1 standard; variance from those properties has not been an issue in general, and the criteria are well understood. For each series being evaluated, five commercially available samples (selected by the participant) are sent once every three years by manufacturing participants and annually by non-manufacturing participants.

Passing the initial testing establishes that the participant understands and can meet North American water absorption criteria. For more details on the PTCA program, the PTCA Program Participation Agreement is publicly-available and can be found at www.ptcaonline.org/PTCA_Participation_Agreement.pdf.

PORCELAIN TILE CERTIFICATION
AND THE PORCELAIN TILE CERTIFICATION AGENCY (PTCA)

If a box of tiles has the PTCA certification mark on it, is PTCA stating that those tiles meet ANSI A137.1 water absorption criteria?

No. PTCA establishes that the program participant understands North American water absorption criteria and is able to meet such.

The quality of the tiles being sold is exclusively controlled by the actual manufacturer.

If a box of tiles has the PTCA certification mark on it, is the program participant stating that those tiles meet all ANSI A137.1 criteria?

While the program participant may independently claim compliance with all ANSI A137.1 porcelain tile criteria, that is not required by PTCA of program participants.

By participating in the PTCA certification program, the program participant (i.e., the manufacturer and/or seller) is stating that the tiles it produces or sells labeled with the PTCA mark meet the ANSI A137.1 porcelain tile water absorption requirements.

Non-manufacturing participants are further required to obtain a written assurance from the actual manufacturer that it will immediately notify the participant of any changes in the conforming porcelain tiles or any manufacturing variances that may affect the certification.

To further ensure the program's effectiveness, participants have agreed not to use the PTCA mark in any way misleading or confusing to buyers, including displaying the certification mark in a way that would imply non-certified products are certified. Participants also are not allowed to transfer use of the mark to any other person or entity.

As noted above, PTCA certification does not mean the tiles tested met all ANSI A137.1 or ISO 13006 criteria, which would require testing for other physical properties such as dimensions, warpage, breaking strength, etc. That assurance would need to come from the manufacturer or via a third-party lab.

If a box of tiles has the PTCA certification mark on it, can those tiles be used in freeze/thaw and wet environments without concern?

While the tiles may be perfectly appropriate for such use, the PTCA certification mark does not suggest that. The suitability of any tiles for specific applications requires an analysis of the project conditions by a qualified individual and proper installation. The certification mark does not assure fitness for any particular purpose.

What are the benefits of the PTCA program?

The PTCA program is designed to directly benefit consumers purchasing porcelain tiles and, indirectly, everyone involved in the supply chain.

Participants benefit by being able to independently confirm to customers that what they are producing or selling is truly porcelain, and by being able to differentiate their products from falsely-labeled porcelain products.

Producing porcelain tiles can be a more intensive and costly process than producing non-porcelain tiles, so certification is a good way for manufacturers and sellers to confirm that investment to the market.

For distributors PTCA certification helps differentiate real porcelain tiles from those that are falsely-labeled as porcelain.

Who polices PTCA-certified tile?

The marketplace does. If a question arises about whether a tile sold as PTCA-certified truly meets the water absorption criteria for porcelain tiles, PTCA is authorized to acquire further samples and test such for compliance. The board of PTCA then reviews the available data and relevant actions taken by the program participant to decide whether to withdraw PTCA certification and use of the mark.

Anyone who suspects a non-porcelain tile is being sold as PTCA-certified tile is encouraged to notify PTCA at 630-942-6588 or info@ptcaonline.org.

TCNA BULLETIN

WHAT IS TRUE PORCELAIN?

CERTIFIED PORCELAIN TILE
0.5% or less water absorption

The difference between real and false porcelain cannot be detected by eye.... Suppliers of falsely-labeled porcelain are defrauding the consumer and benefitting from the popularity and market value of genuine porcelain.

Porcelain tile has become increasingly popular over the past decade. The American National Standard Specifications for Ceramic Tile (ANSI A137.1) require tile to have a water absorption of 0.5% or less to be classified as porcelain when tested per ASTM C373.

Manufacturing tile that meets this standard—true porcelain—requires porcelain-grade clays and other unique raw materials, plus precision milling processes and kilns set to extremely high firing temperatures (2100˚F to 2500˚F). The required raw materials, energy, and manufacturing equipment needed to produce such low porosity, high density tile are why real porcelain is typically more expensive than non-porcelain tile.

The difference between real and false porcelain cannot be detected by eye—the only way to know is to have a laboratory verify the tile's water absorption is 0.5% or less. Through its lab, Tile Council has identified 348 series (out of 1,703 total tested) that did not meet the PTCA water absorption criteria necessary to be certified as porcelain.

Suppliers of falsely-labeled porcelain are defrauding the consumer and benefitting from the popularity and market value of genuine porcelain. This is particularly true for imported tile, and considering that approximately 70 percent of the tile sold in the United States is imported, much of the "porcelain" being sold may be falsely-labeled.

ASTM C373 Water Absorption Test

For ceramic tile, water absorption refers to the maximum amount of water that a tile can be made to absorb. In the lab test ASTM C373, water is drawn into the deepest pores of the tile by a strong vacuum.

So, measuring water absorption can also be looked at as measuring available tile porosity—the more water that can be absorbed, the more porous (less dense) the tile.

STEP 1

Tile sample is dried in an oven to ensure accurate dry weight.

STEP 2

Dried tile sample is weighed using a digital scale accurate to 0.001 gram.

STEP 3

Water is drawn into the tile sample by a vacuum and soaking it.

STEP 4

Saturated tile sample is weighed to determine the amount of weight gain due to absorption of water.

STEP 5

Water absorption is calculated.

The change in weight is expressed as the percentage of the tile's dry weight.

Eric Astrachan

Executive Director

Tile Council of North America

The Tile Council of North America (TCNA), through its industry leadership and interest in health and environmental transparency, commissioned a research study with Environmental Health & Engineering, Inc. (EH&E) to assess exposure to respirable crystalline silica during the installation of ceramic and glass tile (hereafter “tile”) manufactured in Italy, Mexico, and the United States. The analysis considered information on tile provided by approximately 95 manufacturers, representing nearly 190 brands, with support from Confindustria Ceramica, Centro Ceramico Bologna, and the TCNA Product Performance Testing Laboratory.

With crystalline silica listed under California’s Proposition 65 law (Prop 65), this study was undertaken to assess whether labeling under Prop 65 was required for tile products due to possible exposure from cutting tile.

The study found that the potential excess lifetime cancer risk (ELCR) associated with tile-related crystalline silica exposure for the average Californian who installs tile is 1.3 in 10 million (1.3 x 10-7), or 0.013 per 100,000, a value that is 75-times below the threshold of 1 in 100,000 established under the Prop 65 regulation.[1]

In addition to establishing that labeling was not required per Prop 65 for the brands examined, the study also provided an invaluable assessment of exposure factors from a variety of cutting tools. In particular, emissions from cutting tile by the score and snap method were 50 times lower than found from wet-cutting, and over 1000 times lower than from motorized dry cutting.

In conjunction with a prior OSHA determination that wet-cutting tile with a stationary masonry saw requires no personal protective equipment (PPE)[2], these results show no PPE is required when scoring and snapping tile.

This should provide real comfort to anyone that installs tile! You can read the full EH&E report on the ensuing pages.[3]

Sincerely,

Eric Astrachan

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1 Conclusions apply only to the brands studied.

2 Using a saw with integrated water delivery system that continuously feeds water to the blade per OSHA regulations, found at 29 CFR 1926.1153(c), Table 1.

3 The foregoing is provided as a general summary for informational purposes only; refer only to the report for details and the conclusions drawn by EH&E.

ENVIRONMENTAL HEALTH & ENGINEERING, INC.

Human Health Risk Assessment for Proposition 65: Crystalline Silica

Prepared For:
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June 1, 2018

EH&E Project 21332

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LIST OF ABBREVIATIONS AND ACRONYMS

AER	air exchange rate
AIHA	American Industrial Hygiene Association
BLS	Bureau of Labor Statistics
cm	centimeter
EF	emission factor
EH&E	Environmental Health & Engineering, Inc.
ft^2	square feet
HHRA	Human Health Risk Assessment
ICP-AES	inductively coupled plasma-atomic emission spectroscopy
in	inch
IUR	inhalation unit risk
kg	kilogram
Liberty	Liberty Mutual Industrial Hygiene Laboratory
m	meter
mg	milligram
mg/m^3	milligram per cubic meter
NIOSH	National Institute for Occupational Safety and Health
OEHHA	California Office of Environmental Health Hazard Assessment
OSHA	U.S. Occupational Safety and Health Administration
Prop 65	Proposition 65, Safe Drinking Water and Toxic Enforcement Act of 1986, California
SUD	Safe Use Determination
TCNA	Tile Council of North America
TWA	time-weighted average
USEPA	U.S. Environmental Protection Agency
XRD	x-ray diffraction
µm	micrometer
$\mu g/m^3$	micrograms per cubic meter
°	degree
°C	degrees Celsius
°F	degrees Fahrenheit

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LIST OF DEFINITIONS

Particulate Matter—a mixture of solid particles and liquid droplets suspended in air. Can contain organic and inorganic particles such as dust, pollen, soot, smoke, and liquid droplets. Also referred to as aerosol, or dust.

Respirable Particulate Matter—airborne particles measured with a DustTrak DRX Aerosol Monitor (TSI Incorporated) equipped with a 4 µm impactor or a sampling device designed to meet the characteristics for respirable particle size selective samplers specified in the International Organization for Standardization (ISO) 7708:1995: *Air Quality – Particle Size Fraction Definitions for Health-Related Sampling* (OSHA 29 CFR 1926.1153).

Respirable Crystalline Silica—quartz, cristobalite, and/or tridymite contained in airborne particles that are determined to be respirable by a sampling device designed to meet the characteristics for respirable particle size selective samplers specified in the International Organization for Standardization (ISO) 7708:1995: *Air Quality – Particle Size Fraction Definitions for Health-Related Sampling* (OSHA 29 CFR 1926.1153).

Tools:
Angle Grinder—a handheld power tool used to grind, polish, or cut materials. Also known as a grinder or dry saw.

Core bit—a handheld power tool used to make round holes.

Dust Shroud—a type of dust control system for motorized cutting tools.

Nippers—a manual tool that looks like a pair of plyers and is used to remove small amounts of tile which needs to be fitted around an odd or irregular shape.

Manual Cutter—snap cutter and nippers.

Motorized Cutting Tool—wet saw or angle grinder.

Snap Cutter—a manual tile cutting tool that uses a scoring handle equipped with a blade to score the surface of tile and mechanical leverage to snap the tile along the scored line. Also called manual tile cutter, score and snap, or score and snap cutter.

Wet Saw—a motorized tile cutting saw equipped with an integrated water delivery system that continuously feeds water to the blade.

1.0 EXECUTIVE SUMMARY

Environmental Health & Engineering, Inc. (EH&E) assessed potential risks to human health from exposure to respirable crystalline silica during installation of ceramic and glass tile (hereafter "tile") manufactured in Italy, Mexico, and the United States.[1] Tile products are non-friable and as a result, there is no inhalation exposure to respirable crystalline silica from installed tile. During installation, however, cutting tile can release respirable size particles containing crystalline silica into the air.

The methods that we used conform with standard practice for Proposition 65 (Prop 65) in the state of California and the professional practice of environmental health science. Our assessment of potential tile-related exposures was based upon a robust set of information on work practices, measurements of emissions to air, and exposure concentrations that were developed from research conducted expressly for this assessment. The guideline value for cancer potency used in our analysis was obtained from reports published by the California Office of Environmental Health Hazard Assessment (OEHHA) related to 2 prior Safe Use Determinations (SUDs). One of those SUDs was submitted by the National Paint and Coatings Association for crystalline silica in interior flat latex paint. The other SUD was prepared by the Sorptive Minerals Institute for crystalline silica in sorptive mineral-based pet litter. We used inputs to the analysis recommended by OEHHA unless we had strong research-based evidence to rely upon. In cases where OEHHA had no recommended values, we developed conservative risk inputs based on recommendations from the U.S. Environmental Protection Agency (USEPA), scientific literature, and best professional judgement.

The results of our assessment indicate that the potential excess lifetime cancer risk (ELCR) associated with tile-related exposures for the average Californian who installs tile is 1.3 in 10 million (1.3×10^{-7}), or 0.013 per 100,000, a value that is 75-fold below the threshold of 1 in 100,000 established under the Prop 65 regulation. Sensitivity analyses demonstrated that reasonable alternative values and inputs to the analysis did not significantly influence our conclusions.

[1] This report is a companion to the *Human Health Risk Assessment for Proposition 65: Metals in Ceramic and Glass Tile* report completed by EH&E.

2.0 INTRODUCTION

This report describes our assessment of potential human health risks associated with crystalline silica in tile manufactured in Italy, Mexico, and the United States. The analysis considers information on tile provided by approximately 95 manufacturers, representing nearly 190 brands.[2] The research was commissioned by the Tile Council of North America (TCNA), with additional support from Confindustria Ceramica, Centro Ceramico Bologna, and the TCNA Product Performance Testing Laboratory. The research was conducted by EH&E.

The objective of our risk assessment was to evaluate tile as a source of exposure to respirable crystalline silica in the context of the Prop 65 regulation in the state of California. We developed inputs for our evaluation from information published in the scientific literature, interviews with tile installers, and exposures during installation of tile. We combined that information following standard methods for human health risk assessment to characterize risk of cancer for the average Californian who installs tile.

Section 3 provides a fulsome background and overview of our assessment. In Section 4, we describe the scope of the assessment. The hazard characterization component of the assessment, including relevant health protective guideline values, is presented in Section 5. In section 6, we present details of the exposure assessment for crystalline silica in tile, including exposure factors and exposure concentrations. The results from our assessment of potential health risks are presented in Section 7. The discussion of the findings from the assessment are presented in Section 8. The conclusions drawn from this analysis are provided in Section 9. Section 10 contains a bibliography of the literature and other data sources relied upon for this report. Lastly, Section 11 recognizes the participating manufacturers included in our study.

[2] The conclusions from this report apply to brands of participating manufacturers and should not be generalized to brands of other manufacturers without additional analysis.

3.0 BACKGROUND

In this section, we first discuss the aspects of the Prop 65 regulation that define the exposure scenarios targeted by this research. Next, we describe the types of tile installed in buildings and tile installation practices. In the remainder of this section, we summarize prior research on exposures to respirable crystalline silica associated with cutting of building materials.

3.1 PROPOSITION 65

Prop 65 is intended to inform consumers about products that contain chemicals known to the state of California where exposure to such chemicals pose potential risks of cancer, developmental, and/or reproductive effects in humans. If typical use of a product results in chemical exposures for the average Californian that are above thresholds established by the law, then the business is required to provide “clear and reasonable” warnings to individuals within the state of California.

The chemical-specific exposure thresholds, above which labeling is required are referred to as “safe harbor” levels. The need for labeling is generally evaluated by completing an exposure assessment that compares the magnitude of exposure for the average Californian to the appropriate safe harbor levels. For chemicals regulated by Prop 65 that do not have a safe harbor level defined, a risk assessment utilizing appropriate guideline values may be conducted.

In the next section, we describe the information in the literature that is available to evaluate exposures to chemicals regulated by Prop 65 that could occur during handling and installation of tile by the average Californian who installs tile.

3.2 DEFINITION OF TILE

The American National Standard Specifications for Ceramic Tile, ANSI (American National Standards Institute) A137.1 defines tile to be “*a ceramic surfacing unit, usually relatively thin in relation to facial area, having either a glazed or unglazed face and fired above red heat in the course of manufacture to a temperature sufficiently high to produce specific physical properties and characteristics* (ANSI, 2017). Similarly, the American National Standard Specifications for Glass Tile, ANSI A137.2 defines glass tile to be “*a tile having an overall non-crystalline microstructure with* SiO_2 *as the primary constituent and manufactured by one or more of three primary processes: cast, fused, or low temperature-coated*” (ANSI, 2014).

ANSI A137.1 identifies 4 different types of ceramic tile: porcelain tile, pressed floor tile, glazed wall tile, and quarry tile (ANSI, 2017). Certain tile types can be further distinguished by the color of clay used to manufacture the tile. For example, pressed floor and glazed wall tiles can be composed of either reddish or whitish clay and are therefore referred to as “red body” or “white body” tiles. Table 3.1 displays the different tile classifications.

Table 3.1 Ceramic and Glass Tile Types[1]

Tile Type		Description
Ceramic	Porcelain	• Ceramic tile with water absorption of 0.5% or less.[2] • Must be made with porcelain-grade clays and raw materials and fired in kilns set to firing temperatures of approximately 2000 °F to 2300 °F (1093 °C to 1260 °C). • May be pressed or extruded.
	Pressed Floor Tile Red Body	• Primarily used on floors but can also be used for walls and countertops. • Manufactured by having the body of the tile formed by pressure. • Can be vitreous, semi-vitreous, or non-vitreous.
	Pressed Floor Tile White Body	• Primarily used on floors but can also be used for walls and countertops. • Manufactured by having the body of the tile formed by pressure. • Can be vitreous, semi-vitreous, or non-vitreous.
	Glazed Wall Tile Red Body	• Non-vitreous and intended for use on walls.
	Glazed Wall Tile White Body	• Non-vitreous and intended for use on walls.
	Quarry	• Water absorption up to 5% and formed by an extrusion process from natural clay or shale.
Glass		A tile having an overall non-crystalline microstructure with SiO_2 as the primary constituent and manufactured by one or more of three primary processes: cast, fused or low temperature-coated (ANSI, 2014).

°F degrees Fahrenheit
°C degrees Celsius
≤ less than or equal to
> greater than

1 Mosaics were not included within this table because they are smaller cuts of various tile types.
2 Water absorption is defined as the percentage of weight a tile gains when water soaks into the body and is an indication of the porosity of the tile. The industry generally recognizes 4 categories of water absorption capacity: impervious (≤0.5%), vitreous (0.5 – 3%), semi-vitreous (3 – 7%), or non-vitreous (>7%).

Sources:
ANSI. 2014. *ANSI A137.2-2013 American National Standard Specifications for Glass Tile*. Washington, DC: American National Standards Institute.
ANSI. 2017. *ANSI A137.1-2017 American National Standard Specifications for Ceramic Tile*. Washington, DC: American National Standards Institute.
UL Environment. 2014. *Ceramic Tile, Industry-wide Report Products Manufactured in North America, Environmental Product Declaration*. Marietta, GA: UL Environmental. Retrieved from http://www.tcnatile.com/images/pdfs/EPD-for-Ceramic-Tile-Made-in-North-America.pdf.

According to TCNA, approximately 3 billion square feet (ft^2) (280 million square meters [m^2]) of ceramic tile are purchased annually in the United States and used in multiple applications in commercial and residential buildings (TCNA, 2018). To meet this demand, manufacturers produce tile in numerous sizes, textures, and colors to appeal to consumer taste, style, preference, and trends (ANSI, 2018). Trends in tile are primarily aesthetically driven. The most commonly sold colors are neutral or earth tones. National retailers report that their top selling tiles are various shades of white, grey, and brown. Guidance on choosing tile is readily available to consumers on the internet and is consistent with the top sellers reported by retailers.[3] For example, soft hues and neutral colors are said to make a space feel big and hence are recommended for small spaces.[4]

3.3 COMPOSITION OF TILE

Tile products generally consist of 2 major components, the body and the surface application (UL Environmental, 2014). The body of the tile is largely made up of clay and other raw materials such as sand, scrap tile material from prior production, and silicate minerals (UL Environmental, 2014). The surface application of a tile typically consists of glaze and/or stain. Through the firing process the body and surface application fuse into a single material (ANSI, 2017).

Our literature search identified information on the composition of tile, and we further examined the composition of the raw materials from which most tile is made. Clays are primarily mixtures of amorphous minerals composed of aluminum, silicon, and oxygen, as well as crystals of quartz and other materials (Nayak and Singh, 2007; Alloway, 2013). Sand does not have a defined mineral composition, but its primary component is silica in the form of quartz (USGS, 2000). Tile production also uses various silicate minerals including feldspar, nepheline, granite, pyrophyllite, wollastonite, talc, and kaolin (UL Environmental, 2014). Minerals are categorized as silicate when the molecular composition contains silicon and oxygen (Panchuk, 2017).

Glaze is a thin, usually smooth, coating that is applied to tile products prior to being fired in a kiln to enhance performance or add color and other aesthetic properties (UL Environmental, 2014). The glazing materials are composed of water, glass frits, minerals, opacifiers, pigments, and/or stains (Casasola et al., 2012). The glaze is applied by pouring, spraying, printing, as well as other methods and then firing the tile to form a decorative layer (TCNA, 2006; American Tile & Stone, 2017).

3.4 TILE INSTALLATION

Tile installation consists of numerous tasks including cleaning and preparing the surface to be covered, measuring and cutting tile to fit the space, arranging or setting tile, applying grout, applying finishes, and clean up (BSL, 2015). Of these duties, the task of cutting tile poses the greatest potential for exposure to constituents in tile. Tile cutting releases dust by removing a narrow section of tile with a motorized tool or fracturing the tile with a manual cutter such as a score and snap cutter, i.e., “snap cutter.”

To understand the different methods of tile cutting, we reviewed literature and regulations, and conducted interviews with professionals in the tile industry. The interviewees included Five Star

[3] We reviewed tile selection guidance available at Wayfair.com and Lowes.
[4] We reviewed tile selection guidance available at Wayfair.com, homedit.com, and thespruce.com.

certified contractors, professional tile installers, and representatives of TCNA, the National Tile Contractors Association, and the Ceramic Tile Education Foundation.

Multiple tools are used to cut tile. The types of tools discussed in the literature are water (wet) saws, snap cutters, nippers, hole cutters, hole saws, drills, and grinders (Meehan and Meehan, 2005; Schweit and Nicholas, 2008; Home Improvement Group, 2010). The selection of a tile cutting tool is dependent on the type and dimensions of tile being cut, the type of cut being made, and preference of the installer. Manual cutters such as snap cutters and nippers are used to make simple straight and curved cuts on a variety of tile types (Schweit and Nicholas, 2008). Wet saws are well suited for making more intricate cuts such as miters or inside cuts, and working with stone, porcelain, and glass tiles (Meehan and Meehan, 2005; Schweit and Nicholas, 2008). Motorized dry cutting tools such as hole saws, drills and grinders are used less frequently and are generally limited to making curved and hole cuts in tile, usually to accommodate plumbing fixtures and pipes (Schweit and Nicholas, 2008). Overall, snap cutters and wet saws are the most frequently referenced tools for tile cutting in professional tile handbooks and job descriptions for tile installers (Meehan and Meehan, 2005; Schweit and Nicholas, 2008; Home Improvement Group, 2010; BSL, 2015).

Information on tool use gathered during our interviews with experts in the tile industry and tile installers was consistent with the literature. Interviewees indicated that most cuts required during a tile job can be completed with a snap cutter and/or a wet saw. They also indicated that snap cutters and wet saws are the most frequently used and preferred tile cutting tools. Interviewees also reported that motorized dry cutting tools are used infrequently, with uses limited primarily to specialized cuts that are often performed outdoors. Additional information from the interviews is presented in Section 6.

Information on tools used to cut tile is also available from the U.S. Occupational Safety and Health Administration (OSHA) standard for crystalline silica (OSHA 29 CFR 1926.1153). In that standard, OSHA recommends types of tools, work locations, and in some cases personal protection equipment, for cutting materials that contain crystalline silica. For example, the standard identifies motorized cutting with an integrated water delivery system, i.e., wet saw, as a method that produces exposure concentrations of respirable crystalline silica below levels that indicate the need for exposure monitoring (OSHA 29 CFR 1926.1153).

3.5 RELEVANT PRIOR STUDIES

We searched the peer-reviewed scientific literature and government or industry-sponsored research to identify sources of information relevant to assessing human exposure to respirable crystalline silica in tile. We then examined the utility of that information for identifying concentrations of crystalline silica in tile and assessing the level of tile-related exposure to respirable crystalline silica for the average Californian who installs tile.

3.5.1 Occupational Exposures / Concentrations

We identified and reviewed multiple studies relevant to cutting construction materials containing crystalline silica to help develop our study design. One study conducted by OSHA focused on occupational exposures to crystalline silica among U.S. workers in different occupational fields. Researchers determined that the arithmetic mean 8-hour time-weighted average (TWA) exposure to respirable crystalline silica among tile, marble, and mosaic workers was 0.036 milligrams per cubic meter (mg/m^3) (Yassin et al., 2005). Notably, the measurements reported in this study are not specific to tile, but also include exposures for people working with natural stone materials. Nonetheless, the occupational exposure concentrations available in this paper were useful for understanding the approximate level of the respirable crystalline silica concentrations in typical workplaces where tile is being installed.

A study conducted by National Institute for Occupational Safety and Health (NIOSH) assessed exposures of roof installers to respirable crystalline silica during dry cutting and installation of cement roof tile (Hall et al., 2013). The continuous monitoring of particulate matter indicated that approximately 17% of particulate matter generated during dry cutting of cement roof tiles was in the respirable size fraction. The 8-hour personal breathing zone respirable crystalline silica concentrations ranged from 0.04 mg/m^3 to 0.44 mg/m^3 (40 to 440 micrograms per cubic meter [$\mu g/m^3$]). The percent weight of crystalline silica (quartz) of respirable particulate matter ranged from 9.5 to 21.7%. Quartz concentrations in bulk samples of the roof tiles ranged from 13 to 24% weight; other forms of crystalline silica (cristobalite and tridymite) were not detected. Although not specific to installation practices of ceramic or glass tile, the information on concentrations of airborne crystalline silica associated with cutting these construction materials was helpful for selecting sampling methods for our research.

3.5.2 Emission Rates

In another published study, investigators from NIOSH evaluated emission rates for respirable particulate matter and respirable crystalline silica from cutting fiber-cement siding in a laboratory-based test duct (Qi et al., 2016). They quantified the emission factor (EF) as the amount of particulate matter generated per standardized cut of cement board in a chamber, accounting for the flow rate and volume of the chamber, the sampling time during the cutting, and the width and number of cement boards that were cut. In addition to characterizing the emission rates, these authors demonstrated that emissions of respirable crystalline silica were proportional to the concentration of crystalline silica in the cement board.

Exposures to respirable dust and respirable crystalline silica have also been evaluated in relation to the type of tool used to cut stone, cement, and related materials. One study measured a 91% reduction in respirable crystalline silica exposure during block and brick cutting when using a stationary wet saw compared to dry cutting with no control (Meeker et al., 2009). Another study found respirable particulate matter concentrations generated from cutting curbs and slabs with a wet saw were at least 90% lower than concentrations generated from a motorized dry saw with no control system (Thorpe et al., 1999). In a controlled study of emissions generated by cutting cement roof tile, the authors reported that use of a wet saw reduced respirable particulate matter concentrations by 99% compared to a motorized dry saw (Carlo et al., 2010). According to OSHA's exposure profile for stationary masonry saws, wet cutting masonry resulted in a mean 8-hour TWA respirable crystalline silica exposure concentration of 34 $\mu g/m^3$ compared to a mean respirable crystalline silica exposure concentration of 329 $\mu g/m^3$ from dry cutting operations (Federal Register, March 25, 2016).

3.6 SUMMARY AND CONCLUSION

As described above, our search of the scientific literature did not identify any studies that specifically characterized exposures associated with installation of tile. However, the information did indicate that emissions and exposure concentrations are likely to be strongly related to the method used to cut tile. We also concluded that the information available at this time was not adequate for assessing potential exposures to respirable crystalline silica in tile for the average Californian who installs tile. However, the prior research was useful for identifying exposures of interest and evaluating alternative approaches for gathering information specific to tile. Information from the literature was also useful for selecting exposure scenarios to include in our research. As a result, we focused on developing EFs for respirable crystalline silica during motorized and manual tile cutting. The EFs provide a means for applying exposure modeling to different exposure scenarios to estimate lifetime average daily exposure and associated cancer risk of respirable crystalline silica.

4.0 SCOPE OF THE ASSESSMENT

In this section of the report, we describe the scope and objective of the risk assessment in the context of the background information presented above.

Tile products are non-friable and as a result, there is no inhalation exposure to respirable crystalline silica from installed tile. During installation, however, cutting tile can release respirable size particles of tile into the air. The particles provide a pathway of potential exposure to chemical substances in tile, such as respirable crystalline silica. Respirable crystalline silica is identified as a human carcinogen in the scientific literature and by numerous regulatory and other authoritative organizations.

People in proximity to tile cutting have the greatest potential to be exposed to respirable particles generated from tile. This population includes people who cut tile and people who spend time near where tile is being cut. For those reasons, our assessment focused on professional and non-professional tile setters.

The U.S. Department of Labor (DOL) identifies professional tile setters by occupational code 47-2044 (BSL, 2018a). People in this occupation prepare surfaces to be covered, measure and cut tile to fit the space, arrange or set tile, apply grout, apply finishes, and clean up (BSL, 2015). Statistics published by DOL indicate that 7,150 professional tile setters worked in California in 2017 (BSL, 2018a).

Non-professional tile setters are people who set tile but are not employed in the field. A representative sample of the United States for calendar year 2015, the latest data available, indicated that 1.4% of owner-occupied households completed a non-professional bathroom renovation or remodeling project in the prior year (Census Bureau, 2015). Not all of these projects would necessarily involve cutting or setting tile. If they did, however, non-professionals would set tile in approximately 106,500 California households each year (Census Bureau, 2017). On average, 2.95 people live in each California household (Census Bureau, 2017). Tile installation could be completed by 1 or more people living in each household. In consideration of the average number of residents per household, our base case analysis assumed that 2 non-professionals participated in each tile installation on average. Based on that value, approximately 213,000 non-professionals in California install tile each year while completing a home renovation or remodeling project.

These 2 groups, the professionals and non-professionals, comprise the population of people who install tile in California. For that population, we assessed potential risks of cancer associated with lifetime average exposure to respirable crystalline silica in tile during installation following standard methods for human health risk assessment (USEPA 2009; WHO 2010).

5.0 HAZARD CHARACTERIZATION

OEHHA and USEPA publish quantitative estimates of cancer potency for specific compounds. These guideline values represent conservative, i.e., health protective, estimates of the potential risk of cancer per unit of exposure averaged over a lifetime (Castorina and Woodruff 2003; USEPA 2018).

However, neither OEHHA nor USEPA has developed a cancer potency value or No Significant Risk Level (NSRL) for respirable crystalline silica. Instead, the guideline value for cancer potency used in our analysis was obtained from reports published by OEHHA related to 2 prior SUDs. One of those SUDs was submitted by the National Paint and Coatings Association for respirable crystalline silica in interior flat latex paint (OEHHA, 2003). The other SUD was prepared by the Sorptive Minerals Institute for respirable crystalline silica in sorptive mineral-based pet litter (OEHHA, 1999). The cancer potency value also known as inhalation unit risk (IUR) for respirable crystalline silica reported in the latex paint and pet litter SUDs ranged from 6.8×10^{-7} to 1.85×10^{-5} per $\mu g/m^3$ (Goldsmith et al., 1995). To be health protective, we used the more conservative upper bound IUR value of 1.85×10^{-5} in our analysis (Goldsmith et al., 1995).[5]

[5] The USEPA defines inhalation unit risk as "the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air." Source: https://ofmpub.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do?details=&glossaryName=IRIS%20Glossary

6.0 EXPOSURE ASSESSMENT

6.1 OVERVIEW

We evaluated several different approaches to assess potential tile-related exposure to respirable crystalline silica. Ultimately, we chose to employ a microenvironmental modeling approach that combines information on respirable crystalline silica emissions during tile cutting and exposure factors for tile setters. We developed inputs for the model from interviews of tile setters, measurements of chemical concentrations in commonly sold tile products, controlled experiments to quantify emissions of chemicals when a tile is cut, and searches of the relevant literature. We corroborated the modeling results with observations and measurements made at construction sites during times when tile was being installed.

6.2 EXPOSURE FACTORS

In this section of the report, we describe the results of the interviews conducted to develop exposure scenarios and exposure factors.

To gather information on exposure scenarios and exposure factors, we interviewed a representative from each of 18 companies that in total employ 830 tile setters and tile helpers. The companies install tile in California and 17 other states including: Arizona, Florida, Georgia, Idaho, Illinois, Indiana, Michigan, Minnesota, Mississippi, Nevada, New Jersey, North Carolina, Pennsylvania, Texas, Utah, Virginia, and Wisconsin. The responses represent the average tile setter at each company.

We collected exposure factor inputs such as frequency of tool use, time spent in various tile-related microenvironments, and the years, weeks, days, and hours spent setting tile over a lifetime. We utilized the information obtained from interviews to develop exposure factor inputs for characterizing lifetime average daily exposure.

Over the course of a job, tile setters spend time in 3 main microenvironments; the installation site, the adjacent room (indoor cutting area), and outdoors. The tile setting area is the space where the tile is being installed. The indoor satellite cutting area is a space adjacent to the tile setting area, where tile setters generally locate and operate stationary tools such as a wet saw. When conditions permit, tile setters occasionally use motorized cutting tools in outdoor locations as indicated in the table. A summary of the information on tool use and microenvironmental time-location patterns obtained from our interviews is shown in Tables 6.1 and 6.2.

All interviewees reported using snap cutters and wet saws on a regular basis. Because these tools are used daily at work, the interviewees were able to provide precise information on the frequency and location with which they used snap cutters and wet saws. For example, snap cutters are always used in the installation site, directly adjacent to the work of the tile setter because they are compact and produce minimal dust. Wet saws are typically set up in 1 location, which does not usually change throughout the day. They can be set up in the installation site but because of their size are generally used in a room adjacent to the tile installation or outside.

Interviewees reported using handheld tools, such as core bits, nippers, and angle grinders, less frequently than wet saws and snap cutters. Several of the interviewees indicated they only use 1 or 2 types of handheld tools. For example, 6 interviewees representing 570 installers said they do not use angle grinders at all. Consequently, we had fewer responses to analyze for handheld tools than for wet saws and snap cutters. Distinct use patterns were evident for handheld tools nonetheless. Principally, handheld motorized cutting tools, with or without dust control systems in place, are most commonly used outdoors or an indoor space near the installation area.

Table 6.1 Relative Frequency of Tools Used to Cut Tile[1]

Cutting Method	Tool	Percentage of total cuts with each tool
Manual Cutting	Snap Cutter	76%
	Nippers	0.25%
Wet Cutting	Wet Saw	17.5%
	Angle Grinder with Wet Sponge	0.4%
	Core bit with Wet Sponge	2%
Dry Cutting	Angle Grinder	1%
	Core bit	0.15%
Dry Cutting with control other than water	Stationary Saw with Dust Capture	1%
	Angle Grinder with Dust Shroud	1.7%
Total		100%

1 Based on interviews of professional tile installers as well as literature on tile installation referenced in Sections 3 and 6 of this report.

Table 6.2 Location of Tool Use[1]

Cutting Method	Tool	Percentage of Uses by Microenvironment[2]		
		Installation Site	Adjacent Room	Outside
Manual Cutting	Snap Cutter	100%	0%	0%
	Nippers	100%	0%	0%
Wet Cutting	Wet Saw	5%	50%	45%
	Angle Grinder with Wet Sponge	15%	35%	50%
	Core bit with Wet Sponge	10%	50%	40%
Dry Cutting	Angle Grinder	15%	30%	55%
	Core bit	20%	30%	50%
Dry Cutting with control other than water	Stationary Saw with Dust Capture	25%	35%	40%
	Angle Grinder with Dust Shroud	10%	50%	40%

1 Based on interviews of professional tile installers as well as literature on tile installation referenced in Sections 3 and 6 of this report.
2 Rows total to 100 percent.

To gather information on the typical amount of tile cut during an installation, we asked tile professionals about 2 common types of tile installations: bathrooms and kitchens. For a bathroom with 50 square feet of floor tile and 150 square feet of wall tile, interviewees reported that on average this space would require approximately: 2.75 days for an individual installer to complete (22 hours), 60 lineal feet of tile cut, and 2 hours of cutting. On average, for a room with 200 square feet of floor tile, interviewees reported that the space would require approximately: 1.75 days to complete (14 hours), 50 lineal feet of tile cut, and 1.1 hours of cutting.

Inputs for the lifetime frequency and duration of tile setting work for professional and non-professional tile setters were gathered from interviews. Professionals generally reported spending 25 years in the field; 3 as a helper and 22 as a tile setter. On average, they work 49 weeks per year, 5 days per week, and 7.5 hours per day.

In contrast, non-professionals set tile much less frequently than professionals. As noted in Section 4, data from the U.S. Census Bureau indicate that bathrooms are renovated or remodeled in approximately 106,500 owner-occupied households per year in California. To be conservative, we assumed that new tile is set on the floor and walls of the room for each renovation and remodeling job. This input will lead to overestimates of actual exposures because some remodeling and renovation jobs consist solely of installing natural stone or replacing plumbing fixtures, cabinetry, paint, or wallpaper. The census data are silent on the number of tile jobs that a non-professional tile setter will undertake over their lifetime. To fill that information gap, we made a set of reasonable, but conservative assumptions. First, we assumed that non-professionals perform an average of 1 tile setting job in each residence that they occupy. According to human activities exposure factors published by USEPA, Americans relocate their residence every 12 years on average (USEPA, 2011). We further assumed that non-professionals set tile between the ages of 18 and 68, a period of 50 years. Combining these assumptions, we estimate that the average non-professional tile setter completes 4.2 projects, which we rounded up to 5, over their lifetime. We also conducted a sensitivity analysis in which the average non-professional completed 1 tile installation job every year for 50 years.

6.3 EXPOSURE CONCENTRATIONS

6.3.1 Overview

In this section of the report, we describe the tile products and the process used to characterize exposure concentrations.

6.3.2 Tile Inventory

Through TCNA, we requested that manufacturers in Italy, Mexico, and the United States provide us with samples of their most commonly sold porcelain, pressed floor red body, pressed floor white body, quarry, wall tile red body, wall tile white body, and glass tile products. Table 6.3 displays a summary of the number of unique tile products we received by tile type.

Table 6.3 Number of Tile Products Received by Tile Type

Tile Type	Total by Type
Glass Tile	6
Porcelain Tile	13
Pressed Floor Tile Red Body	8
Pressed Floor Tile White Body	2
Quarry Tile	9
Wall Tile Red Body	3
Wall Tile White Body	6
Total	47

In addition to representing 7 different types of tile, the tile products received had diverse physical characteristics. Tiles ranged in size from 0.0026 to 2.7 ft^2 (0.00024 to 0.25 m^2) with a median of 0.94 ft^2 (0.087 m^2). The tile products also varied in thickness from 0.21 to 0.50 inches (in) (0.53 to 1.27 centimeters [cm]). As illustrated by the photo in Figure 6.1, the collection of tile products gathered for this research consists primarily of neutral tones and is consistent with the "top sellers" described above in Section 3.2.

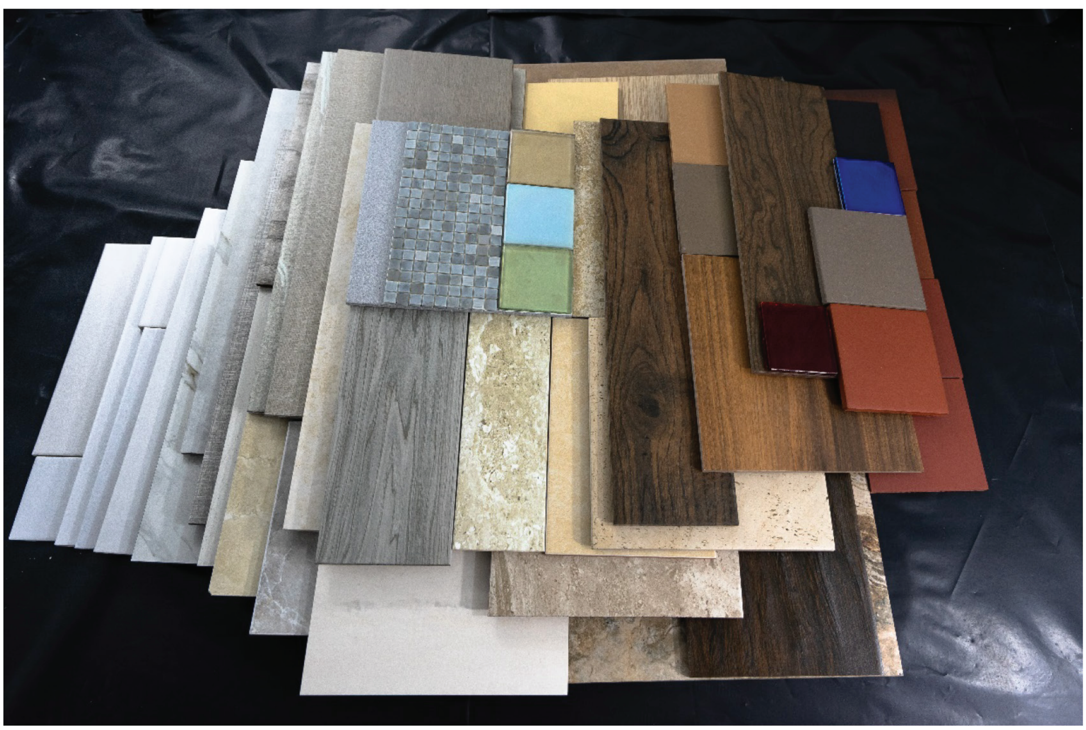

Figure 6.1 Photograph of Tile Inventory Representing Products for Research

6.3.2.1 *Analytical Method for Crystalline Silica in Tile*

We selected 2 to 5 products from each type of tile for chemical analysis. We removed 12 square inches (77.42 square centimeters) from the corner of 1 tile of each product to obtain a bulk sample that would result in approximately 60 milliliters of dust after being pulverized to be suitable for analysis. For quality control purposes, a replicate section of tile was obtained from 3 of the products to create duplicate samples, which received the same analysis as the primary sample.

The sections of tile were shipped to the National Brick Research Center at Clemson University (Anderson, South Carolina) and pulverized in a puck mill to a nominal grain size of 200 micrometers (µm). The pulverized tile samples were shipped to Liberty Mutual Industrial Hygiene Laboratory (Liberty) (Hopkinton, Massachusetts) for analysis.

A subsample of the pulverized tile was analyzed at Liberty for concentrations of crystalline silica according to NIOSH 7500. Prior to analysis, the pulverized tile was screened with a 10 µm sieve to obtain respirable sized particles. The samples were weighed and then transferred to small glass vials, mixed with isopropanol, and sonicated to disperse the sample. The samples were then deposited onto silver membrane filters and assayed for crystalline silica (quartz, cristobalite, and tridymite) by X-ray diffraction (XRD).

When testing samples for crystalline silica, a qualitative XRD scan is done to determine the presence of silica polymorphs by their characteristic diffraction peaks. Liberty's XRD analysis for every sample includes diffraction angle scans in a "low region" (20 to 22.5°) and a "high region" (26 to 27.5°). The primary diffraction peaks for quartz are detectable in the high region and the primary diffraction peaks for cristobalite and tridymite are detectable in the low region. Tridymite is an uncommon form of crystalline silica; therefore, Liberty's standard practice is to conduct a qualitative XRD scan for the presence of tridymite and follow up with further analysis if present in the sample. Quartz and cristobalite were further quantified by XRD in accordance with NIOSH Method 7500. The detection limits were 0.02% weight for cristobalite and quartz in bulk samples.

6.3.2.2 Analytical Results for Crystalline Silica in Tile

We analyzed a total of 28 samples of tile, including 25 primary samples and 3 duplicate samples, for 3 forms of crystalline silica. Crystalline silica in the form of quartz was detected in all but 4 of the 25 (85%) tile samples, with glass tile being the exception. Cristobalite and tridymite, less abundant forms of crystalline silica, were not detected in any of the tile products. The detected concentration of quartz ranged from 7.6 to 25% weight.

6.3.2.3 Survey of Tile Manufacturers

We administered surveys to tile manufacturers in North America and Italy to collect information of the content of silica (SiO_2) in ceramic tile. Tile manufacturers obtain information on the total silica content (including amorphous and crystalline silica) of tile products for quality control. We received 164 survey responses. The median concentration of silica (including amorphous and crystalline forms) reported by tile manufacturers was 70% weight.

6.3.3 Emissions Tests

6.3.3.1 Overview

In this section of the report, we describe the process used to characterize emissions of crystalline silica in air during cutting of tile. Here, we provide a brief overview of the methods that are detailed in the remainder of this section.

We conducted simulations of tile cutting and analyzed the data from the simulations to determine emissions of crystalline silica. The simulations focused on particulate matter emissions generated by tools that are representative of use practices of tile installers and are also permitted by the OSHA respirable crystalline silica standard; specifically, an electric-powered wet saw and a manually operated snap cutter. The experimental design was adapted from approaches recommended by governmental organizations, such as the California Department of Public Health, for evaluating chemical emission rates from surface finish materials in buildings (OEHHA, 2003; OEHHA, 2016).

We developed EFs (emissions per standard tile cut) for crystalline silica in respirable particulate matter. The objective of this analysis was to assess the feasibility of estimating potential inhalation exposure concentrations based on the crystalline silica composition of a tile product.

6.3.3.2 Experimental Design for Emissions Tests

We quantified airborne emissions of respirable particulate matter during the cutting of tile products for which we also determined the concentrations of crystalline silica. A brief description of the experimental design and methods are provided here.

The testing was conducted in a 23.1 cubic meter chamber (Clean Air Products Inc., Model CAP591) located at EH&E's facility in Needham, Massachusetts. The chamber is finished with painted aluminum walls and linoleum floor tiles. A small oscillating fan, set to high, was operated within the chamber to promote mixing. A second fan, referred to as the make-up air fan, was used to draw air into the chamber at a flow rate of 5.8 cubic meters per hour, which provided an air exchange rate (AER) of 0.25 per hour.

Emissions were characterized during cutting of tile with both a wet saw and a snap cutter. The model of the wet saw was a MK Diamond HD-101R tile saw, which was rented from a home improvement store that has operations in most of the United States and offers similar rentals, if not the same equipment. The wet saw was fitted with a new Ridgid 10-in Premium Tile Diamond Blade. The model of the snap cutter was a QEP 10600BR 24-in Brutus, which was also rented from a home improvement store. We determined the wet saw and snap cutter used for the trials were representative of cutting tools utilized by professional tile installers indicated from our interviews. In addition, these cutting tools are readily available for rental from common home improvement stores for use by non-professional tile installers.

The length of tile cut and frequency of cuts made during each trial was designed to produce concentrations of respirable dust that were quantifiable with a continuous-reading nephelometer (DRX Aerosol Monitor 8533, TSI Inc.) over the course of each test. The wet saw trials were also designed to yield quantifiable concentrations of crystalline silica in time-integrated respirable dust samples that were collected over the duration of each trial. Based on the results of pilot testing conducted to inform the ultimate protocols, trials involved cutting 1 foot (0.30 m) of tile (if possible) every minute for a total of 25 minutes with the wet saw and every 30 seconds over 30 minutes with the snap cutter. This methodology was chosen because we could reach steady state in the chamber relatively quickly and collect a quantifiable concentration of crystalline silica in respirable particulate matter samples.

6.3.3.3 Analytical Method for Respirable Crystalline Silica

Particles in the respirable size range were deposited onto pre-weighed PVC filters using Sensidyne FSP-10 large capacity size selection cyclones in accordance with NIOSH 0600. Samples were shipped to Liberty and analyzed for particle mass concentrations and crystalline silica content according to NIOSH 7500. The filters were first weighed for gravimetric determination of respirable particulate and then placed into crucibles and ashed at 600 °C in a muffle furnace. The residual material was mixed with isopropanol, sonicated to disperse the samples, and deposited onto a silver filter membrane and assayed for quartz, cristobalite, and tridymite by XRD. The detection limit for respirable particulate was 1.8 x 10^{-4} mg/m^3. The detection limit for cristobalite and quartz was 3.5 x 10^{-5} mg/m^3.

6.3.3.4 Analytical Results for Respirable Crystalline Silica During Wet Saw Cutting

During 26 tile cutting trials with the wet saw, we collected a total of 30 filter samples (20 primary samples and 10 duplicates). Filter samples were analyzed for respirable dust and 3 forms of crystalline silica in the respirable particle size fraction. Crystalline silica in the form of quartz was detected in all the samples of respirable dust. Cristobalite and tridymite, less abundant forms of crystalline silica, were not detected in any of the samples. Crystalline silica in the form of quartz was present in respirable particulate matter with detected concentrations ranging from 4.9 to 22%.

6.3.3.5 Analytical Results for Respirable Crystalline Silica During Snap Cutting

During 6 tile cutting trials with the snap cutter, we collected a total of 10 filter samples (6 primary samples and 4 duplicates). Filter samples were analyzed for respirable particulate matter and 3 forms of respirable crystalline silica. The concentration of respirable particulate matter was only detected for 1 out of the 6 tile cutting trials using the snap cutter. Quartz, cristobalite, and tridymite were not detected in any of the filter samples.

6.3.4 Quality Assurance

Our technical teams made planned efforts in each phase of the project to ensure completeness and accuracy of data collection, analytical methods, data entry, calculations, and reporting of results. David L. MacIntosh, Sc.D., C.I.H., Principal Investigator, was responsible for technical oversight of the overall project and for ensuring that high data quality objectives were met by the project team.

All sampling and analytical procedures for the project utilized appropriate and valid monitoring procedures approved and recommended in relevant published sources from regulatory agencies, such as OSHA and NIOSH (refer to Table 6.4).

Table 6.4 Sampling Equipment and Analysis Method by Exposure Measure

Sample Type	Sampling Equipment	Analysis
Temperature and Relative Humidity	Q-Trak Indoor Air Quality Monitor 757 (TSI Incorporated, Shoreview, MN)	Not applicable; direct read device
Area RPM	Particulate matter Trak DRX Aerosol Monitor 8533 with a heated inlet (TSI Incorporated, Shoreview, MN)	Not applicable; direct read device
Crystalline Silica in Tile	Bulk Sample (National Brick Research Center at Clemson University, Anderson, SC, & Liberty Mutual Industrial Hygiene Lab, Hopkinton, MA)	NIOSH 7500
Respirable Crystalline Silica in Air	PVC 3-piece cassette, 37 mm pre-weighed with Sensidyne FSP-10 large capacity size selection cyclone and GAST high flow rate pump (Liberty Mutual Industrial Hygiene Lab, Hopkinton, MA)	NIOSH 7500
Respirable Particulate Matter in Air	PVC 3-piece cassette, 37 mm pre-weighed with Sensidyne FSP-10 large capacity size selection cyclone (Liberty Mutual Industrial Hygiene Lab, Hopkinton, MA)	NIOSH 0600

RPM Respirable Particulate Matter
NIOSH National Institute for Occupational Safety and Health
mm millimeter

Source:
NIOSH. 1994. *NIOSH Manual of Analytical Methods* (NMAM) Fourth Edition. Washington, DC: Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

The quality assurance program included criteria for determining acceptable data quality, sampling handling and custody procedures, calibration and performance evaluation procedures, and data reduction and reporting procedures. We checked sample log sheets against chain of custody forms, reviewed chamber and laboratory blank results, checked instrument and laboratory reports against chain of custody forms and field notes, checked compiled data against laboratory reports, screened compiled data for improbable extreme values, generated preliminary plots of results by sample for review, and checked units in compiled data against units in field instrument and laboratory reports. If differences were found between 2 or more data sources, we evaluated the available records to determine which source was correct.

As part of the quality assurance program, we assessed blank values and method precision. Precision, as the root mean square error of duplicate measurements, was targeted to be less than or equal to 30%. The level of precision for analyzed metals in tile and inhalable particulate matter met the target of less than or equal to 30%.

6.3.5 Emissions Analysis

6.3.5.1 Overview

We analyzed data generated from the measurements of bulk tile and measurements during the tile cutting trials to derive EFs for respirable crystalline silica when cutting tile with a wet saw and a snap cutter. In brief, we fit data from the chamber tests to a first-order compartment model to determine emission rates of respirable particulate matter while cutting tile. Because tiles of different lengths and thicknesses were cut during the trials, we standardized the emissions to a fixed length of cut and thickness of tile following the methodology used by NIOSH when characterizing respirable crystalline silica emissions from cutting cement board (Qi et al., 2016). We defined a standard cut as a 1-foot (0.30-m) long cut of a 3/8-inch (0.95-cm) thick tile. We calculated emissions of respirable crystalline silica by multiplying the respirable particulate emissions by the corresponding concentrations of crystalline silica. In the final step of the analysis, we examined the relationships of crystalline silica concentrations in bulk tile with the corresponding emissions to develop EFs for a standard cut of tile. Details of this analysis are provided in the remainder of Section 6.3.5.

6.3.5.2 Emission Rates

As expected, plots of particulate matter data from the chamber tests demonstrated that respirable particulate matter concentrations during each trial increased approximately linearly initially and then approached steady-state levels during the trial. The pattern was consistent with accumulation according to first-order dynamics. We therefore used a first-order compartment model to calculate the emission rates of respirable particulate matter during each trial.

Before fitting the models, we calibrated the continuous particle readings made with the nephelometer. This calibration was necessary because although nephelometers are convenient for measuring airborne particle concentrations over short time scales, the mass concentrations reported by these devices are dependent upon the light scattering characteristics of the particulate matter being measured (Yanosky et al., 2002). To account for this effect, nephelometer readings are calibrated with collocated gravimetric measurements (TSI Incorporated, 2012). We used results from the filter samples to derive a calibration factor for calculating mass-based concentrations of particulate matter levels over time during each trial. The calibration factor was the ratio of the TWA particulate matter concentration determined gravimetrically to the corresponding TWA determined with the nephelometer.

After calibrating the continuous particle readings, we used non-linear least squares regression to fit the parameters of a first-order compartment model to data from the accumulation period of each test. The accumulation period was defined as the time over which tile was cut with the pre-specified length and frequency. The modeling software uses an iterative process to solve Equation 6.1 for emission rate and removal rate. Because particulate matter concentrations within the chamber reached levels that were at least 100-fold higher than background levels in the chamber at the start of each trial, C_o can be assumed to be effectively zero.

$$C_t = C_o + (\frac{ER}{k \bullet V})(1 - e^{-kt}) \qquad \text{(Equation 6.1)}$$

C_t airborne particulate matter concentration at time t (milligram per cubic meter, mg/m^3)
C_o background airborne particulate matter concentration (mg/m^3)
ER airborne particulate matter emission rate in the test chamber (mg per second, mg/s)
k airborne particulate matter removal rate estimated for each trial (per second)
V volume of the test chamber (m^3)
t time (seconds)

6.3.5.3 Emissions per Standard Cut

We followed methods reported in the literature to standardize the emission rates across the tile products to the material released during a 1-foot (0.30-m) long cut of a 3/8-inch (0.95-cm) thick tile first-order compartment model (Qi et al., 2016). These dimensions were selected to represent a typical tile. Emissions of respirable particulate per standard cut were calculated as shown in Equation 6.2.

$$E = \frac{ER}{f * l * h} \qquad \text{(Equation 6.2)}$$

E airborne particulate matter emission per standard cut (mg per 1-foot [0.30-m] of 3/8-inch [0.95-cm] tile)
ER airborne particulate matter emission rate in the test chamber (mg per second, mg/s)
f frequency of cuts (cuts per second)
l $\frac{\text{length of cut (ft)}}{\text{1 standard cut (12 in [0.30 m])}}$
h $\frac{\text{thickness of tile cut (in)}}{\text{1 standard cut (0.375 in [0.95 cm])}}$

After standardizing the particulate emissions for each trial, we then calculated the corresponding emissions of crystalline silica. We multiplied E for respirable particulate by the fraction of crystalline silica present in the sample of respirable particulate matter from that trial.

6.3.5.4 Emission Factors

The final step of the data analysis was to determine an EF for respirable crystalline silica when making a standard cut. An EF is a representative value that relates the quantity of a substance emitted to air with an activity that is associated with the emission (USEPA, 1995). For example, an EF for tile would describe the amount of silica released to the air per foot of tile cut. EFs are typically averages derived from the relevant and applicable data (USEPA, 1995). According to this framework, emissions for a constituent of tile are linearly related to the concentration of the constituent in bulk tile. In that case, the EF is the slope of the line between respirable crystalline silica emissions per standard cut and crystalline silica concentrations in tile.

We derived an EF for respirable crystalline silica. Respirable crystalline silica emissions and concentrations in tile fit key assumptions for linear regression, thus, we analyzed the relationship between the crude values for each. For example, emissions of respirable crystalline silica were approximately normally distributed for a given concentration of crystalline silica in tile and of approximately equal variance across the range of crystalline silica levels in tile, i.e., homoscedastic. We then used ordinary least squares regression to derive an EF for respirable crystalline silica as well as to characterize the strength of the association between the emissions and concentrations in tile.

6.3.6 Tool-Specific Concentrations

We used a standard one-compartment model to characterize steady-state concentrations of respirable crystalline silica in indoor air of tile installation work spaces identified in Section 6.2. Exposure concentrations in outdoor areas were assumed to be zero. The form of the model and inputs to the model are shown in Equation 6.3.

$$C_t = \frac{S_t * x * y * \frac{1}{w}}{(k_{dep} + k_{AER})\, V} \qquad \textit{(Equation 6.3)}$$

C_t steady-state concentration of respirable crystalline silica in air for cutting tool *t* (mg/m^3)
S_t emission of respirable crystalline silica per standard 1-foot cut using cutting tool *t* (mg)
x total number of 1-foot (0.30-m) cuts per tile job (ft/m)
y fraction of standard cuts made with cutting tool *t* (unitless)
w number of working hours per tile job (hours)
k_{dep} particulate matter deposition rate (per hour)
k_{AER} air exchange rate (per hour)
V volume of room (m^3)

Inputs to the exposure model were derived from measurements, scientific literature, and recommendations from OEHHA. The inputs to the exposure model are described below.

We developed the emission terms (S_t) in Equation 6.3 from simulations of tile cutting under controlled testing conditions. In brief, we found that emissions of respirable crystalline silica were directly related to their concentration in bulk tile. We also found that emissions differed by the type of cutting tool. We calculated tool-specific S_t for crystalline silica by multiplying the median concentration of crystalline silica measured in bulk tile by the corresponding tool-specific EF.

The total length of tile cut per installation, fraction of cuts made with each cutting tool, and number of working hours per tile job were determined from interviews of tile installers. We used a measured deposition rate (k_{dep}) of 3.6 per hour for the wet saw and 1.1 per hour for the snap cutter. We applied the same atmospheric deposition rates for respirable particulate matter measured during our testing of wet saws to handheld, powered cutting with no controls or with a dust shroud in our exposure concentration modeling. We used an air exchange rate (k_{AER}) recommended by USEPA of 0.45 per hour (USEPA, 2011). This value is conservative compared to a prior SUD for latex paint which used a value of 0.50 per hour (NPCA, 2002) and the median air exchange rate measured in California homes of 0.87 per hour reported in the scientific literature (Yamamoto et al., 2010).

Based on information from the interviews and observations from installation sites, each use of a stationary cutting tool, i.e., snap cutter, wet saw, and stationary saw with integrated shroud and vacuum for dust control, was estimated on average to make a 1-foot (0.30-m) long, straight or gently arced cut through the body of a tile. However, handheld tools such as angle grinders, core bits, and nippers, are used to make substantially different types of cuts.

The tile setters we interviewed indicated that they typically use handheld tools to shave or touch-up the edge of a cut made with another tool, or to make a curved cut to accommodate doorframes, cabinetry, or plumbing penetrations. Consider, for example, the cut-out for a standard 3/4-inch (1.91-cm) diameter shower or sink pipe surrounded by a 3-inch (7.63-cm) diameter flange. The cut-out for this penetration will necessarily be smaller than 1.5 inches (3.81 cm) in diameter with a corresponding circumference no greater than approximately 4.5 inches (11.43 cm). In comparison, touch-up work is generally limited to lengths of 1 to 2 inches (2.54 to 5.08 cm) or less. Therefore, touch-ups made with an angle grinder or nipper would remove even less tile material than a typical cut-out. Based on these considerations and to be conservative, we set the length of each cut made with a handheld tool to 6 inches (15.24 cm).

6.3.7 Tile Setting Microenvironments

Using the tool-specific emission rates and other results of the tile cutting research, we estimated steady-state concentrations of respirable crystalline silica in each microenvironment.

We summed the tool-specific results to obtain the exposure concentration for each tile setting work area or microenvironment (Equation 6.4), following the superposition principle.

$$C_n = \sum C_{ws} + C_{ss} + C_{ds} \qquad \textit{(Equation 6.4)}$$

C_n concentration of respirable crystalline silica in microenvironment i (µg/m^3)
C_{ws} concentration of respirable crystalline silica from wet saw emissions (µg/m^3)
C_{ss} concentration of respirable crystalline silica from snap cutter emissions (µg/m^3)
C_{ds} concentration of respirable crystalline silica from handheld power tool without dust control (µg/m^3)

6.3.8 Time-Weighted Average Concentrations

We calculated the time-weighted average exposure concentration for a tile setter as shown in Equation 6.5, following the standard microenvironmental modeling approach (USEPA, 2009).

$$EC = (\sum_{i=1}^{n} t_1 C_1 + t_2 C_2 + \cdots + t_i C_i) \qquad \textit{(Equation 6.5)}$$

EC 8-hr time weighted average exposure concentration (µg/m^3)
t fraction of time spent in microenvironment (refer to Table 6.5) (unitless)
C_n steady-state concentration of respirable crystalline silica in microenvironment i (µg/m^3)
n number of microenvironments (unitless)

The 3 microenvironments in our assessment included the installation site, adjacent room (indoor cutting area), and outdoors. We calculated the concentration of respirable crystalline silica in the installation site and adjacent room. Because tile installers position themselves away from dust produced by a cutting tool and because dilution is rapid outdoors, we assumed that exposure concentrations outdoors were negligible. The fraction of time spent in each microenvironment is shown in Table 6.5.

Table 6.5 Average Percentage of Time Spent in Tile Setting Microenvironments During a Tile Installation Project

Location	Helper	Setter
Installation Site	56%	81%
Adjacent Room	25%	6%
Outside	19%	13%

6.3.9 Lifetime Average Daily Exposure

We calculated lifetime average daily exposure (LADE) for tile-related inhalation exposures following guidance from USEPA for human health risk assessment (Equation 6.6) (USEPA, 2001).

$$\mathrm{LADE} = \mathrm{EC} \times \frac{\mathrm{ET} \times \mathrm{EF} \times \mathrm{ED}}{\mathrm{AT}} \qquad \textit{(Equation 6.6)}$$

LADE	Lifetime Average Daily Exposure (µg/m^3)
EC	Exposure Concentration (µg/m^3)
ET	Exposure Time (hours/day)
EF	Exposure Frequency (days/year)
ED	Exposure Duration (years)
AT	Averaging Time (hours)

We calculated LADE for the average Californian who installs tile as the population-weighted average of professional and non-professional tile setters in California. For professional tile installers, we used an exposure time of 7.5 hours per day, an exposure frequency of 245 days per year and an exposure duration of 25 years. For non-professional tile installers we used an exposure time of 7.5 hours per day, an exposure frequency of 2 days per year and estimated that non-professional tile installers complete 5 tile installations over a lifetime. As noted in Section 4, data from the U.S. Department of Labor indicates that 7,150 people in California install tile as a profession (BSL, 2018b). Similarly, based on data published by the U.S. Census Bureau, we conservatively estimated that 213,000 non-professionals install tile as part of 5 separate home renovation or remodeling projects over their lifetime (USEPA, 2011; U.S. Census Bureau, 2015; U.S. Census Bureau, 2017). We averaged exposure to respirable crystalline silica over a 70-year lifetime, recommended by the California Office of Human and Ecological Risk (HERO, 2014) and USEPA (USEPA, 2011).

7.0 RISK CHARACTERIZATION

To express cancer risk quantitatively, we followed standard methods and calculated excess lifetime cancer risk (ELCR) as the product of the LADE for respirable crystalline silica and its guideline value for cancer potency (Equation 7.1). We calculated ELCR for the population of tile setters in California.

$$\mathrm{ELCR} = \mathrm{LADE} * \mathrm{IUR} \qquad \text{(Equation 7.1)}$$

ELCR	Excess Lifetime Cancer Risk (unitless)
LADE	Lifetime Average Daily Exposure (µg/m^3)
IUR	Inhalation Unit Risk (per µg/m^3)

We compared the cancer risks to the threshold of 1 in a 100,000 (10^{-5}) for risk management established by Prop 65. Guideline values for cancer potency include science policy decisions that are intended to ensure that actual risks are not underestimated. As a result, for compounds with ELCR less than 10^{-5}, the exposure is not likely to be associated with a substantive increase in the probability of cancer. Similarly, an ELCR greater than 10^{-5} does not indicate that formation of a malignant tumor is imminent, but instead denotes conditions that may warrant additional evaluation of the risk posed by the substance (USEPA, 2018).

The potential LADE, IUR, and ELCR associated with respirable crystalline silica from our analysis for the average Californian who installs tile are shown in Table 7.1. The potential ELCR is 1.3 x 10^{-7}, or 0.013 per 100,000. This level of potential cancer risk is 75-fold below the threshold of 10^{-5} for ELCR under Prop 65.

Table 7.1 Potential Excess Lifetime Cancer Risk for Respirable Crystalline Silica from Tile Installation for the Average Californian who Installs Tile

Chemical	IUR (µg/m^3)$^{-1}$	LADE (µg/m^3)	ELCR
Respirable Crystalline Silica	1.85 x 10^{-5}	7.0 x 10^{-3}	0.013 in 100,000 (1.3 x 10^{-7})

IUR Inhalation Unit Risk Factor. Upper bound of cancer potency (Goldsmith et al., 1995)
µg/m^3 microgram per cubic meter
LADE Lifetime Average Daily Exposure
ELCR Excess Lifetime Cancer Risk

Source:
Goldsmith DF, Ruble RP and Klein CO. 1995. Comparative Cancer Potency for Silica from Extrapolations of Human and Animal Findings. *Scandinavian Journal of Work, Environment & Health* 21(Suppl 2):104-107.

8.0 DISCUSSION

The results of our human health risk assessment indicate that potential cancer risk associated with respirable crystalline silica tile-related exposures for the average California who installs tile is 75-fold below the Prop 65 threshold of 10^{-5}. This finding is based upon a robust set of information on work practices, measurement of emissions to air, and exposure concentrations that were developed from research conducted expressly for this assessment. We used inputs to the exposure and risk assessment recommended by OEHHA unless we had strong research-based evidence to rely upon. In some cases, however, certain types of detailed information were not available from OEHHA or USEPA. In those situations, we relied upon the scientific literature and best professional judgement to fill the information gap.

For example, OEHHA does not publish recommended exposure factors for installation of tile. In the absence of such data, we estimated that the average non-professional tile setter completes a room-scale tile installation project 5 times over their lifetime. This input was based on duration of residency data recommended by USEPA, the proportion of U.S. households that completed a “do-it-yourself” bathroom renovation or remodeling projects reported by the U.S. Census Bureau, and best professional judgement (refer to Section 6.2 for details). To evaluate the sensitivity of the risk assessment results to the input for number of tile installations completed over a lifetime, we re-calculated ELCR using an alternative worst-case input that non-professionals complete 1 tile setting project every year for 50 years. The resulting cancer risk for the population of tile installers in California increased approximately 40% over the baseline ELCR of 0.013 per 100,000, but was still more than an order of magnitude below the Prop 65 threshold of 10^{-5}, indicating that our base case findings are not sensitive to the tile installation frequency for non-professionals.[6]

Similarly, OEHHA does not have default values for the frequency with which the various types of tools are used to cut tile and the length of those cuts. To fill that gap, we gathered information on tool use and cuts from interviews of tile installers. To be conservative in the analysis, we assumed that each use of every handheld tool produced a 6-inch (15.24-cm) cut through the entire body of a tile. However, the tile setters we interviewed indicated that in practice, handheld tools are primarily used to shave the edge of a cut made with another tool or to make a curved cut to accommodate plumbing penetrations or corners of door frames and cabinetry. We made visits to multiple construction sites and our observations corroborated the responses from the interviewees. We expect that emissions to air will be lower when an angle grinder, core bit, and nipper are used in those ways compared to making a 6-inch (15.24-cm) long cut through the body of a tile. Had we incorporated a more realistic use case for handheld tools into our analysis,

[6] The resulting ELCR for respirable crystalline silica under the assumption of 50 tile installations over a lifetime for a non-professional tile installer is 0.018 per 100,000.

the potential ELCR for respirable crystalline silica would have been further below the Prop 65 threshold of 1 in 100,000.

We also used a conservative input to account for limited information available on the effectiveness of an integrated shroud and vacuum system for controlling emissions of respirable particulate from powered handheld cutting tools, such as an angle grinder. Specifically, we assumed that such a system has no efficacy for controlling emissions from handheld tools. In practice however, we expect that emission control technique has some efficacy for handheld tools. If a control efficiency greater than zero for integrated shroud and vacuum systems was incorporated into our analysis, the estimated exposures and cancer risks would be lower than our base case results.

OEHHA also does not provide default values for atmospheric deposition rates of respirable particles generated during tile cutting. To fill this gap, we relied upon data from our tile cutting testing. Even then, some information gaps remained, and we relied upon best professional judgment to develop the necessary inputs. For example, we applied the same atmospheric deposition rates for respirable particulate matter measured during our testing of wet saws to handheld, powered cutting with no controls or with a dust shroud in our exposure concentration modeling. The rationale for using the same deposition rate for wet saws and dry saws is supported by the literature on particle characteristics and removal processes. The deposition rate for particles is primarily based on the aerodynamic size and density of the particulate matter although it can also be affected by humidity if the particles are soluble in water (USEPA, 1998; Shaughnessy and Sextro, 2006). The aerodynamic size distribution of particles emitted while cutting tile is primarily determined by the cutting mechanism of the tool, i.e., motorized cutting with a diamond blade or scoring and manually snapping tile. Tile cutting with a motorized tool, using a diamond blade, releases particles by removing a narrow section of tile. The particles generated from different motorized cutting tools with a diamond blade should have approximately the same size distribution. Additionally, as crystalline silica is not soluble in water, the particle size distribution should not be affected by humidity associated with wet cutting (Kotz et al., 2008; Shaughnessy and Sextro, 2006). Based on these reasons, we determined from the literature that the deposition rate of particles generated from motorized cutting would not be affected by the controls in place such as water delivery or vacuum systems.

The exposure assessment conducted for this analysis indicates that tile-related concentrations of respirable particulate matter in locations where tile is set are strongly associated with the type of tool used to cut tile and the dust control systems used. This finding is consistent with the results of prior research conducted by other investigators. For example, wet cutting, i.e., motorized cutting with integrated water delivery system, has been shown to be effective at reducing exposures to respirable crystalline silica compared to dry cutting. One study measured a 91% reduction in respirable crystalline silica exposure during block and brick cutting when using a stationary wet saw compared to dry cutting with no control (Meeker et al., 2009). Another study found respirable particulate matter concentrations generated from cutting curbs and slabs utilizing a wet saw were reduced by at least 90% when compared to concentrations generated from using a motorized dry saw with no control system (Thorpe et al., 1999). In a controlled study of emissions generated by cutting cement roof tile, the authors reported that use of a wet saw reduced particulate matter concentrations by 99% compared to a motorized dry saw (Carlo et al., 2010). According to OSHA's exposure profile for stationary masonry saws, wet cutting resulted in a median 8-hour TWA respirable crystalline silica exposure concentration of 34 $\mu g/m^3$ and a mean exposure concentration of 41 $\mu g/m^3$ (Federal Register, 2016). These exposure concentrations were substantially lower than the mean respirable crystalline silica exposure concentration of 329 $\mu g/m^3$ from dry cutting operations.

Our testing also indicates that manual cutting tools produce lower emissions of crystalline silica compared to wet and dry saws. For example, we found that emissions of respirable particulate matter during use of a snap cutter are approximately 50-fold lower than during use of a stationary powered saw equipped with an integrated water delivery system. We also found that score and snap emissions are approximately 1,000-fold lower than emissions from a handheld saw without emission controls. Clearly then, work practices that favor the use of manual cutting tools and wet saws, and avoid use of motorized dry cutting without a dust control system, are effective at minimizing tile-related exposures to respirable crystalline silica.

Our interviews of tile installers indicate that the use of motorized dry cutting is decreasing in the tile industry. The change in behaviors appears to be partly in response to the availability of more information and research on health risks associated with respirable crystalline silica exposures from cutting building materials. In 2017, OSHA established a new permissible exposure limit and action level (AL) under the respirable crystalline silica standard for the construction industry. In the new standard, OSHA recommends the types of tools that can be used to cut materials containing crystalline silica as well as where those tools can be used (indoors or outdoors) and what personal protective equipment is appropriate for maintaining exposures below the AL. The standard indicates that motorized cutting with an integrated water delivery system, i.e., wet saw, produces exposure concentrations of respirable crystalline silica that generally do not warrant exposure monitoring (OSHA 29 CFR 1926.1153). OSHA also indicates that employee exposures should be evaluated over the workday when other cutting practices, such as motorized dry cutting, are applied to materials that contain crystalline silica. Our research indicates that eliminating the use of dry cutting without dust controls will reduce exposure to respirable crystalline silica for the population of tile installers in California. After eliminating the use of dry cutting without dust controls from our analysis, the potential ELCR for the average tile installer was reduced to 0.011 per 100,000, over 90-fold below the threshold of 1 in 100,000 for ELCR under Prop 65.

9.0 CONCLUSION

Our human health risk assessment indicates that potential risks of cancer associated with tile-related exposures to respirable crystalline silica for the average Californian who install tile are below thresholds established under the Prop 65 regulation. The potential excess lifetime cancer risk of approximately 1.3 in 10 million (1.3×10^{-7}), or 0.013 per 100,000, is 75-fold below the Prop 65 threshold of 1 in 100,000.

10.0 REFERENCES

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11.0 PARTICIPATING MANUFACTURERS

The conclusions from this report apply to brands of participating manufacturers from whom we received data as of July 25, 2018, including tile products and completed surveys and should not be generalized to other tile products without additional analysis.

11.1 NORTH AMERICA

Alcobe Ceramicos S.A. de C.V., ALCESA
American Wonder Porcelain
ARTO, Monrovia, Oleson, Studio, California Revival, 2D Impressions, Decos
Atlas Concorde USA, Inc., Atlas Concorde USA
Caesar Ceramics USA, Caesar USA
Ceramiche Marca Corona USA LLC, 1741 Di Marca Corona, Marca Corona Contract
Crossville Inc., Crossville (including products made for Crossville by Ilva S.A. and Eliane S.A. - Revestimentos Ceramicos)
Dal-Tile Corporation, Daltile, American Olean, Marazzi, Ragno, Mohawk Hard Surfaces
Del Conca USA, Inc., Del Conca USA
Florida Tile, Inc.
Florim USA, Inc.
Interceramic
Ironrock Capital Inc., Metropolitan Ceramics®, METROBRICK®, Royal Thin Brick®
Manufacturas Vitromex S.A. de C.V. & Vitromex USA, Inc., Vitromex, ARKO, Artemis, Oem Brands and Unbranded Products
Mirage Granito Ceramico U.S.A. Inc., Mirage USA
Nitropiso S.A. de C.V., Tecnopiso, Nitropiso, Nitrotile
Porcelanite Lamosa S.A. de C.V., Porcelanite, Lamosa, Firenze
Sonoma Tilemakers
Summitville Tiles, Inc.
UST Inc., Landmark Ceramics

11.2 ITALY

Abk Group Industrie Ceramiche S.P.A., Abk, Ariana, Casa Tua, Flaviker
Abm S.R.L., Candia Valpanaro, Art Casa
Altaeco S.P.A., Appiani, Ceramica Vogue
Armonie by Arte Casa Ceramiche S.P.A., Armonie
Casalgrande Padana S.P.A., Casalgrande Padana
Cedir Ceramiche di Romagna S.P.A., Cedir, Imolagres
Ceramica Colli Di Sassuolo S.P.A., Ceramica Colli Di Sassuolo
Ceramica Del Conca S.P.A., Del Conca, Pastorelli

Ceramica Euro S.P.A., *Ceramica Euro S.P.A., Fly Zone*
Ceramica Faetano S.P.A., *Faetano, Fondovalle*
Ceramica Mediterranea S.P.A., *Mediterranea*
Ceramica Sant'Agostino S.P.A., *Ceramica Casamia, Ceramica Gresitalia, Ceramica Sant'Agostino*
Ceramica Valsecchia S.P.A., *Valsecchia*
Ceramiche Ascot S.P.A., *Ascot Ceramiche, Dom Ceramiche*
Ceramiche Atlas Concorde S.P.A., *Atlas Concorde, Atlas Concorde Solution, Ceramiche Keope/Keope contract, Supergres*
Ceramiche Caesar S.P.A., *Caesar, Fap Ceramiche*
Ceramiche Ccv Castelvetro S.P.A., *Ceramiche Ccv Castelvetro*
Ceramiche Mac3 S.R.L., *Mac3*
Ceramiche Marca Corona S.P.A., *1741 Di Marca Corona, Marca Corona, Marca Corona Contract*
Ceramiche Mariner S.P.A., *Mariner*
Ceramiche Moma S.P.A., *Idea Ceramiche, Paul & Co.*
Ceramiche Refin S.P.A., *Ceramiche Refin*
Ceramiche Serra S.P.A., *Ceramiche Serra*
Ceramiche Settecento Valtresinaro S.P.A., *Settecento - Mosaici e Ceramiche D'Arte*
Cerindustries S.P.A., *Cerdomus, Porcellana Di Rocca*
Coem S.P.A., *Blu Art Stone, Ceramica Fioranese, Ceramiche Coem Manifattura*
Cooperativa Ceramica d'Imola S.C., *Imola, Lafaenza, Leonardo*
Eco Ceramica S.P.A., *Eco Ceramica, Arkadia*
Elios Ceramica S.P.A., *Elios Ceramica*
Emilceramica S.R.L., *Emilceramica, Emilgroup, Ergon, Viva, Provenza, Acif*
Etruria Design S.R.L., *Etruria Design*
Faro Ceramiche S.R.L., *Faro Ceramiche, Dolcevita, Basilica*
Fincibec S.P.A., *Century, Fincibec, Fire, Monocibec, Naxos*
Florim Ceramiche S.P.A, *Casamood, Cedit Ceramiche d'Italia, Cerim, Floor Gres, Rex Ceramiche Artistiche, Casadolcecasa, Florimstone*
Gambinigroup S.P.A., *Gambini Tile On Time*
Gamma Due S.P.A., *Ornamenta*
Gold Art S.P.A., *Energie Ker*
Gruppo Beta S.P.A., *Astor, Edimax*
Gruppo Ceramiche Gresmalt S.P.A., *Abitare La Ceramica, Materia Design, Sintesi Ceramiche*
Gruppo Ceramiche Ricchetti S.P.A., *Cerdisa, Cisa, Ricchetti*
Gruppo Romani S.P.A., *Cerasarda, Cercom, Cir, Ngt, Seremissima*
Gs Luxury Group S.P.A., *Ducati, Gs Luxury, Tonino Lamborghini Tiles X Style*
Happy House S.R.L., *Happy House*
Herberia S.P.A., *Herberia*
Horus Art Ceramiche S.R.L., *Horus Art Ceramiche*
Industrie Ceramiche Piemme S.P.A., *Ceramiche Piemme Floor And More, Valentino Lifestyle By Ceramiche Piemme*

Italgraniti Group S.P.A., Impronta, Italgraniti
Keradom S.R.L., Keradom
Kronos 2 Ceramiche S.P.A., Kronos Ceramiche
La Fabbrica S.P.A., Ava
La Fenice S.R.L., La Fenice
Laminam S.P.A., Laminam, Restile
Marazzi Group S.R.L., En Place, Forme, Gallery, Marazzi, Masterker, Ragno, Unika, Villa
Mirage Granito Ceramico S.P.A., Infinity, Mirage
Novabell S.P.A., Novabell
Nuova Ri.Wal Ceramiche S.R.L., Saime e Alfalux
Nuovocorso S.P.A., Nuovocorso
Panariagroup Industrie Ceramiche S.P.A., Blustyle By Cotto D'este, Fiordo Industrie Ceramiche, Lea Ceramiche, Love Tiles, Margres, Panaria Ceramica
Rondine S.P.A., Rondine
San Valentino Manifatture Ceramiche S.P.A., San Valentino Manifatture Ceramiche
Santa Marla S.R.L., Capri
Savoia Italia S.P.A., Savoia Italia, A.L.CO Ceramiche
Sichenia Gruppo Ceramiche S.P.A., Phorma, Sichenia
Sicis S.R.L., Sicis
Sima Ceramiche S.R.L., Simagres
Stile Italia S.R.L., Stile Italia
Terratinta Group S.R.L., Terratinta Ceramiche, Ceramiche Magica
Unicom S.R.L., Unicom Starker
Vallelunga & Co S.R.L., Vallelunga
Verde 1999 S.R.L., Verde 1999, Ceramiche Campogalliano, Ceramicasa
41zero42 S.R.L., 41zero42

WHEN QUALITY IS THE BOTTOM LINE **MATCH ACT-CERTIFIED INSTALLERS TO THE JOB AT HAND**

ACT
ADVANCED CERTIFICATIONS FOR TILE INSTALLERS

Construction and building design professionals are encouraged to integrate installer qualifications as requirements for bidding contractors, under "quality assurance" sections of their specs.

Requiring evidence of program completion or certifications under "submittals" is also recommended to help ensure the specified requirements for installers are met.

For ready-to-use boilerplate spec language, see the Installer and Contractor Qualifications Guide in the 2018 TCNA Handbook*, or, for easy copy and paste, visit TCNAtile.com.*

Tile setting has become a more and more specialized trade, yet it remains largely unregulated when it comes to requirements for installers, whether for training or for proven adherence to best practices and industry standards. The easy entry into tile setting means a contractor may have seasoned, skilled craftworkers or untrained installers with little experience under their belts. And, without an established skills baseline, the contractors that don't invest in installer training and education have a competitive edge, if the only consideration for choosing from a pool of tile contractors is which one has submitted the lowest bid, the norm for the vast majority of commercial work today.

This is the system for awarding tile jobs—too often to unqualified companies—that ACT (Advanced Certifications for Tile Installers) seeks to improve by establishing a skills baseline that allows consumers to compare costs and qualifications.

Launched in 2014, ACT is a program of written and hands-on testing for defined skill sets, like large format tile installation. While other training and certification programs are available to tile installers, ACT has garnered wide support from the tile industry because it is standards-based and highly demanding.

ACT tests are not show-up-for-a-demonstration-and-get-your-certificate events. A percentage of installers fail, which differentiates ACT as a meaningful certification, not an educational session. The tests have strictly enforced time limits, and installers' hands-on work is evaluated and scored in-person, by approved evaluators only. Upon completion of the hands-on component by the installer, the evaluator literally tears it apart. By prying up tiles and probing fresh mortar beds, ACT evaluators judge what's below the surface, a crucial component of the program, as so much of what is required for a successful tile installation lies below the finished tile work.

ACT tests are administered by the Ceramic Tile Education Foundation (CTEF) and the International Masonry Institute (IMI), which collaborated to develop the program, with support from product manufacturers and industry organizations including the National Tile Contractors Association (NTCA), Tile Contractors Association of America (TCAA), Tile Council of North America (TCNA), and the International Union of Bricklayers and Allied Craftworkers (IUBAC).

ACT
ADVANCED CERTIFICATIONS FOR TILE INSTALLERS
GROUTS

ACT Certification: **GROUTS**

Specify ACT GROUTS certification on every job where cementitious grout, epoxy grout, or modified epoxy emulsion grout will be used.

Critical Installation Skills Tested: Proper mixing, installation, and curing of cementitious grout, epoxy grout, and modified epoxy emulsion grout

ACT
ADVANCED CERTIFICATIONS FOR TILE INSTALLERS
LARGE FORMAT TILE

ACT Certification: **LARGE FORMAT TILE / SUBSTRATE PREP**

Specify ACT LARGE FORMAT TILE certification when tile larger than 15" long will be installed by a thin-bed method.

Critical Installation Skills Tested: Flattening a substrate to receive large tile and installing large tile within industry tolerances for coverage, flatness, and lippage

ACT
ADVANCED CERTIFICATIONS FOR TILE INSTALLERS
MEMBRANES

ACT Certification: **MEMBRANES**

Specify ACT MEMBRANES certification when a sheet or liquid membrane will be used for waterproofing or crack isolation.

Critical Installation Skills Tested: Application of sheet and liquid membranes with emphasis on avoiding installation errors that affect waterproofness

ACT
ADVANCED CERTIFICATIONS FOR TILE INSTALLERS
SHOWERS

ACT Certification: **SHOWERS**

Specify ACT SHOWERS certification when designing showers with a mortar bed and tile floor over a shower-pan membrane.

Critical Installation Skills Tested: Creating a watertight (leak-proof) shower base that effectively evacuates water

ACT
ADVANCED CERTIFICATIONS FOR TILE INSTALLERS
MUD WALLS

ACT Certification: **MUD WALLS**

Specify ACT MUD WALLS certification when a mortar bed has been selected as the substrate for tiling walls.

Critical Installation Skills Tested: Installing wall mud to ANSI standards, with emphasis on proper materials and precision of finished work (flat, plumb, level, square)

ACT
ADVANCED CERTIFICATIONS FOR TILE INSTALLERS
MUD FLOORS

ACT Certification: **MUD FLOORS**

Specify ACT MUD FLOORS certification when a mortar bed has been selected as the substrate for tiling floors.

Critical Installation Skills Tested: Installing floor mud to ANSI standards, with emphasis on proper materials and precision of finished work (flat, level)

TCNA BULLETIN
CHOOSING YOUR TILE CONTRACTOR




TILE. It's the go-to finish when you're looking for high fashion and high function. But you might not get either if you leave it to just anyone to install. Unlike plumbing, electrical, and structural masonry trades, tile installers and the tile contractors that employ them are not generally required to meet minimum trade craft criteria to be in business.

The difference between trained, experienced installers and inexperienced installers is noticeably reflected in their work, and the difference between a quality contractor and a deficient one is reflected in their service and business operations.

Together, contractor and installer transform your concept into reality. Whether you're a design/build professional selecting tile contractors on a regular basis or a homeowner with a single tile project, it's just not possible to overestimate the importance of finding qualified contractors and installers.

The Reputable Tile Contractor

- ☑ **Operates a legitimate business,** with responsible business practices and a policy of standing behind their work.
- ☑ **Invests in continuing education** necessary to stay up-to-date on current building codes, regulations, standards, and best practices. On-the-job training is the most popular way to learn a construction trade, but formalized training is a must for ensuring correct installation methods are being taught to and used by installers on your project.
- ☑ **Carries all required business licenses and insurances,** and doesn't push liabilities for property damages or worker injuries onto others.
- ☑ **Does not misclassify workers** to avoid paying into social security, unemployment, workers' compensation, and other employee programs.
- ☑ **Has a traceable business location** so customers can be sure post-installation questions and issues are addressed and resolved.
- ☑ **Has a track record for quality and service:** Good contractors can easily produce references and verifiable documentation of their commitment to quality and service.

Architects and Specifiers

Include language in job specifications requiring qualified labor and enforce it with the GC. See the TCNA Handbook for a list of industry recognized prequalification programs for installers and contractors such as the CTEF Certified Tile Installer Program, the ACT (Advanced Certifications for Tile Installers) Program, the NTCA 5-Star Contractor Program, and the TCAA Trowel of Excellence Program.

General Contractors

Deliver a quality tile installation by fulfilling contractor qualification requirements in job specifications. When not included, utilize internally developed qualifications. Require proof of qualifications to be included with all project bids. Thoroughly compare estimates from bidding contractors before awarding contracts. Often, higher estimates reflect better materials and additional necessary components and tasks, like substrate preparation and movement joints.

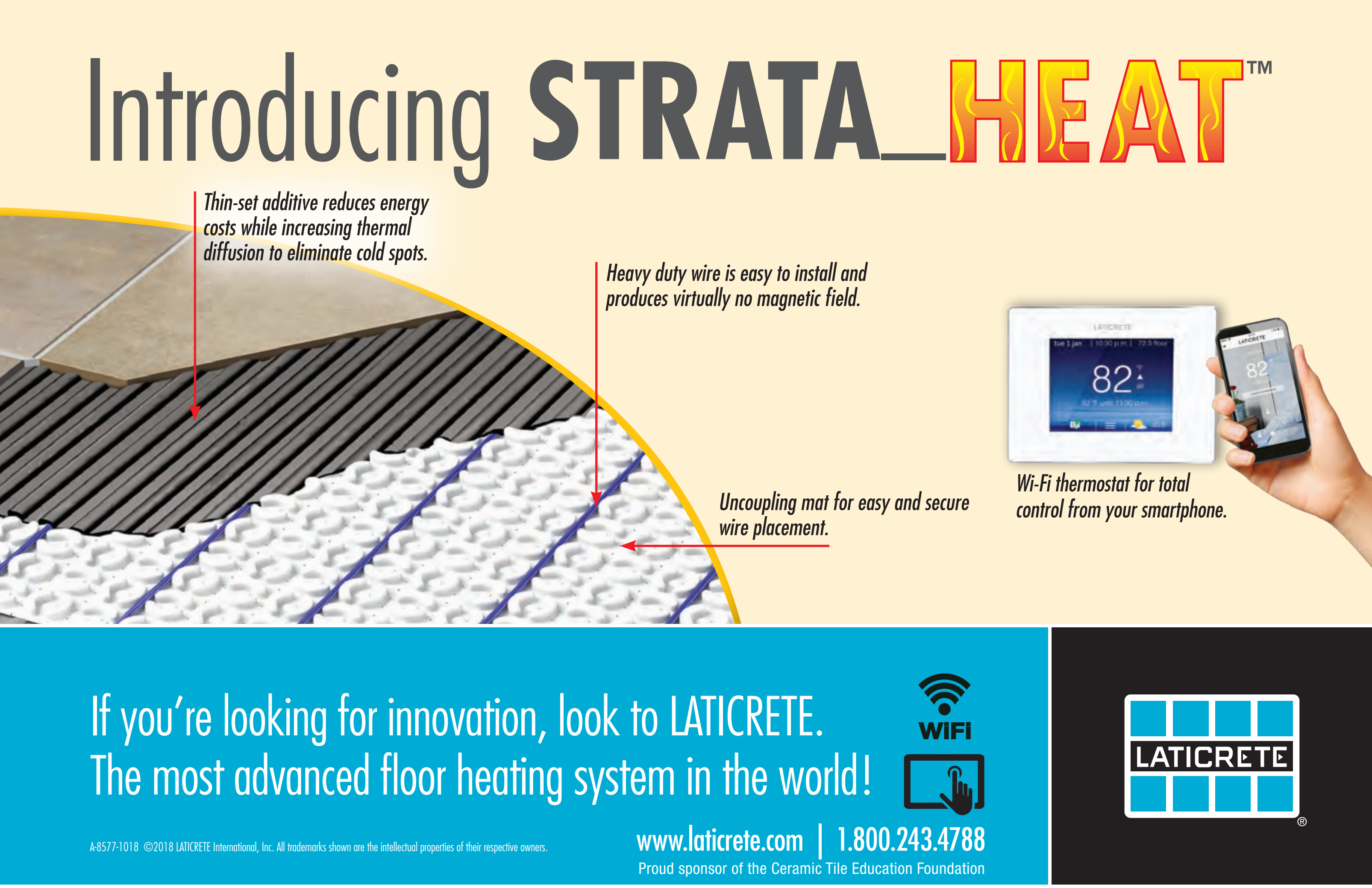
Homeowners

Don't hesitate to ask contractors for proof of insurance, their license (where required), and their installation qualifications. Thoroughly interview bidding contractors and check several references. Utilize consumer resources available from your state on the internet and from the Ceramic Tile Education Foundation.

"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."

— TCNA Handbook

Call CTEF at 864-222-2131 or visit CeramicTileFoundation.org for assistance finding or specifying a quality contractor.



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Tile Heritage Foundation: Guardian of American Tile History

Tile Heritage Foundation was established in 1987 as a member supported, not-for-profit organization whose sole purpose is to protect and preserve the history of the American Tile Industry.

Tile Heritage is dedicated to promoting an awareness and appreciation of ceramic surfaces in the United States.

The Foundation is a repository, an archive, which embraces all aspects of the industry from its inception in the 1870s through to the present time, validating its significance for posterity.

The Foundation's archives include an estimated 40,000 documents and an equal number of images, both historic and contemporary. Manufacturing, distribution and installation histories are represented.

The body of information on hand, coupled with expertise resulting from over 70 years of combined experience in the field and access to a network of experts worldwide, provides assurance of both helpful and accurate answers to questions and solutions to problems.

Above, a "bottle" kiln at the American Encaustic Tiling Co. with tiles being loaded into saggars for firing. At left, a fanciful, dust-pressed American Encaustic frieze for the center of a fireplace surround, circa 1890s. Photos from the Tile Heritage Digital Library.

Manufacturing represents the cornerstone of the tile industry.

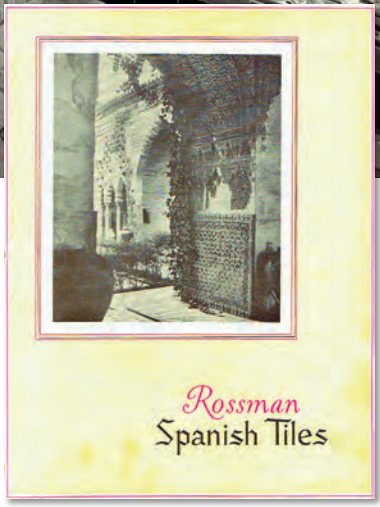
The American Encaustic Tiling Company in Zanesville, Ohio, was the largest tile manufacturer in the country by 1930. Its first commission in 1876 was to produce encaustic floor tile for the Muskingham County Courthouse in Zanesville (below, right).

The primary goal of Tile Heritage is to assist in the preservation of ceramics surfaces, which includes its legendary history, significant installations, as well as the objects themselves. By providing pertinent information, unbiased consultation and specific recommendations when needed, the Foundation serves both the industry and the public at large as no other agency can.

At left, an undated picture of the office staff at the American Encaustic Tiling Company in Zanesville. From the women's attire and hairstyles, a likely date would be mid-1920s.

Photos from the Tile Heritage Digital Library.

Marketing, sales, and distribution have served as an essential realm within the tile industry since tiles were first made to sell.



During the last half of the 1920s a number of companies hosted exotic showrooms in major urban centers with sales supported by sophisticated printed materials in full color. Rossman Corporation was one of these with representation in New York City, Chicago and San Francisco featuring both imported and domestic tiles.

Photos from Tile Heritage Archives, E.L. Bradley Collection. Gift of Rodger Dunham.

The offices of E.L. Bradley in San Francisco, which represented Rossman, were rather dark and austere by today's standards. Lots of handwritten letters, typewriting and teletype options, but none of the convenient forms of communication we have today.

"Tile Heritage speaks for all of us interested in the world of tiles."

Marie Glasse Tapp, Founder
Tile Restoration Center

Honoring the work and artistry of tile installers through the archiving of their accomplishments validates tiles for posterity.

Henry Krier (1886-1967), a legend in his own right in Southern California during the '20s and '30s, learned his trade in Germany, emigrated to the United States early in the 20th century, establishing himself as a mason and then as a productive tile contractor.

Henry Krier, posing proudly in front of his home/office, c. 1938. Tile Heritage Archives, Krier Collection. Gift of Rick Baratta.

STATE OF CALIFORNIA
REGISTRAR OF CONTRACTORS

№ 152

CONTRACTOR'S LICENSE

PURSUANT TO THE PROVISIONS OF CHAPTER 791, STATUTES OF 1929 AND AMENDMENTS THERETO, AND THE RULES AND REGULATIONS WHICH ARE NOW OR MAY HEREAFTER BE PRESCRIBED, THE REGISTRAR OF CONTRACTORS DOES HEREBY GRANT TO

HENRY KRIER
802 S CALIFORNIA STREET
MONROVIA CALIFORNIA

THIS LICENSE TO ENGAGE IN THE BUSINESS OR ACT IN THE CAPACITY OF CONTRACTOR WITHIN THE STATE OF CALIFORNIA.

WITNESS MY HAND AND OFFICIAL SEAL THIS DATE.

JULY 21, 1931
DATE

REGISTRAR OF CONTRACTORS

SIGNATURE OF LICENSEE

"The Legacy of Henry Krier" by Lynn Downey, was published in "Flash Point," vol. 2, no. 3 by the Tile Heritage Foundation in 1989.

"Each time I kneel, it'll cost you money!" **HK**

*With the development of the vision for Tile Heritage an important aspect has always been education through integration—**the bringing together of all those with a vital interest in ceramic surfaces.***

Tiled bath set by Henry Krier at the castle of Evangelist Aimee Semple McPherson at Lake Elsinore, California, 1929.

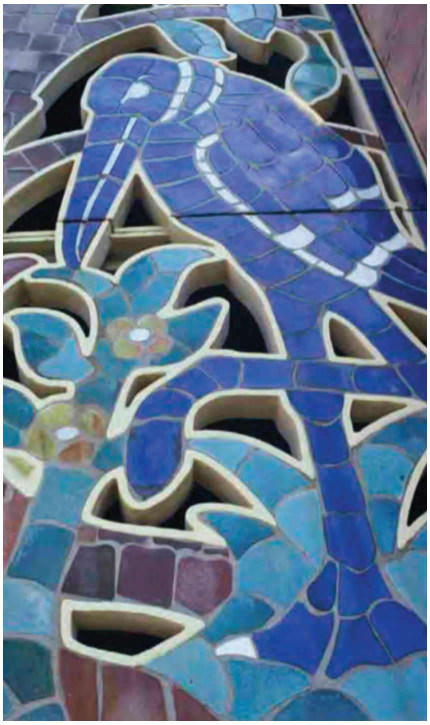
Photo by Albert E. Cawood. Tile Heritage Archives, Krier Collection. Gift of Rick Baratta.

Identification encourages restoration of historic tile installations.

Tiles by Handcraft Tile Co. of Milpitas, California adorn this 1937 Spanish Colonial residence in San Jose.

TILE INSTALLATION IDENTIFICATION. *The Tile Heritage Foundation offers tile identification services to the public at no charge. Simply email foundation@tileheritage.org with clear, low res images of individual tiles or tile installations along with whatever relevant information is readily available: site (city/state), size, date (approximate), architect/designer if known. If the experts at Tile Heritage are not able to identify the work, your email will be forwarded to others who are likely to know.*

Tile Heritage has been involved with Bok Tower Gardens in Lake Wales, Florida since 1994 when we were contacted to verify the identity of the tile installations at Pinewood, a Spanish Colonial house built in 1931. Currently, the Gardens are engaged in an extensive restoration of the exterior of Bok Tower itself, the 205-foot, 60-bell carillon decorated with a series of colorful tile grilles that provide the openings for the bell chamber. Sadly, the grilles, fabricated in 1929 by the Enfield Pottery and Tile Works, have been compromised by atmospheric conditions over the past 90 years, turning a brilliant red-orange glaze into a pale yellow. Fortunately, the structural integrity of the grilles remains true.



Tile Heritage involves more than the identification and protection of tiles. *The Foundation represents the need to preserve a perception of ourselves. The archival records held by THF are of national importance—they tell our story! We are all part of this heritage!*

Preservation of significant installations is of paramount importance.

Port of Long Beach Administration Building. Photo courtesy Long Beach *Press-Telegram.*

GREAT NEWS from the board president of Long Beach Heritage: All documents have been signed by Port of Long Beach for the removal of the tile mural pictured above; work began on September 28, 2018 after sample tiles had been safely removed. This positive outcome is the result of several years of negotiation, advocating with the Port for the mural's preservation. The historic ceramic tile mural on the front of the vacated Port Administration Building in Long Beach, California was produced in 1959 at Gladding, McBean under the direction of Sheridan Stanton and painted by Paul Marciel Souza, a well-known Southern California artist. The 74-foot mural was schedule for demolition in 2018 unless the tiles could be removed and relocated. Congratulations are in order!

Tile Heritage documents the location and producers of contemporary installations as well. Their future is often as vulnerable as historic works and the need to preserve them in situ equally important.

"Water Through Time," is the creation of Susan Dunis and Sienna Dunis Ginn of Dunis Studios in Wimberley, Texas. The 15 x 5-foot mural was mounted on the Briscoe Western Art Museum in San Antonio in 2014. Photo courtesy of Susan Frost.

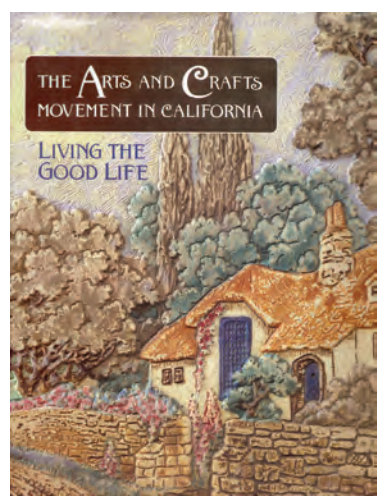
Educational outreach has always been fundamental to the mission of the Tile Heritage Foundation.

"California Tile," an exhibition of historic tiles, opened at the San Francisco Airport Museum in 2004, where it remained for over nine months. Tile Heritage supplied tiles from its collection and provided all of the tile graphics from its slide library.

Over the past 25 years a number of prestigious institutions have partnered with Tile Heritage or borrowed historic materials for their periodic exhibitions. The Oakland Museum was the first for "The Arts and Crafts Movement in California: Living the Good Life" in 1993, introducing a variety of historic California tiles and publishing a 328-page hard cover catalog that featured a decorative tile cover and included a chapter devoted to these tiles.

In 2004 the California Heritage Museum in Santa Monica sponsored a 2-volume publication, "California Tile: The Golden Era 1910-1940" to coincide with its tile exhibition of the same name. Joseph Taylor of Tile Heritage served as the book's editor.

That same year the San Francisco Airport Museum presented "California Tile" in its North (United) Terminal, an extraordinary exhibition of both historic tiles and tile graphics (above) provided by the Tile Heritage slide library. The display was seen by millions of travelers over its nine month duration. Recently, the museum has hosted an Arts and Crafts exhibition (2017-18), for which Tile Heritage has provided a selection of historic tiles.



A Claycraft Potteries tile was chosen for the cover of this exhibition catalog.

"Educate" is what we do best!

To be most effective, education necessitates direct communication.

Screening raw clay dug from the mountains near La Madera, New Mexico to make tiles from scratch, a 2-day workshop at "Spirit in Clay," in the fall of 2000.

Between 1991 and 2005 Tile Heritage presented annual symposiums in different cities around the United States, partnering with local organizations, to bring like minds together and to raise a community's consciousness about the significance of local tile installations within these diverse venues. The program, most often 4-5 days, included workshops, tours and lectures on both historic and contemporary tile-related subjects. Useful tile tour maps were created as a lasting memento.

Tile Heritage tour discovers encaustic tiles at Sacred Heart Music Center in Duluth, Minnesota in 2005.

"Communicate" is what we do!

Email provides our principal means of communication today both from the office and when we're "on the road," responding to daily inquiries from throughout the United States

As a guest of Tile Council of North America at Coverings, Tile Heritage engages with industry people concerning historic installations as well as preservation and restoration issues. Las Vegas 2011.

Thirty years ago one would be hard pressed to find a book on American tiles; today there are scores to choose from, covering both historic and contemporary ceramic surfaces. Tile Heritage published 42 issues of "Flash Point" (ISSN 1078-5647) between 1988 and 2003; 18 issues of *Tile Heritage: A Review of American Tile History* (ISSN 1978- 5655) have been published as well. Since 2004 "E-News" and "Shards & Snippets" serve as the Foundation's principal means of outreach; all back issues are available online.

Please visit: www.tileheritage.org.

The Foundation is now engaged in maintaining the industry's history as a living archive through a publicly accessible finding-aid Index.

Tile Heritage Foundation's archived tile collections, available by appointment.

"Where art and architecture meld and merge in the world of tile, Tile Heritage Foundation is there, preserving and documenting to educate the future of our industry."

Eric Astrachan
Tile Council of North America

The tile collection alone contains over 4000 different glazed and decorative samples from scores of American companies dating to the 19th century. All of the tiles in the collection have been donated; Tile Heritage does not buy or sell historic material.

The present time is of critical importance as we strive to enhance the accessibility of the Tile Heritage archives and collections *for industry-wide and public use. Our goal is to keep the archives "alive" with our ongoing development of the *online Finding-aid Index. It is imperative that this work be completed. Expanding our industry partnership is essential to its success.*

The Tile Heritage Library contains hundreds of books and over 40,000 documents. The collections include over 700 original company catalogs and more than 40 tile-related periodicals dating back to the 1880s.

"Tile Heritage represents the 'soul' of the industry in America."

Donato Grosser

Tile Heritage Foundation's archived periodical collections.

****A Feather in our Cap! Tile Heritage Archives has been accepted as a contributor by the Online Archive of California (OAC), providing access to the Tile Heritage Archives Index nationwide and beyond!***

A broad funding base is essential for the long-term sustainability of Tile Heritage. Membership and sponsorship have always provided the core of the Foundation's financial stability.

For the past 30 plus years Tile Heritage has received substantial support from sponsors in the tile industry. Diverse membership within and beyond the industry has also played a major role. The Foundation has benefited from substantial grant support as well.

Industry Sponsors play a major role in providing sustainability for the Tile Heritage Foundation.

THF engages in creative, public-centric fundraisers such as tile festivals, tile tours, lectures, auctions and other events, often creating venues that showcase contemporary tile making.

Tile Festival at the Moravian Pottery and Tile Works, Doylestown, PA.

TEAM UP WITH TILE HERITAGE!

Email: foundation@tileheritage.org

www.tileheritage.org

Tile Council of North America (TCNA) has embraced Tile Heritage for many years recognizing the importance of maintaining the historic tile industry archives and collections.

TCNA advocacy and inclusiveness has contributed greatly to the Foundation's validation and visibility.

"It is very important that we, as an industry, promote an appreciation of tiles—to know what came before. Individually we are not always able to do that, but by supporting the Tile Heritage Foundation we can preserve the history. As an industry we should support that work."

Svend Hovmand, Crossville Ceramics

We invite you to partner with the Tile Heritage Foundation by becoming an Industry Sponsor—protecting tile history today, validating that history for tomorrow!

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http://www.tileheritage.org/pdfs/1Studio_Factory_handprint_2018.pdf
or . . . Email for planning assistance: foundation@tileheritage.org

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Release date: January 2019

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