



Optical haze – a consumer’s perspective

In this paper **Colin Cass** examines the surface effect found on some polished porcelain tiles that has been termed “optical hazing”. It is an effect that is considered undesirable by many consumers and it therefore leads to complaints, some of which end up in complex litigation because the effect cannot be seen when the tiles are tested for surface quality according to ISO10545. Colin recently presented this paper at Qualicer 2010.

The “optical hazing” effect is sometimes visible on a whole consignment of tiles and sometimes only on a scattering of individual tiles. It is generally only visible in certain types of low angle natural light.

Some of the possible causes of the effect are explored and methods for meeting consumers expectations are suggested. A method of reducing and sometimes eliminating the problem

on installed tiles is discussed, and recommendations for further investigations into the problem are made.

This paper is not a scientific analysis of the cause or causes of optical hazing, rather, it is an examination of a consumer problem in a way that allows the tile manufacturers and sellers to better meet reasonable consumer expectations when supplying one of the most widely used tile formats in the world.

While the surface effects that are causing consumer complaints are generally referred to as **optical hazing**, they take several forms some of which do not fit comfortably under this title. For the purposes of clarification the following definitions are used for the most common effects causing complaint.

Optical Hazing: A fuzzy halo seen around certain types of reflected light, also seen as a milky pattern immediately beside low angle reflected natural light.

Shadowing: Permanent dark smudges only visible on tiles in low angle reflected natural light

Sealer marks: Regular factory processing marks only visible immediately beside low angle reflected natural light.

These effects do not photograph readily, and they may appear or disappear depending on the position from which they are observed, this also makes measurement of the effects most difficult. Their manifestation may also change as natural lighting conditions vary. Examples of these effects may be observed in **photos 1 to 6** on these pages.

ABOVE Photo No. 2. Note the shadow line on the left becomes hazy about half way down. This localised loss of reflectivity is being called optical hazing in the tile industry



Photo No. 1. The same halogen light reflected off 3 different tiles gives 3 different levels of haze around the light. This is considered to be conventional optical hazing. There are few complaints about this type of hazing, all the tiles pass the requirements of ISO10545

None of the effects in **photos 1 to 6** are visible when the tiles are tested according to of ISO10545 part 2 section 7 "Surface quality", that is, from a distance of 1 metre in 300 lux fluorescent light. In fact, all but the effects seen in photo No. 1 require low angle natural light and they are not generally visible in fluorescent (or incandescent) light as shown in **photo No. 7**.

Optical hazing was sometimes associated with cement residues being locked into the surface of the tiles. However, this is a misdiagnosis as this problem is more accurately called "grout haze", and it can usually be addressed by a mild acid wash which usually fixes the problem. The effects seen on the surface of the tiles in **photos 2 to 6** cannot be removed with such acid solutions or by any other means.

The impact on the consumers

The immediate impression on seeing polished porcelain tiles is that they are hard and glossy. It is reasonable for consumers to expect that the tiles will have uniform characteristics, that the gloss will be consistent, that their surface will be blemish free and that the surface will be easy to maintain and not have marks visible on it that are caused by the manufacturing process.

Instead, some consumers are presented with tiles that have visible effects on their surface that lead to complaints. The

complaints appear to vary from very real and valid through to somewhat trivial and invalid. However, there is little technical information available that can assist in resolving the difference between the valid and invalid complaints. The author is also not aware of any valid and reliable methods for measuring the extent of these effects. This makes the setting of parameters for passing or failing any assessment of the effects arbitrary.

While the effects complained about are strictly aesthetic, and they do not interfere in the physical performance or longevity of the tiles, they still do not meet the consumer's expectations. On top of this, there have been legal precedents set in Australia that make aesthetics an attribute that contributes to "fitness for purpose". (McGuffie Vs Wodonga Carpets)

Apart from objecting to regular patterns on the surface that appear to indicate that something went wrong during the manufacturing process, the most common complaint is that the tiles cannot be made to look clean. This hits at one of the key reasons tiles are selected in the first place, that of being easy to clean.

The complaints are often made by persons who expected a mirror like finish on their tiles, and in some cases this perception was encouraged by sales staff or manufacturer's promotion material. When the surface of the tiles is inspected beside a mirror the reflective values are usually quite similar. An example of a



Photo No. 3 The cloudy marks on the tiles in the shaded area typifies the complaint being called "optical hazing" The tiles have a slight travertine vein running east-west the opposite direction to the hazing



Photo No. 4, in the same room as photo No. 3 shows a typical complaint of "shadowing" in the reflected light



Photo No. 5 shows shadows that appear to be consistent with Sousa's static head polishing time modelling.¹

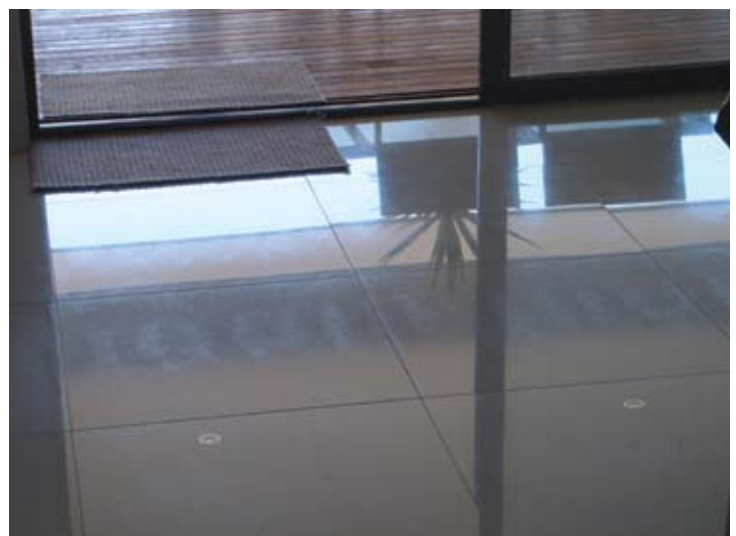


Photo No. 6 shows typical factory applied sealer marks in the central shadow beside the reflected natural light

¹ F. Sousa, J. Aurich, W. Weingaertner, & O. Alarcon titled "Analytical determination of the distribution of polishing time over the surface of polished tiles". Published in the journal of the American Ceramic Society No. 90. Nov. 2007. pp 3468-3477

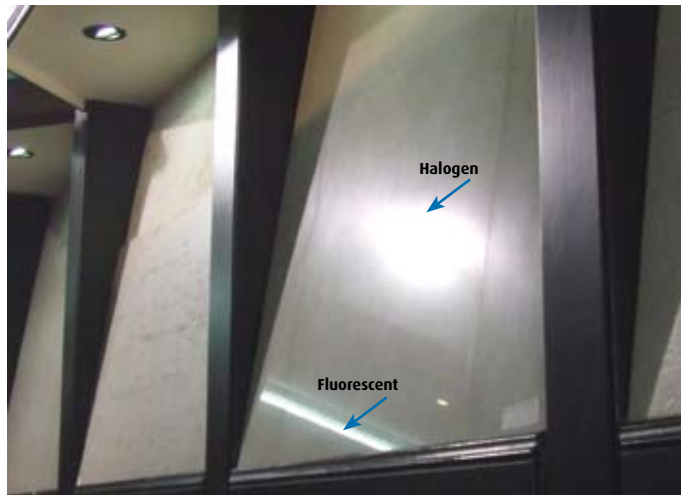


Photo No. 7 shows haze around a halogen reflection but no haze around a fluorescent reflection



Photo No. 8. The halogen down light reflects similarly off the polished tile and the mirror producing haze

halogen light reflected off both a mirror and a tile can be seen in **photo No. 8**. There is a tendency for sales staff to “over-sell” polished porcelain as a high gloss maintenance free flooring material leading to consumer expectations being raised to the point where perfection is expected. This has led to many hundreds of complaints in Australia with most retailers now developing policies and procedures for handling polished porcelain reflectance complaints. This includes signs in showrooms, disclaimers on invoices and brochures explaining optical hazing as an inherent feature of some tiles. These approaches are likely to have limited legal status and they don’t meet the primary objective of having satisfied customers. Arbitrators of disputes in these matters have already found in favour of customers on the grounds that the surface effects visible are significant enough to warrant replacing the tiles regardless of whether the standard test passes them as first quality.

Part of the human condition appears to be that when a problem is noticed with a product it becomes the dominant feature of that product; in this case the effect is looked for whenever the room is entered. This can lead to simple irritation about the effects to resentment about the product and those involved with its supply. Providing clear technical evidence that the tiles meet the international requirements for first quality tiles, and that the performance characteristics of the tiles are not impaired in any way does not make the problem go away or become acceptable to the consumer. The tile industry should probably be adopting a policy of trying to please all consumers and avoid even the invalid complaints, that is, make tiles that conform to consumer expectations. Failure to address responsibly the valid complaints has an adverse impact on the reputation of the tile industry.

General observations and possible causes of unwanted reflectance effects

More than 90% of the complaints about surface effects on polished porcelain are about tiles of Chinese manufacture, though there are occasionally complaints about European, Middle Eastern and South East Asian product. The tiles are mostly from double charged pressing, and most complaints are with tiles that have been “factory sealed”. A huge proportion of polished porcelain tiles used in Australia are also of Chinese origin, (over 45% of Australia’s tiles are imported from China, representing about 15 million square metres²) but Chinese tiles are still dramatically over represented in the complaints.

The lighting conditions in which the effects are visible are specific. The effects are not readily visible in fluorescent or incandescent lighting, they are usually only visible in, or directly beside, low angle reflected light from the sky. The more natural light entering the building the greater the chance the effects will be observed,

and the common architectural feature of floor to ceiling doors and windows found in Australia may be one reason there are so many polished porcelain reflectance complaints.

With most tile showrooms displaying tiles in artificial light, often fluorescent, consumers may not be able to see an effect that is later visible in their premises. To compound the problem further, the problematic tiles are often delivered with a light wax coating completely covering the surface. This wax is applied at the factory to protect the tiles while in transit (and to a degree to protect them during and after laying). This wax means that the surface proper of the tiles is not usually observed until after the tiles are laid. This usually makes any resolution of a dispute about the tiles more complicated because now the cost of removing and re-laying the tiles is involved instead of simply taking the tiles back and issuing a refund.

There is some evidence that shadowing and optical hazing could be a reverse manifestation of the same effect, although they are not usually visible in the same tiles. **Photos 3 and 4** show both problems in the one consignment, however, the complaint is usually one or the other, only occasionally is it both. The tiles in photos 3 & 4 were laid in a unidirectional manner because they had linear pattern in the double charged layer, (a mock vein cut travertine pattern). The shadowing and hazing on the tiles seen in photos 3 & 4 always ran at 90 degrees to the pattern in the tiles. This could account for why the undesirable surface effects on this floor all went in the same direction. The effects often run at 90 degree to each other where plain coloured tiles have been used.

Many hypotheses have been advanced as to the possible causes of the effects of shadowing and hazing. Some have now been largely discounted while others are coming to the fore.

Some considered that most light was directly reflected from the polished surface, but that some may have penetrated into the mineral components making up the double charging glaze of particular tiles. It was then thought to refract at different angles thus causing the effects. This is no longer thought to play any part in the manifestation of these surface effects.

Possible contributing factors are now believed to be the slightly higher porosity of the Chinese product, possibly combined with the use of static head polishing machines. The higher porosity is likely to leave more micro cracks and facets in the surface of these tiles making them more likely to trap materials that show up as stains as well as reflecting light differently. More porous tiles with more micro cracks also require sealing if they are to perform as well as denser tiles with fewer micro cracks. This may be a reason that the problems are mostly found on factory sealed tiles.

The surface gloss of the tiles exhibiting these effects is generally indistinguishable from the surface gloss of the tiles that do not exhibit the problem. Measurements taken with a gloss meter have not been able to discern any difference between areas on the

2 Tile Today magazine, issue 60 Sept. 2008. pp.18-19 atp@infotile.com.au

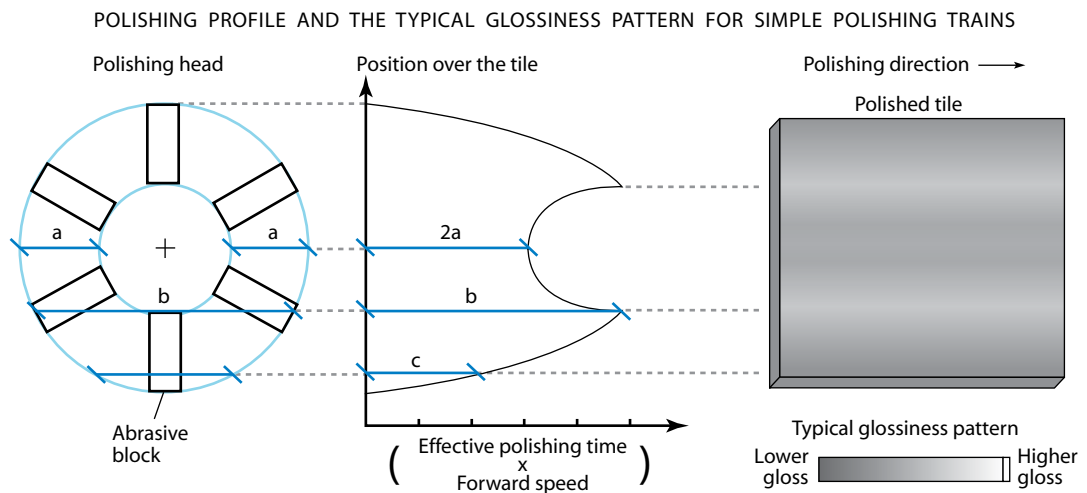


Figure 1. Polishing time modelling for a static head polishing machine

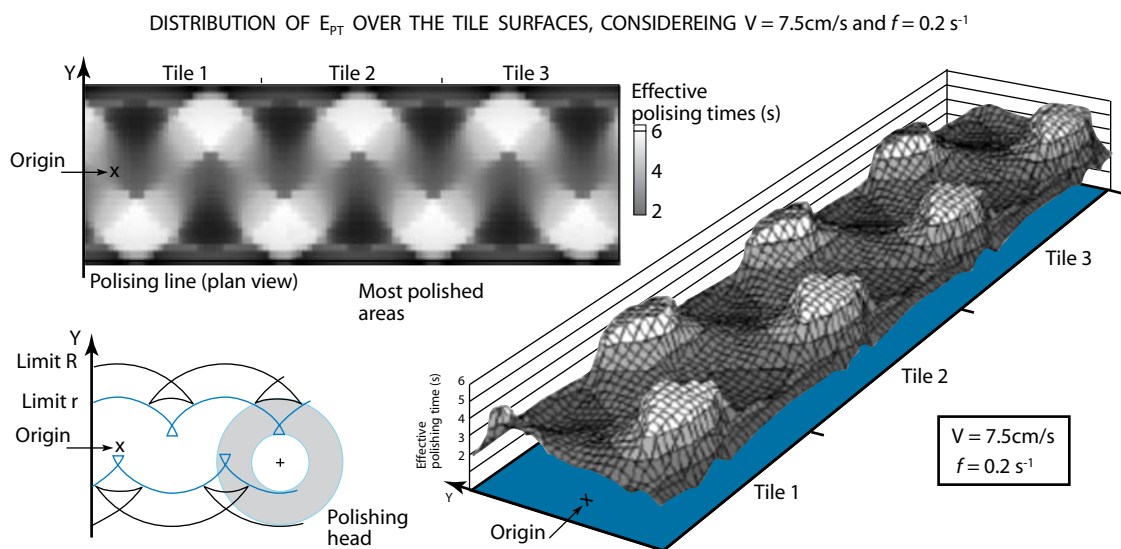


Figure 2. Polishing time modelling from a sliding head polishing machine.

tiles that have the effects and the areas on the same tiles that do not exhibit the effects. Gloss meter readings taken from the surface of polished ceramics have been found by some ceramic scientists to be unreliable, and it appears that there is currently no acceptable practical means of measuring the surface effects being complained-of. The application at the factory of certain sealers may complicate the issue of measuring surface gloss.

The problems could be linked to the polishing procedures used in the factory. The linear marks associated with “shadowing” that are causing complaint (occasionally the hazing also takes this linear form) appear to be regularly aligned with the zones that receive the longest contact with the grinding and polishing stones. (Fickerts) This feature can be possibly be associated with **figure 1** taken from the paper of F. Sousa, J. Aurich, W. Weingaertner, & O. Alarcon titled “Analytical determination of the distribution of polishing time over the surface of polished tiles”.³

The above light lines indicating the areas on the surface that have the highest gloss, equate very closely with the lines of shadowing seen in **photo No. 5**.

The use of polishing equipment incorporating transverse oscillation (sliding heads) is now becoming the norm in industry.

It is unlikely that this change to sliding polishing heads will mean reflectance effects no longer happen in a regular and linear fashion, it may make them more difficult to see, and make their appearance occur in a less linear way. A model of the length of time that the polishing heads were in contact with the surface of the tile when transverse oscillation polishing machines were used can be seen in **figure 2** which is from the same paper by Sousa *et al*.

That there are parts of the surface of the tiles that receive more grinding and polishing time can be regarded as probably leading to micro deviations from a perfectly true or flat surface. Preliminary investigations undertaken at the University of New South Wales indicated shadowing was related to a 4 to 7 micron deviation in plane. Obviously, such minor deviations in flatness should not be considered a defect in the tile. However, this does open up an area of study that could “cast light” onto the causes of hazing and shadowing on the surface of polished porcelain tiles. **Photo No. 9** shows that the perfect grid of the squares in the light box is reflected with some distortions from the surface of the polished porcelain tiles.⁴ This shows that the surface of the tiles is not truly flat. Finding regular visual deviations that coincide with unwanted

³ F. Sousa, J. Aurich, W. Weingaertner, & O. Alarcon titled “Analytical determination of the distribution of polishing time over the surface of polished tiles” *ib id*.

⁴ Photo taken in the School of Optometry, University of New South Wales, Australia, with the assistance of Professor Stephen Dain.

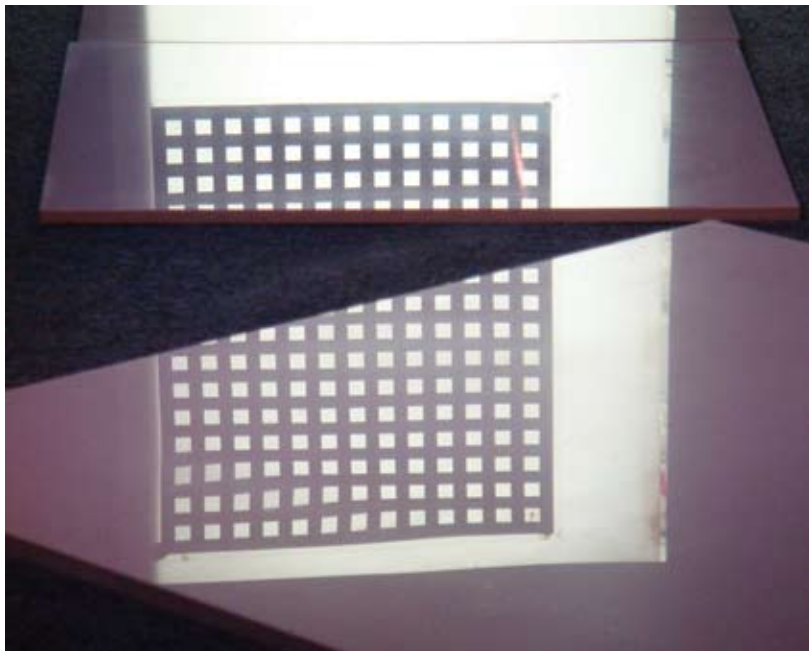


Photo No. 9. The perfect squares on the light box are distorted in their reflection off the polished tiles showing the surface of the tiles is not flat

visual effects on the surface of the tiles would also appear to be a starting point to see if planarity and the visual effects are linked.

This possible link between polishing time and regular effects on the surface of the tiles should not be confused with the effect seen in **photo No. 6** where the pattern on the surface of the tiles is believed to be related to the mechanical rotational application (or misapplication) of sealer to the surface of the tiles after polishing is complete.

It is understood that the bulk of factory sealed tiles coming from China are sealed using one of two main procedures. In manual or mechanical processes that are widely described as making the tiles “super glossy” they have either an acrylic or sometimes a “nano” sealer applied, or they undergo the application of a thermally cured epoxy sealing process. It is thought to be this latter thermally cured epoxy sealer that can result in the effects seen in **photo No. 6**. These marks have until recently been impossible to remove. They detract from the appearance of the floor tiling and could be legitimately regarded as an undesirable effect that equates to a defect. However, once again, when these tiles were assessed according to the test method set down in ISO 10545 part 2 section 7, none of the defects to be looked for that are set out in that section were visible and the tiles passed the test method.

Avoiding customer complaints regarding undesired reflectance problems on the surface of polished porcelain tiles

Prevention is better than cure, and there are some relatively simple steps and procedures that can generally prevent tiles that display undesired effects on their surface from being installed or even being sold in the first place.

It would appear to be incumbent on tile manufacturers and sellers to undertake actions to prevent consumers being supplied with tiles that are likely to cause complaint. It is also in their own interest to have satisfied customers. Complaints related to undesired effects on the surface of polished porcelain tiles should be able to be detected before the tiles are sold if they are properly inspected.

The first, but probably most difficult step to coordinate would be for the tile manufacturers to examine representative samples of their tiles from production in and beside low angle reflected natural light. This would probably show them which production runs are likely to cause complaints about hazing problems. In a recent tour of four tile factories in the Foshan district of China it was observed that all were checking for surface quality under

fluorescent light only. If low angle natural light inspections were undertaken manufacturers could be in a position where they could declare their tiles to be “haze free” thereby reinforcing market confidence.

The next best procedure would be for tile merchants to remove any transit wax coating from a representative sample of all new batches of tiles and then inspect them in lighting conditions where low angle reflected natural light (and some shadow) is available. If undesired effects are visible a plan can be implemented to address the matter before the tiles are sold.

These inspections, combined with staff training about reflectance issues and the promotion of the particular characteristics of polished porcelain tiles, should stop all legitimate complaints.

Some sellers of tiles have tried to get some protection from consumer complaints by the use of disclaimers and showroom signs alerting customers to undertake such actions as inspecting their tiles in the lighting conditions prevalent in their projects before installation. Such procedures may be helpful, but customers may not have the ability to know what they should be looking for and problematic tiles could still get laid. Ultimately the responsibility for providing customers with product that does not cause complaint would appear to rest with the sellers.

Complications have arisen in some cases where a third party is involved in removing the transit wax after the tiles have been laid. The sellers of the tiles then maintained that the problems arose from the wax removal processes adopted by the third party. This may or may not be the case.

Some importers are insisting that the tiles that are supplied to them are not factory sealed; they then require the tiles to be sealed after laying. This may address sealer related surface marks that arise in the factory, but it is unlikely to have any impact upon the problems of shadowing and hazing. This factory sealing should not be confused with the transit wax. This wax is often applied whether or not the tiles are sealed at the factory.

Ultimately, the best solution is for the manufacturing process to be modified so the undesired effects do not appear, but at this stage it is uncertain what causes the effects, the effects cannot be validly and reliably measured and the effects are not technically defects. Therefore, fixing this problem at its source may be a slow process and there are likely to be innumerable complaints before the problems are eradicated at the factory.

It would appear that it is not the responsibility of consumers or even of well informed tile installers to undertake wax removal and in-situ reflectance testing of tiles before installation unless this was a specific instruction from the tile supplier. Both consumers and tilers need the confidence that the tiles that are to be laid will not have undesirable surface effects that only appear after the tiles have been laid and the protective wax removed.

Addressing the issue of undesired reflectance problems on tiles that have already been installed

From when the first complaints were received about reflectance effects on the surface of some tiles, attempts have been made to remove those effects. Dozens of different products and processes were used to try to strip, or clean, or seal or re-polish the tiles, without success. Varying degrees of success were achieved on the epoxy sealer marks using a hot burnishing technique, but the improvements were not always permanent and the marks sometimes came back when the tiles cooled. However, very recently, a methodology that involves chemically removing some of the gloss from the tiles, then restoring that loss of gloss with synthetic diamond polishing has been shown to dramatically reduce or completely remove the complained-of effects. This process is slow and expensive but it is still far cheaper, quicker and more environmentally friendly than removing the floor tiles and replacing them.



Photo No. 10. Shadowing on a floor in Sydney before treatment



Photo No. 11. The same area after de-glossing and re-glossing treatment. Note only the 4 tiles out from the doorway were treated as a test to meet customer satisfaction.

An example of a shadowing problem before and after the de-glossing and re-glossing treatment can be seen in **photos 10 & 11**.

A flow chart has also been developed which sets out a recommended procedure for handling consumer complaints about polished porcelain reflectance effects.

CONCLUSIONS

It is understood that manufacturers, importers and retailers of polished porcelain tiles have an obligation and a desire to satisfy customer expectations. However, there has been a spate of complaints about undesirable surface effects on this type of tile in Australia recently and complaints have also been lodged in the UK.

“Under these circumstances, there appears little to protect consumers, sellers, or manufacturers of polished porcelain tiles that exhibit these unwanted characteristics. But in the end, consumer protection legislation, along with consumer buying habits are likely to win out, and the tile industry has a problem which it needs to address”

The effects falling under the descriptions of “Optical hazing”, “Shadowing” and “Sealer marks” are real. They occur almost exclusively in tiles of Chinese manufacture. The effects are sometimes difficult to see and are only visible in certain lighting conditions. The severity of the effects can range from trivial through to readily visible and equating to a defect. Sometimes there are only a few tiles affected but usually there are many, sometimes the area where the effects are visible are relatively small and other times the area is large.

However, even in cases where the effects are obviously a manufacturing defect, the tiles meet the requirements for establishing surface quality set down in ISO 10545 part 2 section 7 because the viewing angle and the lighting requirements do not allow these effects to become observable. The list of defects that are noted in the ISO test method currently does not include haze or reflective characteristics of the surface of tiles.

There are several possible causes of the different manifestations that are causing complaint about the marks on the surface of some polished porcelain tiles. It has not yet been established exactly what causes the undesirable effects though thermally cured epoxy sealer is closely linked to one problem and tile surface geometry is possibly linked to shadowing and optical hazing. More technical and scientific studies into the causes appear justified if consumers are to be offered reasonable protection from polished porcelain tiles that display unwanted surface effects.

A problem also arises because there appears currently to be no objective way to measure or quantify these surface effects that are only visible in or beside low angle reflected natural light. The gloss meters, which have been shown to be valid and reliable in the paint and auto industries, are apparently not capable of discerning the marks that are causing complaint on the surface of polished porcelain tiles.

Under these circumstances, there appears little to protect consumers, sellers, or manufacturers of polished porcelain tiles that exhibit these unwanted

characteristics. But in the end, consumer protection legislation, along with consumer buying habits are likely to win out, and the tile industry has a problem which it needs to address. Eventually, there is likely to be some definitive standards and tests which will set allowable limits for the effects seen, but this is likely to be many years away.

In the end these unwanted surface effects are negatively impacting upon the image of polished porcelain tiles in the market place and it has led to profound dissatisfaction particularly when customers are advised their tiles are first quality and that technically the effects are not faults.

Fortunately, in the short term, careful inspection of a representative sample of the tiles in and beside a natural low angle light source should be able to identify tiles with these surface problems and stop them from being sold. This action should be accompanied by sales staff training and selling procedures that develop a close match between consumer expectations and tile performance.

For those cases where the problem has been complicated by the tiles being laid before the undesirable effects were noticed, then there is now a de-glossing and re-glossing procedure available that should address consumer complaints without the necessity to remove and replace tiles.

Eventually, these surface reflectance problems need to be addressed by the manufacturers and this will only occur if there are suitable scientific and technical studies undertaken by those associated with the industry.

RECOMMENDATIONS

Currently, the best method of avoiding consumer dissatisfaction because of the appearance of unwanted aesthetic surface effects on polished porcelain tiles is for systems of product inspection to be implemented.

Manufacturers, importers and sellers of polished porcelain tiles, particularly those emanating from China, should undertake routine inspections of representative samples of their products to ensure they do not exhibit the undesirable surface effects that are only visible in or beside low angle reflected natural light. This is likely to involve the removal of the thin wax coating applied over the surface of the tiles to protect them in transit.

Sellers of these tiles should implement some training and procedures to increase the likelihood that the performance and appearance of the tiles sold closely match the expectations of consumers.

If sellers of tiles that display these unwanted effects are found in a position where the tiles have already been laid and their customers are complaining, they should consider becoming involved with the treatment of the tiles with a de-glossing and re-glossing treatment currently only offered by one company in Australia.

In the longer term, the solution to this problem lies in altering the manufacturing processes that cause it. It would appear that the ceramic tile industry, particularly the Chinese manufacturers involved in the production of polished porcelain tiles, would benefit from technical and scientific studies that establish the cause or causes of optical hazing, shadowing and sealer marks on polished tiles.

Studies that could possibly be considered are:

- Methodologies for the identification and measuring of surface effects on polished porcelain tiles that are only visible in or beside low angle reflected natural light.
- Determining if the planarity of the surface of polished porcelain tiles is a factor in the appearance of optical hazing or shadowing only visible in or beside low angle reflected natural light.
- The effects of various light types and sources on the observability of unwanted surface effects on polished porcelain tiles
- The impact of sintering, porosity or polishing procedures on the appearance of unwanted visual effects on polished porcelain tiles when viewed in or beside low angle reflected natural light.
- Determining the impact that various types of factory applied sealer have on the appearance of unwanted surface effects on polished porcelain tiles
- The long term efficacy of the various types of factory applied sealers
- The efficacy of the post installation removal of undesirable effects on polished porcelain tiles

Once conclusive results from studies such as those listed above are available then ISO Technical Committee 189 may possibly be able to consider expanding the test methods for surface quality to include reflectance characteristics when it is reviewing the content of the international standards relating to ceramic tiles. **TT**

Colin Cass. B. Ed. Dip. T. (Technical), Techtile Consulting Pty. Ltd, Sydney, Australia. colin@cass.org

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