REFLECTIONS ON BUILT-UP AND BITUMINOUS ROOFING

How Energy Regulations Requiring Reflectivity Affect Traditionally Non-reflective Options

By Thomas J. Stock, CDT

Foreword

Bituminous systems have a long and proven history of waterproofing performance but have recently had to address increasing performance-based requirements imposed to conserve energy and protect the environment. These requirements typically revolve around minimum values for reflectivity and emissivity to keep heat off the roof and thereby reduce the cooling load in the building. Traditionally, asphaltic systems have had a layer of granules, gravel, or coating to protect the asphalt from the damaging effects of heat and ultraviolet radiation. These effects may cause the asphalt to more rapidly give up its oils, which accelerates the aging process. These surfacing layers were designed solely for protecting the asphalt, and therefore – with the exception of coating – were at a severe disadvantage when programs and legislation geared toward reflectivity and emissivity were enacted.

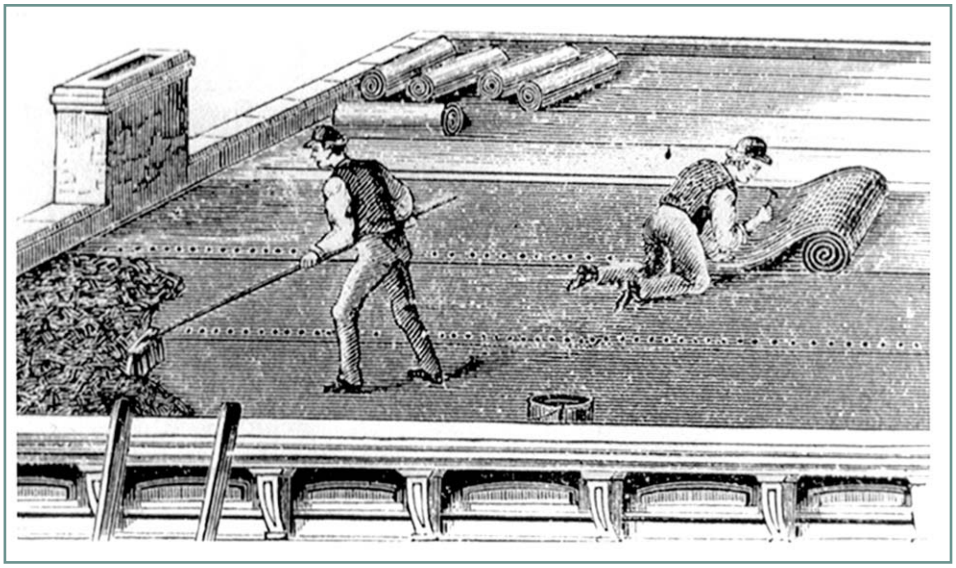
History

In what started as "composition roofing" in 1845, Samuel Warren devised a system comprised of pine tar applied over a substrate of paper. The paper reinforcement provided a base for the waterproofing pine tar and presumably introduced the concept of laps to the low-slope roof. The final step of broadcasting sand over the surface to protect the pine tar layer and add more durability completed this early roof assembly.

Years later, coal tar made its way onto the roof, replacing pine tar as the waterproof layer of choice, with gravel becoming the chosen protection layer. By 1880, natural asphalt was introduced onto the roof and asphalt and asphaltic systems have remained a prominent waterproofing material to this day.

Today's bituminous membranes are produced with refined asphalt and have been improved with reinforcements consisting of fiberglass, polyester, or a combination of the two. With the introduction of polymer modifiers such as SBS (styrene-butadiene-styrene) and APP (atactic polypropylene), the application methods and physical properties have benefited. These modifiers extended the useful temperature range of asphalt and expanded the application methods. Torchable and self-adhered membranes join traditional hot mopping and cold adhesive as accepted application methods. Polymer modifiers have helped ensure that elongation and recovery are now viewed as valuable properties, much as that of tensile strength. With many options

Traditional BUR installation methods work well for new factory-coated cap sheets.



Early days of composition roofing.

available and a proven history of performance by asphaltic membranes today, it is clear why they hold such a prominent position in the modern roofing market.

Modern Roofing Market

Today's roofing market is segmented as shown in *Figure 1*. EPDM, TPO, and PVC combine for a 38% share of the national roofing market as what are commonly referred to as "single plies." This description refers to the fact that these membranes are typically put down as the primary waterproofing for the roof in just one layer or ply. Though relatively new to the market when compared to bituminous membranes, these single-ply systems have quickly proven worthy of merit as demonstrated by their market share and recent growth curve.

Bituminous systems are comprised of BUR, SBS, and APP, and still command the prominent part of the roofing market with a 48% share. Of this bituminous market share, BUR has the majority stakehold at 19%. It is widely believed that a multiple-layer roof fosters a more forgiving method of application, as deviations in the application of a single layer may not compromise the waterproofing of subsequent layers. Therefore, it is seen as a more "bullet-proof" roof, and that is why it continues to hold a prominent market share and enjoys a fervent following by those who believe BUR to be the best roofing system available.

California is an excellent example of a proven BUR market. A behemoth of an economy, it ranks seventh in the world in Gross Domestic Product (GDP) if individual states were compared to the countries of the world. California's GDP is slightly less than China but has an economic capacity greater than Spain, South Korea, Mexico, and India.[1] It is the largest economy in the United States and therefore commands a large portion – if not the majority – of almost any national product segment. The roofing market in California alone represents 12% of the entire United States market, and its system of choice is built-up roofing. This system has a solid history in California as the state's temperate climate, combined with the relatively consistent and plentiful amount of labor, give BUR quite an advantage over other roofing systems. BUR has therefore claimed 45% of the roofing market in California,[2] where trends in energy and conservation often get their start.

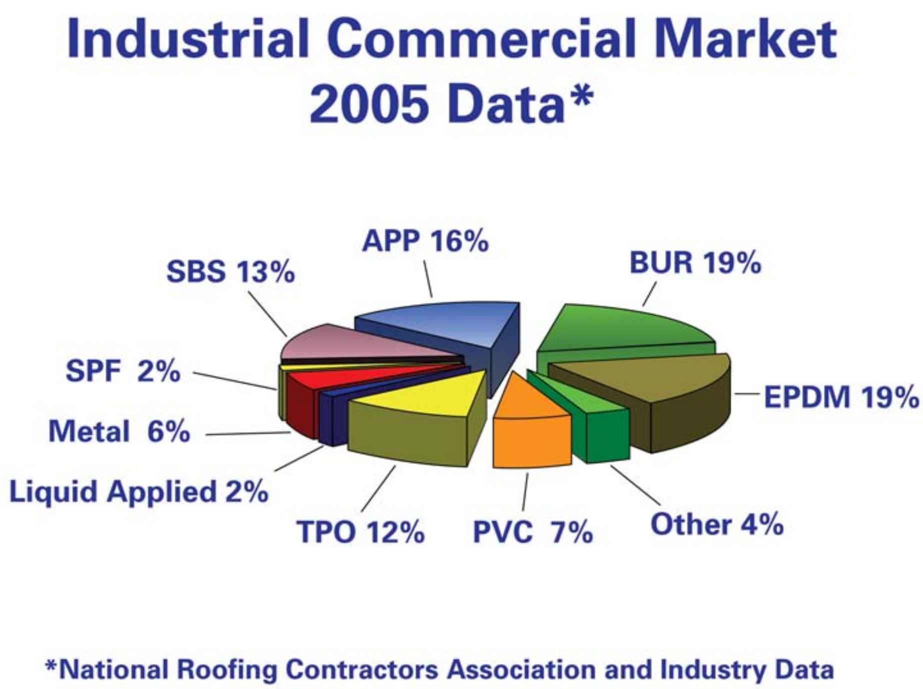


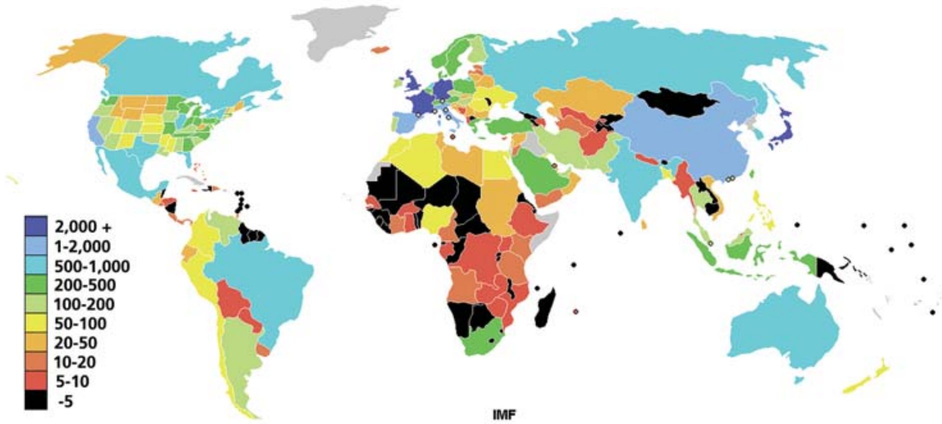
Figure 1.

Trends

Nationally, the trend toward energy conservation has been growing. The oil embargo of the 1970s started the conservation efforts and brought to our consciousness the need to conserve resources. But only recently have consistently high energy costs forced us to examine how we use, conserve, and save energy in all of its forms. This has been exacerbated by the rising price of oil as the energy we use for transportation, heating, air conditioning, and manufacturing has all been affected. Key phrases and words such as "urban heat island," "solar reflective index," "reflectivity," and "emissivity" have become commonplace in our everyday dealings as roofing professionals.

Realizing the significant contribution roofs make to the overall footprint of a changing and developing municipality, programs such as Energy Star® and LEED™ (Leadership in Energy & Environmental Design) have been created to facilitate the movement to a more energy-conscious building envelope and roof. Mandates and regulations have also been created by various states and municipalities to promote energy conservation with emphasis on the

Right: California economy in relation to economies of countries worldwide.



roof as a means to control some of the engineered environments within. The Chicago Energy Code is one such regulation that is starting to direct the roofing habits of that city and its surrounding areas, but the largest single regulation driving mandated energy savings is Title 24 in California.

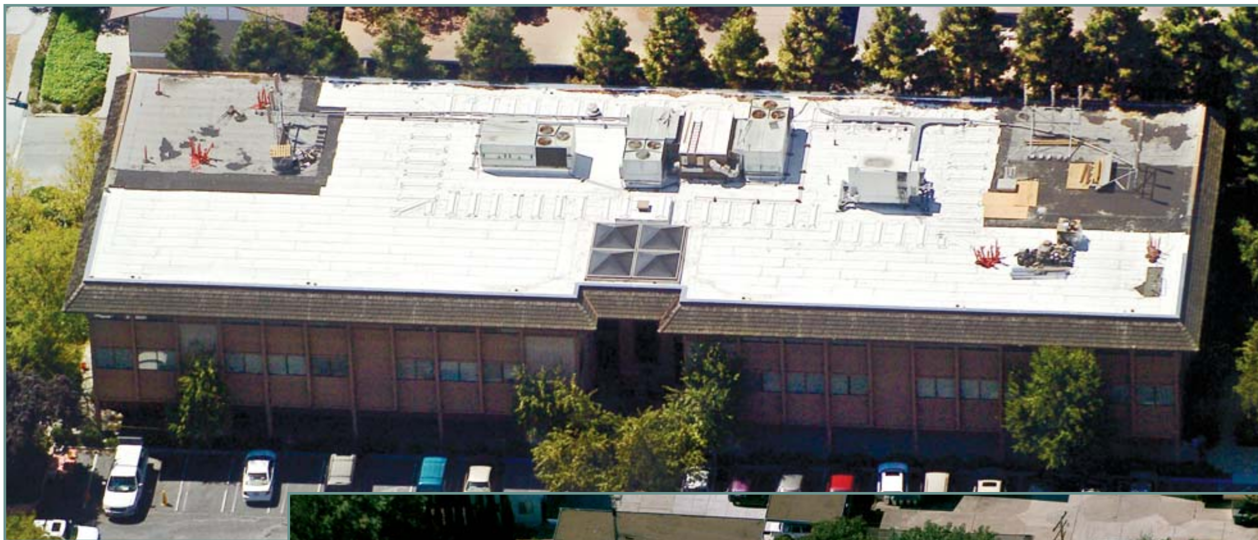
Energy Conscious

Title 24 went into effect in California on October 1, 2005. While it was brought about by the rolling blackouts that hit California in 2003, the state has been actively pursuing energy conservation since the Warren Alquist Act in 1978. Since that time, California has remained fairly constant in its annual energy consumption per capita at about 7,000 kilowatt hours (KWh). Meanwhile, the rest of the country has gone from a per capita usage of 8,000 KWh to 12,000 KWh, representing a 50% increase in less than 20 years with no sign of energy conservation![3]

Leading the country in energy conservation efforts, California set out to save its energy by setting mandates for the efficiency of a building. In the creation of Title 24, California would enact a Building Standards Code consisting of 11 parts, each focused on optimizing the building. Part 6 of Title 24 is defined as the "Energy Code" and was created as a building envelope conservation effort that assumed a certain size building could be optimized to stay within an "energy budget." This "energy budget" is based on a computer simulation of the building's one-year energy use. Low-slope roofing (defined as having a slope less than 2:12) plays a predominant part in achieving this budget.

As previous studies of the urban heat island effect can attest, lighter-colored roofing surfaces serve to reflect the sun's rays and therefore keep the surface of the roof cooler. This, in turn, reduces the solar load and heat transformation through the roof, thereby reducing the energy consumption load on the local municipality. The creators of Title 24, Part 6, took this into account, setting limits for both reflectivity and emissivity in the hopes of reducing the peak load on the energy infrastructure and thereby reducing the need for new power plants.

Mandating a certain reflectivity made sense, as the heat energy from light would be reflected away from the surface and keep



Factory-coated BUR cap sheet on Armado Plaza, Dublin, CA.

Factory-coated BUR cap sheet on Concord Center office building, Concord, CA.

the surface cooler. Emissivity would also play a key role in the code as both were regulated for minimum requirements. Emissivity is the ability of an object to give up heat. A high reflectivity does not ensure a high emissivity. A very good example is a piece of metal left in the hot sun. While it may be very shiny and very reflective, if left in the sun for very long, it becomes very warm to the touch and potentially very hot. It would not be very emissive in nature, explaining why no aluminum coatings to date (to the author's knowledge) meets the requirements of Title 24.

With the goal of driving energy savings and avoiding capital expenditures for added energy infrastructure, the required reflectivity was set at .70 and the emissivity set at .75 to comply with Title 24. It was a great plan that hit the California roofing market with a resounding wake-up call.

Bituminous systems traditionally have not had the advantage of single-ply systems in terms of their color variation, particularly when considering the light-colored single plies, which are very reflective and emissive by their nature. Additionally, smoother surfaces tend toward better reflectivity values. The granulated surfaces of BUR cap sheets therefore act as an impediment to reflectivity, meaning smoother is better. Since built-up roofing (BUR) commands 45%[4] of the roofing market, what would become of California's most prized membrane?

The Challenge

When considering the desired reflectivity obtained from Title 24 legislation, traditional asphaltic-based systems were at a significant disadvantage. BUR cap sheets covered with "white" granules would typically only achieve a 30% reflectivity reading,[5] due in large part to the coverage of the granules and therefore the ability of the reflectometer to see the asphalt background. The jagged surfacing of the granule coating also hampered the existing surface from meeting Title 24 compliance. These factors made for a discontinuous "white" coating, according to the reflectometer, and resulted in low reflectivity readings. Even going to "super-bright" granules would not alleviate this problem, as it was inherent in the topography of the granules and appeared to dampen the future of built-up roofing in its largest market. Solutions outside bituminous membranes already existed, and it was anticipated that Title 24 would perpetuate these solutions and grow their markets.

Coating the surface was considered to be the only viable solution for the BUR market. The creators of Title 24 had anticipated this by legislating a minimum 20-mil thickness on any field-coated application. The thickness of the coating was intended to provide the required reflectivity regardless of the uniformity of the substrate. However, a 20-mil minimum requirement almost assured a two-phase application process, as it can be virtually impossible to apply a sound coating of 20 mils in only one pass. Additionally, manufacturers often require a base and top coat be applied as good roofing practice.

Realizing this two-coat process would most assuredly add cost to a BUR installation and put this system at a disadvantage versus other membrane options, manufacturers quickly went to work to create a solution that would keep built-up roofing a viable and cost-effective solution in California.

The Solutions

Factory-applied coating became a primary emphasis, as it would provide the advantages of controlling the coating thickness and the curing process, and ultimately save the additional labor step of post-coating on the roof. If all of these points were to come to fruition, it became clear that BUR would then be able to compete (if not enjoy a cost advantage) compared to other membrane options.

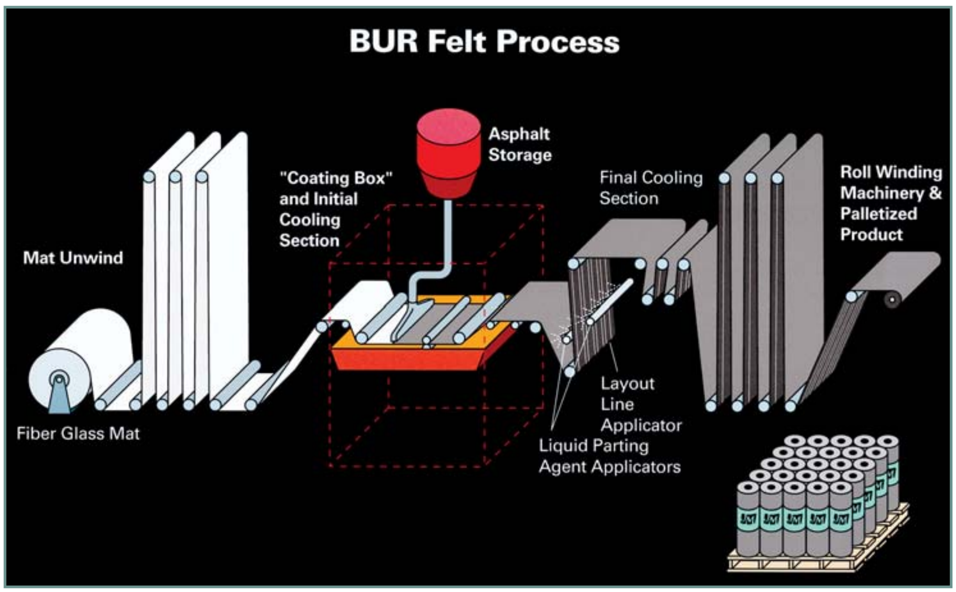
A seemingly good solution would be to coat the sheet after it had been processed through the manufacturing line. This off-line process would involve taking finished rolls and unrolling them to apply a Title 24-compliant coating. Once dry, the membranes would be rolled again, labeled, packaged, and sent out into the field. In practice, this process is very difficult to control, as ensuring correct coating thickness is difficult and air-drying usually takes an inordinate amount of time (sometimes days). Additionally, foreign matter (debris, dirt, etc.) can become embedded into the coating before the drying process is complete.

In-line processes would therefore appear to be more desirable if a quality product could be achieved. Creating a quality product involves controlling many parameters, including: coating chemistry, coating uniformity, coating thickness, and cure. Manufacturers must test a sample of the finished product with the CRRC (Cool Roof Rating Council) to achieve values to meet Title 24, and they must also ensure that the quality produced on the line conforms to those standards.

Drying time is a major obstacle to quality that must be overcome with an in-line coating process. BUR lines often run ply felts at around 1,000 ft/min, and cap sheets typically run around 300 ft/min. This rate of speed can certainly bolster production numbers but means that incorporating new technology into a manufacturing process can often be quite a challenge. For example, the time from application of the asphalt to the virgin reinforcing mat for a cap sheet, to when a finished roll is produced, is usually measured in a matter of minutes. If a manufacturer were to consider applying a coating on-line somewhere in the process (presumably after the asphalt is applied), there would be only minutes for this coating to dry. Knowing that the sheets serpentine their way (and will contact the top and bottom surfaces numerous times on rolls) through cooling sections of a machine to try to cool the sheet before it is wound, this would appear to be quite a daunting task. For manufacturers with the means, modified bitumen manufacturing equipment would seem to be an option to consider, since modified lines usually run slower (about 150 to 200 ft/min). However, modified cap sheets are usually much thicker than BUR cap sheets, and therefore inherently have their own difficulties with coating, including additional mass to cool and the increased amount of asphaltic oils that must be controlled and kept from discoloring the newly applied coating.

Though coating a modified bitumen sheet is achievable, the thickness adds a degree of difficulty not found in BUR; it essentially becomes a question of dealing with the BUR speed or modified thickness. Because it is thinner, the BUR cap sheet provides an excellent substrate if the right combination of coating chemistry, application method, curing, and conveyance can be found that works with the limited amount of time available in the manufacturing process. The coated BUR cap sheet would have a clear advantage, assuming that the solution met the specifications of Title 24 and industry standards. Additionally, the product cannot deviate too much from standard products in order to gain the trust of the roofing industry.

Few products meeting these criteria were available when Title 24 became law on October 1, 2005, but the offerings have grown steadily since. One such product is a BUR cap sheet that has provided many lessons on coating application and field performance during its development. This new product has many innovative features in



Typical built-up roofing manufacturing process.

the way it is manufactured and applied, which has the potential of pushing the industry toward preserving the built-up market in California.

A primary innovation in the product was going to a finer granule. Standard roofing granules are a designated size and are found on most granulated asphaltic cap sheets. This cap sheet utilized granules that were sifted to a smaller size but provided the same protective surface trusted by the roofing community. The smaller granules not only allowed for a smoother surface on which to apply the coating but, according to the ASTM scrub test, also added an unforeseen benefit of greatly increasing the granule adhesion.

In order to compete with field-applied coatings and ensure a durable surface, the solids content of the in-line coating was greatly increased. Field application of a coating with such high solids would be virtually impossible. Additionally, the process inside the plant ran better at high speeds. The sheet was able to maintain its heat through the application process and the energy used to dry the coating could be utilized in drying, not in re-heating the sheet.

Finally, performance on the roof was evaluated. The new BUR cap sheet performed very well in all accelerated testing and proved both durable and aesthetically pleasing when installed. This solution proved that the bituminous industry could be both innovative and adaptive as it works toward preserving the market share for asphaltic systems in California.

Today there are a variety of other options available to address Title 24 and keep the built-up roofing system as a viable option. From a hybrid system consisting of modified plies with a compliant BUR cap sheet to a traditional BUR system with a BUR cap sheet that is also compliant upon installation, BUR now has the products it needs to compete for the low-slope roofs of California.

Conclusion

With the efforts of many manufacturers and through the valuable input from those who specify asphaltic systems, BUR solutions for Title 24 are now readily available. As energy conservation regulations and programs spread across the country and become more prevalent and numerous, it is expected that what was learned in California will be a foundation for continuing to keep asphaltic systems relevant and a viable option when considering properties such as reflectivity and emissivity.

BUR has always been a solid and reliable waterproofing system, but the system as a whole now has more options to appeal to those looking for an energy-conscious, redundant system. These solutions allow built-up roofing applicators and specifiers to continue to utilize the membrane system they feel will give them the best roof possible.

Referemces

1 *www.Wikipedia.org* – "Comparison Between US States and Countries' Nominal Gross Domestic Products."
2 2005 ARMA and industry data.
3 Lawrence Berkeley Lab data.
4 Johns Manville reflectometer testing data.
5 Ibid.

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T.J. Stock is the western region application engineer in charge of the group supporting roof consultants, architects, and other specifiers in the western half of North America for Johns Manville. After five years installing can plants internationally, T.J. joined Johns Manville in 1998 as a project engineer working to install new roofing membrane and insulations plants in various locations throughout North America, including Macon, Georgia, and Fernley, Nevada. From there, he was promoted into the New Product Development Group, becoming a Six Sigma Black Belt while helping to develop and launch new products such as CleanBond® Self-Adhering SBS, Invinsa® Roof Board, and GlasKap CR®. He was then promoted into the Application Systems Group to lead the western region in support of the specifying community for application inquiries regarding building science, rooftop design, code and regulation compliance, and product and systems specification.

SILICOSIS THREATENS ROOFING PROFESSIONALS

According to a recent publication (NIOSH No. 2006-110) by the National Institute for Occupational Safety and Health (NIOSH), respiration of silica by roofing professionals has only been recognized as a health hazard recently. NIOSH has measured breathable silica levels up to four times recommended exposure limits when roofing tiles are cut during the installation process. The cutting generates clouds of silica-containing dust. Exposure may also occur when blowers or dry sweeping methods are used to clean the roof, creating large, silica-containing dust clouds. Anyone who inhales dust generated by cutting cement tiles or cleaning the residue will be exposed to respirable silica, placing them at risk for developing silicosis.

Silicosis is a lung disease caused by breathing dust with silica. The term "respirable silica" is used for silica particles that are small enough to be inhaled and deposited in the deepest parts of the lung. If workers inhale too much respirable silica dust, it causes scar tissue to develop in the lungs, resulting in silicosis. Lung damage may be permanent and disabling and may lead to death. There is no cure for silicosis, but it can be prevented.

For more information, visit **www.cdc.gov/niosh/docs/2006-110/**.

