WHAT DOES NIOSH THINK ABOUT ALL OF THIS? A FEDERAL RESEARCH AGENCY'S PERSPECTIVE & STRATEGIES TO PREVENT SILICOSIS

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Abstract: NIOSH describes the sandblasting silicosis hazard, health effects of some silica substitutes, the need for safe substitutes, and plans to study the substitutes' health effects and effectiveness.

SANDBLASTING SILICOSIS HAZARD

Merewether estimated almost 60 years ago that 5.4% of the sandblasters in his 1936 Great Britain study died from silicosis in a 3.5 year time period (1). A 1980 Department of Labor Interim Report to Congress on Occupational Diseases estimated that more than 1 million U.S. workers are still exposed to crystalline silica, and approximately 59,000 of these workers have a high risk of developing silicosis (2). NIOSH estimated in a 1974 study on abrasive blasting respiratory practices that approximately 100,000 of these workers are employed as abrasive blasters with personal exposures to silica dust environments up to sixty million manhours per year (3).

The NIOSH Alert - Request for Assistance in Preventing Silicosis and Deaths from Sandblasting described 99 cases of silicosis from exposure to crystalline silica during sandblasting. The youngest worker was only 22 years old. The average silica exposure time was less than ten years. Fourteen of these patients are known to have died of respiratory failure caused by silicosis. Unfortunately, no one knows how many recent deaths as a result of silicosis from sandblasting that have not been diagnosed (4).

OTHER COUNTRIES' BANS OR RESTRICTIONS ON BLASTING MEDIA WITH CRYSTALLINE SILICA

Because of the high risk for silicosis in sandblasters and the difficulty in controlling exposures, the United Kingdom prohibited the use of blast abrasives containing free silica through its 1949 Blasting Regulations. This prohibition applied in factories and similar workplaces, but in practice excluded the blasting of buildings or bridges that may involve the use of blast media containing free silica. However, it has been the policy of the United Kingdom's Health and Safety Executive Agency to discourage the use of materials containing free-silica in all blasting operations (5). These regulations were replaced by the 1988 COSHH Regulations, which contained the same restrictions regarding abrasive blasting as the 1949 regulations (6).

Sweden's Health Ordinance AFS 1983:14 states that "Silica-containing material must not be used as a blasting agent in manual blasting. Exceptions are blasting in an enclosed blasting booth with a local exhaust and wet blasting where the blasting agent is added to water." Section 3 of this same ordinance defines silica-containing material as material containing more than 3 percent by weight of silica (7).

Germany's concerning regulations concerning hazardous industrial substances (TRGA) to Appendix II, No. 3 prohibits the use of sand and other sandblasting products containing more than 2% in weight of quartz or other crystalline forms of silicon dioxide. However, these provisions contain exemptions. One exemption is sandblasting on constructions and objects that are predominantly made of materials with a high quartz content such as sandstone, quartzite, or concrete. A second exemption is sandblasting on outer surfaces of constructions and objects standing in the open air that cannot be sandblasted in enclosed areas, provided the sandblasting material cannot be recovered. Competent authorities may make other exceptions in certain justified cases if they determine that there is no risk of injury to the health of employees (8).

Belgium's 1978 Royal Order to amend Parts II and III of the General Labour Protection Regulations prohibits the use of sand or other materials containing more than 1% crystalline silica for abrasive blasting or sand removal procedures. Again, there are major exemptions. This prohibition is exempted if the abrasive blasting operation is carried out in hermetically enclosed rooms, booths, or appliances that are designed for abrasive blasting. However, these rooms must adhere to many provisions such as efficient dust removal systems, isolation of the blaster during operations, and opening of the rooms only after the dust has settled. The other major exemption is blasting on large surfaces or fixed constructions, such as ship hulls, pylons, and metal frameworks where it is technically impossible to substitute a less harmful product for silica (9). Finally, even the small country of the Republic of Surinam has prohibited blasting with any substance containing more than 1% crystalline silica (with major exemptions) (10).

NIOSH recommended in 1974 and again in 1992 that silica sand or other blasting materials that contain more than 1% free silica be prohibited as an abrasive blasting material (4, 11). This recommendation has still not been adopted on a national scale. Today, NIOSH still strongly recommends that silica sand or other blasting materials that contain more than 1% free silica be prohibited as an abrasive blasting material.

RESULTS OF NIOSH STUDIES REGARDING FIBROGENIC AND CARCINOGENIC EFFECTS OF COAL, COPPER, AND NICKEL SLAGS

Because of the well-known hazards of exposure to crystalline silica in abrasive blasting that were previously described, substitutes for silica sand have been used in abrasive blasting for many years. However, little information concerning the toxicity of these materials was known prior to their introduction into commerce. Therefore, NIOSH commenced a series of biological studies of three of the more common abrasive blasting substitutes: coal, copper, and nickel slags. In NIOSH's initial 1980 study by Mackay, the fibrogenic effects of one coal slag and two copper slag samples were examined via intratracheal instillation in rats (12). Pulmonary interstitial fibrosis was seen in the coal slag-treated rats, while no fibrosis was seen in either copper slag treatment group. Granulomas were seen in the lungs of all slag treatment groups. A copper slag used in Poland was proven to be weakly fibrogenic by Szymczykiewicz in 1984 (13).

A second NIOSH study by Stettler investigated the carcinogenic and fibrogenic potentials of two copper slags and one nickel slag which were known to contain varying amounts of the suspect carcinogens arsenic, beryllium, chromium, and nickel (14). Only a slight to minimal alveolar wall fibrosis was seen in the rats treated via intratracheal installation with either copper slag, while the response seen with the nickel slag was consistent with a foreign body reaction. No granulomas were seen in any of the slag-treated animals. Statistically significant, but lesser percentages (9% - 13%) of primary lung tumors (adenocarcinomas and adenomas) were seen in the copper slag treatment groups than in two silica control groups.

A third NIOSH animal study by Stettler investigated further the fibrogenic potential of four different coal slags compared to a quartz positive control (15). A mild to moderate interstitial fibrosis was noted in each of the coal slag groups. However, the coal slag-induced lung fibrosis was much less than that produced by the quartz sample. Other data from this study, including lung hydroxyproline content, pulmonary particulate burdens, pulmonary function, and animal body weights, provided further evidence of a reduced toxicity for the coal slags compared to quartz.

In summary, a total of four coal slags, three copper slags, and one nickel slag have been evaluated in our laboratory. In every instance, the extent of lung fibrosis associated with the slag exposures was much less severe than that seen with quartz. Differences in fibrogenic potentials among the coal slags were relatively minor.

While our data clearly show coal slags to be less fibrogenic than quartz, moderate levels of fibrosis were seen for these materials. However, given the artificial nature of the route of exposure (intratracheal instillation), the large doses used in our studies, and the potential for dust overload, chronic inhalation studies at multiple dose levels are needed to better define the fibrogenic potential of these materials, as well as their carcinogenic potentials.

CURRENT NIOSH IN VITRO ASSAYS FOR SILICA SAND AND SIX SUBSTITUTE ABRASIVES

NIOSH has commenced in vitro assay studies on silica sand, coal slag, garnet, staurolite, iron oxide, and silica sand treated with a dust suppressant. Silica sand will serve as a positive control and iron oxide as a negative control for these studies. Coal slag is being studied since it is the most common substitute; garnet and staurolite have minimal amounts of hazardous ingredients when compared to the other substitutes so they are being studied as potential minimally hazardous or "nonhazardous" substitutes. Treated sand is being studied as another type of positive control. For each of these abrasives, NIOSH selected the brand that had the highest amount of tons sold to the abrasive blasting industry in 1992 to make the study representative of materials that are common to the abrasive blasting industry. Each of these six abrasives were ground to a respirable size of 5 micrometers by a ball mill in order to make the in vitro assay study representative of the dust particles that would enter the respiratory tract of an abrasive blaster. These abrasives were also characterized by the number of particles per gram weight since this factor could influence the toxicity of the abrasives.

NIOSH PLANS TO COLLECT MORE HEALTH-RELATED DATA ON SILICA SAND AND ALL SUBSTITUTE ABRASIVES

NIOSH also plans to conduct in vitro assays on other substitute abrasives in the future. These abrasives may include the following: steel grit, aluminum oxide, crushed glass, olivine, nickel slag, and copper slag. NIOSH also plans to conduct in vivo animal studies via intratracheal instillation on substitute abrasives other than the coal, copper, and nickel slags that were previously studied by Stettler. Quartz will be used as a positive control, with the possibility of coal slag also being used as a positive control and for comparisons to Stettler's studies. The selection process for the abrasives that will be used for these in vivo animal studies will rely on the results of the in vitro assays that were previously described. If any of these abrasives are found to produce adverse health effects, proposals will be made by NIOSH to the National Toxicology Program (NTP) to commence additional long-term animal pathology studies. NIOSH also plans to collect economic, technical, and health-related data for silica sand and eleven substitutes for silica sand in an abrasive blasting laboratory or enclosed booth and at selected field site(s) via a contract.

NIOSH has also collected exposure data regarding crystalline silica and harmful metal levels from various abrasive blasting operations for silica sand, garnet, staurolite, coal slag, steel grit, and olivine. This data is somewhat limited since these surveys were conducted in different abrasive blasting environments which blasted upon different substrates; therefore, comparisons of exposure levels between these different abrasives cannot be drawn. The NIOSH project that will be conducted via a request for contract will collect crystalline silica and harmful metal exposure data for silica sand and eleven substitute abrasives in a homogenous environment so comparison between different abrasive exposure levels can be drawn. NIOSH plans to conduct abrasive blasting surveys for crystalline silica and lead levels during 1996. These surveys will probably involve substitute abrasives for which we have no current exposure data.

TOPICS FOR 1996 NIOSH PUBLICATION ON SUBSTITUTES FOR SILICA SAND IN ABRASIVE BLASTING

NIOSH plans to publish a technical report entitled "Assessment of Substitute Materials for Silica Sand in Abrasive Blasting." Some of the topics that will be discussed in this report regarding silica sand and substitute abrasives include: (1) physical properties, (2) chemical and elemental composition, (3) toxicity, (4) prices and operating cost comparisons, (5) applications, and (6) the United States and other countries' regulations, bans, and/or restrictions. Hopefully, this report will be published in 1996.

1998 NIOSH WORKSHOP

NIOSH has preliminary plans to sponsor a 1998 abrasive blasting workshop when all of the data about silica sand and substitutes for silica sand has been gathered from the following NIOSH projects and publications: (1) in vitro assays and animal pathology studies, (2) NIOSH technical report, (3) and the request for contract project.

CLOSING

Information was provided in this paper to show alternatives to abrasive blasting with silica. However, abrasive blasters must consider the potential health effects of substitutes for silica sand until the current and future research which was previously described is completed. Therefore, any one "best" substitute cannot be identified, but clearly blasting with silica sand or other blasting materials that contain more than 1% crystalline silica is unacceptable. Abrasive blasters should always use the proper engineering controls and personal protective equipment that is essential in abrasive blasting since lead, silica, and any other potential hazards may be contained in the surfaces being blasted. Finally, please read the NIOSH Alert regarding recent deaths due to sandblasting and take up your share of the responsibility to stop these needless illnesses and deaths due to the use of silica sand in abrasive blasting.

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