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**HETA 2000-0134
SFO International Terminal
San Francisco**

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PREFACE

The Field Studies Branch (FSB), Division for Respiratory Disease Studies, of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

FSB also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Paul Hewett and Karen Kestenberg of FSB, Division of Respiratory Disease Studies (DRDS). Analytical support was provided by Division for Applied Research and Technology. Desktop publishing was performed by Terry Rooney.

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Health Hazard Evaluation Report 2000-0134
SFO International Terminal
San Francisco
February 2001

Paul Hewett
Karen Kestenberg

SUMMARY

On January 31, 2000 NIOSH received a confidential request for a Hazard Evaluation (per 40 CFR Part 85) at the San Francisco International Airport (SFO) International Terminal. This airport terminal was then under construction and, according to the requestor, several trades had been routinely and repeatedly exposed to dusts containing fireproofing material and dusts containing epoxy resin, resulting in various respiratory complaints (e.g., irritation, sinus and ear infections, breathing difficulties, flu-like conditions) as well as bloody noses, headaches, and skin rashes. Numerous workers had reported to the on-site health clinic with these complaints, while others obtained medical assistance from private or other medical services.

The primary exposure was to the dust generated when removing fireproofing and during the cleanup by dry sweeping of accumulated fireproofing materials. Because the primary dust generating activities occurred during 1998 and 1999, the NIOSH response was confined to the following:

- ! evaluation of the Material Safety Data Sheets for the fireproofing materials
- ! analysis of several bulk samples of fireproofing materials
- ! a review of the various exposure surveys conducted by Cal-OSHA, the contractor, and SFO
- ! discussions and interviews with those involved
- ! analysis of a brief survey form sent to roughly two dozen current and former workers.

After consideration of the (a) the MSDS's for the Cafco® and Monokote® fireproofing, (b) the previous company and Cal-OSHA surveys, (c) review of the various documents (e.g., work practice guidelines) submitted, and (d) discussions with numerous employees and review of the information forms provided by employees, we conclude that it is likely that dusts resulting from fireproofing materials present more risk to exposed employees that would be expected from substances that truly are "inert or nuisance dusts".

Exposures to each individual worker, construction worker (regardless of occupation or subcontractor) or airport maintenance employee, should be minimized or eliminated through some effective combination of work practices, worker and employer training, work practices, and feasible engineering controls (e.g., wet removal and cleanup, use of dust suppression cleanup materials, vacuum removal at time of removal). If exposures - both full-shift and within-shift peak exposures - are not reliably controlled by the above means, then the employer should provide and require respiratory and other personal protection.

Keywords: SIC 1629 (Heavy Construction, Not Elsewhere Classified), Construction, fireproofing materials, PNOC, PNOR.

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INTRODUCTION

On January 31, 2000 NIOSH received a confidential request for a Hazard Evaluation (per 40 CFR Part 85) at the San Francisco International Airport (SFO) International Terminal. This airport terminal was then under construction and, according to the requestor, several trades had been routinely and repeatedly exposed to dusts containing fireproofing material and dusts containing epoxy resin, resulting in various respiratory complaints (e.g., irritation, sinus and ear infections, breathing difficulties, and flu-like conditions) as well as bloody noses, headaches, and skin rashes. The requestor stated (personal conversation) that numerous workers had reported to the on-site health clinic with these complaints, while others obtained medical assistance from private or other medical services.

The request implicated dusts generated during the installation and removal of fireproofing materials, when surface finishing terrazzo chipping and dry cutting of concrete, and during the application of epoxy-based materials. The primary exposure was to the dust generated when removing fireproofing and during the cleanup by dry sweeping of accumulated fireproofing materials.

The dust generating activities occurred during 1998 and 1999. According to the local California-OSHA (Cal-OSHA) office and the primary contractor (Tutor-Saliba), the construction activities at the site at and after the time of the request involved mostly finish work.

Based upon conversations with the requestor, the primary concern was with the possible health effects related to exposures to fireproofing dust, and the appropriate combination of controls (engineering, work practice, personal protection) that should be used to prevent excessive exposures and any resulting health effects. Given that the exposures occurred during 1998 and 1999, we restricted our response to the following activities:

- ! evaluation of the Material Safety Data Sheets for the fireproofing materials
- ! analysis of several bulk samples of fireproofing materials
- ! a review of the various exposure surveys conducted by Cal-OSHA, the contractor, and SFO
- ! discussions and interviews with those involved
- ! analysis of a brief survey sent to roughly two dozen current and former workers.

BACKGROUND

The city of San Francisco is expanding SFO, to include a new international wing. The work site is controlled by Tutor-Saliba, the primary contractor. Early in the construction process fire proofing materials were sprayed wet onto most interior surfaces. Various occupations, employed by the numerous subcontractors involved in the project, were required to scrape off the dried fireproofing material in order to complete construction activities. The process of scraping off the fireproofing, and subsequent cleanup tended to generate dust.

Fireproofing Materials

Although the request mentions other types of exposures, the primary concern was with dermal (skin) and inhalation contact with fireproofing material dusts. Fireproofing materials are generally applied to structural steel and concrete components of new commercial construction. The purpose of the fireproofing is to insulate and protect the steel from weakening during a fire. In the past, asbestos was frequently a component of such fireproofing materials. Today, fireproofing materials are typically cementitious (e.g., Portland cement-based mixtures containing varying amounts of gypsum, limestone, and fibrous binders). Fireproofing is generally sprayed on wet or moist, which permits it to adhere to surfaces in any orientation. Sometimes a harder "top coat" is applied, particularly when the fireproofing is not completely enclosed or covered.

Formulations are also marketed for repairing small sections where the fireproofing had to be removed (e.g., when installing other equipment or building components).

The fireproofing material, once dried, is extremely friable (e.g., capable of being easily crumbled or reduced to powder). In most commercial construction this is not a problem, as the steel beams coated with fireproofing are quickly enclosed as floors and walls are installed. However, in large construction projects, such as airports, the fireproofing is used to coat a wider range of surfaces, to include access and electrical tunnels, and consequently remains exposed and accessible for longer periods. Other trades must then remove (by scraping) fireproofing in order to weld on the steel beams, or to install electrical systems, baggage handling components, ventilation ducts, and plumbing (Martyny, 2000; Epling, 1995).

Dust Generating Activities

According to the requestor, the electrical workers were required to scrape off the dry fireproofing materials prior to installing electrical conduit and junction boxes. Workers in other occupations were exposed when installing HVAC equipment, baggage conveyors, walls and partitions, ceilings, and prior to welding on structural steel. These activities tended to generate dust, as did the cleanup of the accumulated fireproofing material. The general laborers removed detached and accumulated fireproofing material by dry sweeping, although there were instances when leaf blowers were used. Cleanup activities generated clouds of particulate which exposed workers in other occupations in the vicinity. Efforts were made to reduce dust levels. As sweeping compound was required when dry sweeping, the use of leaf blowers was eliminated. The documents indicate that these guidelines were not uniformly used. By most accounts, piles of fireproofing materials were often allowed to accumulate, leading to re-entrainment due to vehicular and foot traffic.

Health Problems Reported

The request indicated that workers were experiencing “bloody noses, difficulty breathing, sinus infections, ear infections, irritated throat, headaches, skin rash, and flu-like symptoms.” These conditions were associated with (a) spraying and removal of fireproofing and epoxy resin materials, (b) the chipping and dry cutting of concrete, and the grinding of terrazzo, and (c) the application of epoxy-based materials. Because the primary concern was with the dust generated during the removal and cleanup of the fireproofing materials, we decided to restrict this investigation to the fireproofing related issues. (Enclosed is a NIOSH Alert on *Preventing Silicosis and Deaths in Construction Workers, which provides advice on the concrete and terrazzo exposures.*)

According to the requestor, many workers visited the on-site health clinic - the OCIP (Owner Controlled Insurance Program) clinic - operated by SFO. But in the requestor’s experience, complaints were dismissed as being due to colds or sinus/upper airways infections (and treated with antibiotics).

Company Exposure Control and Work Practice Guidelines

According to the documents reviewed, there were continuous and numerous complaints regarding high dust levels and dermal exposures. These complaints started during the installation of the fireproofing materials and continued through 1998 and 1999. Sometime in early 1999, Tutor-Saliba distributed to all sub-contractors a single page work practice guideline entitled “Requirements for Safe Handling of Fireproofing material (Monokote, Cafco)”, dated February 5, 1999. This guideline (reproduced as Appendix A) required that “all workers” be properly trained and educated regarding “safety procedures associated with fireproofing materials use.” These procedures included wetting the fireproofing material when removing or scraping fireproofing material, catching and disposing of the removed material, and use of protective equipment, to include appropriate respirators.

METHODS

Because the majority of the exposure generating activities were discontinued, no field survey or site visit was conducted. Instead, we were limited to (a) an evaluation of the Material Safety Data Sheets for the fireproofing materials; (b) an analysis of several bulk samples of fireproofing materials; (c) a review of the various exposure surveys conducted by Cal-OSHA, the contractor, and SFO; (d) discussions and interviews with those involved; and (e) an analysis of a brief survey form sent to roughly two dozen current and former workers.

Bulk Samples

A representative of Tutor-Saliba provided us with several bulk samples of the raw and installed fireproofing materials. These samples were analyzed for mineral and fiber content, as well as for pH (basic or acidic nature). The intent was to compare the analytical results to the information provided by the manufacturers in the MSDSs.

Each bulk sample was analyzed for mineral and fiber content using polarized light microscopy. The laboratory procedures used were consistent with those outlined in Method 9002 for "Asbestos (bulk)" of the NIOSH Manual of Analytical Methods. The pH was determined by suspending one gram of each bulk sample in 50 milliliters of de-ionized water. Indicator strips were immersed and read immediately after suspension and after twenty-four hours.

Worker Survey Form

We sent a brief survey form to nearly two dozen workers who, according to the requestor, may have experienced similar problems. Other current and former workers, hearing of this investigation, independently contacted us, thus providing additional insight into the situation. The form was mailed to the 22 workers on a list supplied to NIOSH on July 31, 2000 from the confidential requestor. The cover letter and survey form (see Appendix B) was designed to solicit information from current and

former tradesmen regarding duration and frequency of contact with fireproofing materials at the San Francisco Airport terminal during 1998-1999, the use of respiratory protection, and health complaints. A NIOSH self addressed envelope was included for the returned confidential response.

RESULTS

Review of the Material Safety Data Sheets

The requestor implicated both Monokote® and Cafco® fireproofing materials. According to the primary contractor only the Cafco® products were used during the construction of the International Terminal. However, the requestor and other workers claim that Monokote® products were also used at the International Terminal. As was mentioned earlier, the safe handling guidance sheet issued by SFO on February 5, 1999 (see Appendix A), applied to both Cafco® and Monokote®. The products appear to be similar enough that our conclusions and recommendations apply to both products, and perhaps to fireproofing materials in general.

Cafco® fireproofing materials

Copies of the following MSDSs were provided by the requestor: Cafco® Blaze-Shield® II, Cafco® 300, Cafco® Top-Cote, Cafco® Fiber-Patch, and Cafco® Deck-Shield I. The hazardous ingredients information for each of the Cafco® fireproofing products are listed in Table 1. The relevant exposure limits suggested by the manufacturer are consistent with those in Table 3. Each MSDS suggests that the fireproofing material consists of low toxicity compounds. For example, for the Cafco® 300 MSDS the manufacturer simply listed "nuisance particulates" as the only hazardous ingredient. Yet in the various MSDSs are one or more of following cautions:

- "Inhalation over long periods of high amounts of any nuisance dust may overload lung clearance mechanism [*sic*] and may make the lungs more vulnerable to respiratory disease."

- “Some studies conducted over the past 50 years seem to indicate that mineral wool and fiberglass production workers, employed during 1930-1950, have a somewhat higher risk of lung cancer than the average population. These studies did not take into account smoking habits and exposure to other known carcinogens. Current research has failed to confirm those earlier findings.”

- “Avoid inhalation of dust during use. Avoid skin and eye contact.”

- “May provoke asthmatic response in persons with asthma who sensitive to airway irritants.”

Monokote® fireproofing materials

Copies of the following MSDSs were provided by the requestor: Monokote® Type MK-6/ED and Type MK-6/HY. The ingredients of the Monokote® products are listed in Table 2. The MSDS’s for these products also list cementitious substances, but use styrene polymer and cellulose instead of mineral wool as the fibrous component. The MSDS suggests that the nuisance dust exposure limits are appropriate for nearly all of the ingredients.^a However, the MSDSs also contain the following precautions:

- “Exposure to excessive airborne dust may cause coughing, sneezing, and dyspnea (shortness of breath, labored breathing). Long term inhalation of dust may increase the risk of pneumoconiosis (“dusty lungs”), and may also decrease lung function.”

- “If inhaled, get fresh air. [sic] If symptoms of irritation occur and persist, consult a physician.”

^aThe MSDS indicates that virtually zero percent of the product is “silica, quartz”. However, the March 28, 2000 version of the MSDS (available from the W.R.Grace Construction Products website) indicates that current formulations contain 5% silica by weight.

- “Where NIOSH-approved respiratory protection to prevent employee exposures from exceeding the limits specified ...”

The Monokote® MSDS’s contained fairly explicit guidance regarding safe and appropriate work practices:

- “Remove fireproofing materials in a manner so as to minimize the creation of dust. All [emphasis in original] trades must exercise work practices which avoid creating dust. This may be accomplished by:

- N Wetting fireproofing materials using water, prior to its removal.

- N Removing small areas of fireproofing at one time.

- N Maintaining a clean worksite.”

Analysis of Bulk Samples

Analysis using Polarizing Light Microscopy

Cafco® Blaze-Shield II, both unused and applied, consisted of roughly 55-60% glass fibers of varying diameters, which is consistent with the MSDS listing of mineral wool as a major component (see Table 4). Other components detected were non-fibrous glass (10%) and a variety of minerals (30%), including quartz (crystalline silica) and feldspar. Percent composition estimates determined using light microscopy are approximate, but these estimates are consistent with information in the MSDSs. No asbestos materials were detected.

pH determination

The unused Cafco® and Monokote® materials had a pH of 10 to 11, indicating that they are fairly basic (alkaline) (see Table 4). The pH at the point of deposition in the pulmonary system could be higher. The used materials had essentially neutral pH’s of 6 to 7.

Review of Company and Cal-OSHA Surveys

The requestor provided us copies of: (a) several company-sponsored exposure assessment surveys, (b) a study apparently sponsored by the manufacturer

of the Cafco® fireproofing products, and (c) copies of several Cal-OSHA compliance assessment surveys performed by the Cal-OSHA office in Foster City, CA. We obtained copies of additional Cal-OSHA surveys through the Foster City office. The OSHA surveys were generally directed toward subcontractors of Tutor-Saliba. Since all of the surveys dealt with either dust from fireproofing materials or dusts generated when working with broken concrete (one of the concerns of the requestor), we chose to view the concerns of the requestor as being generic in nature, affecting nearly all workers and nearly all subcontractors. A brief summary of each of these surveys can be found in Appendix D.

Most the surveys found that exposure measurements were below the (general industry) OSHA limit for respirable nuisance dust and the ACGIH TLV for mineral fibers. Of the few measurements collected during concrete breakup work, two were at or just above the OSHA general industry limit of 0.1 mg/m³ for respirable crystalline silica.

Regarding the Cal-OSHA surveys, there were citations for failure to implement a effective injury and illness prevention program, implement a hazard communication program, provide hand protection and suitable clothing when dealing with fireproofing materials, to monitor exposures when dealing with broken concrete, and for not using “allaying media” (i.e., dust suppression) media.

The surveys - whether Cal-OSHA or other - were consistent in recommending that good work practices and wet methods be used to reduce the dust exposures. We were struck by the relatively small number of company-sponsored surveys and exposure measurements, especially considering the intensity of the complaints during 1998 and particularly 1999. The few surveys conducted and the few measurements collected per survey shed little light on what was by nearly all accounts an uncomfortable situation for many of the employees.

Summary of the Workers Information Sheets

Of the twenty two information sheets mailed, fifteen were returned to NIOSH.

Both skin and inhalation exposure was reported by all respondents. With the exception of one drywaller who worked at the SFO between 1998-1999, all respondents were either electricians or journeyman electricians. Seven out of fifteen sought medical attention, the remainder did not. Workers who sought the intervention of a physician were diagnosed (unconfirmed) with the following: severe nose bleeds requiring cauterization, bronchitis, pneumonia, asthma, multiple sinus infections, and “influenza type symptoms.” Upper respiratory complaints from individuals not seen by a physician consisted of nose bleeds, sore throat, eye irritation, sneezing, cough and shortness of breath. Also itchy, dry skin was reported in four cases. While some employees used the disposable dust masks provided by the subcontractor, seven out of fifteen stated that they did not receive any instruction regarding respiratory protection. Several individuals indicated that they were instructed to spray the fireproofing with water to cut reduce the dust.

Our brief inquiry was limited to those workers for which we had contact information. Several other current and former workers, upon hearing of our effort to acquire more information, called us directly to express concern regarding exposures and health effects. Their trades included carpenters and ceiling and wall installers. We do not know what fraction of the hundreds of workers in the multiple trades that were involved over the period of construction were exposed to fireproofing, and of that fraction what fraction had complaints or concerns. It is fairly certain, however, that the health related complaints and concerns were not restricted to the requestor.

DISCUSSION

Similar exposures and health effects to those reported at the SFO were noted by Epling et al. (1995) during the construction of the Denver international airport during the early 1990's. The

investigators described “work-related respiratory and flulike [sic] symptoms” in construction workers who were exposed to fireproofing dusts, particularly in the electrical access tunnels. Several explanations for the health effects were examined. The investigators proposed that the febrile and flu-like illnesses seen among indoor workers were related to irritant and alkaline dusts from fireproofing and/or cement. They noted that at this site the fireproofing materials were applied early on in the construction process, followed by the spot removal by other workers in “poorly ventilated areas.” They encouraged further study into the relationship between exposure to alkaline dust and fireproofing dusts to respiratory illness. They also observed that dust exposures tended to be less than the OSHA respirable and total PNOR standards, but that “these standards failed to protect workers” from these illnesses.

Observations

Several observations are suggested from the information that we assembled, as well as from conversations with representatives of SFO, Tutor-Saliba, and individual workers:

- ! Fireproofing material was sprayed onto a wide range of surfaces and that these surfaces remained open and exposed throughout 1998 and 1999.
- ! During the application of fireproofing materials there was little attempt to limit the over-spray, or to clean up the accumulated over-spray.
- ! During 1998 and 1999, and to a lesser extent during 2000, several trades were required to remove fireproofing.
- ! Workers reported that in order to do their job it was necessary to scrape off fireproofing on nearly a daily basis. It was routine for a worker to first remove fireproofing before the doing the work required of the subcontractor.
- ! According to the work practice guidance developed for this construction project (see Appendix A), workers removing the fireproofing had primary responsibility for cleanup and disposal. However, often the removed

fireproofing was allowed to accumulate, to be removed later by the general laborers. For a period of time the general laborers frequently used dry sweeping and leaf blowers when removing the accumulated fireproofing.

- ! A one-page safe work practices guideline was developed by SFO in early 1999 and distributed to Tutor-Saliba and the subcontractors. However, worker interviews indicate that workers in some trades (carpenters for example) were unaware that such a guideline existed. Some contractors abided by the guideline, while others ignored the safe handling and personal protection recommendations.
- ! Several investigations by either Cal-OSHA, SFO, or consulting firms indicated that during the surveys the measured exposures to total or respirable particulate did not exceed the “nuisance” dust limits of 15 mg/m³ for total dust and 5 mg/m³ for respirable dust. Yet, complaints persisted, suggesting either: (a) that the nuisance dust exposure limits were inappropriate for assessing worker risk regarding fireproofing, (b) periodic, but unmeasured high exposures occurred, or (c) both.
- ! Those workers responding to our information request or those who called our office were consistent in complaining of excessive exposures to and frequent contact with fireproofing materials. Workers frequently reported persistent cough, bloody noses, upper respiratory tract irritation, skin irritation and rashes, all associated with exposure to or contact with fireproofing materials.
- ! These complaints are not unique. Similar complaints were registered during the construction of the Denver International Airport. These complaints and the subsequent investigation were described by Epling et al. (1995). The authors concluded that the dust from alkaline fireproofing materials was most likely responsible for the “respiratory and flulike symptoms” reported.
- ! Many of the workers that called us had never been informed of either (a) the MSDSs and their cautions and good work practice/personal protection recommendations, or (b) the good

work practice and respirator use guidelines issued by SFO.

- ! The MSDSs for both the Cafco® and Monokote® fireproofing products contain contradictory information. Both manufacturers suggest that the ingredients present only a low level, “nuisance” hazard. In contrast, both manufacturers go on to indicate that high or prolonged exposures have the potential to increase worker susceptibility to respiratory disease, cause lung damage, or even present a carcinogenic potential. It can be argued that substances or mixtures that have such significant health effects do not qualify for the “nuisance” dust designation.
- ! Even if the nuisance dust limits apply, they are not meant to be applied to extreme, short-term exposures as might occur during the dry sweeping and shoveling of fine powders.
- ! The analysis of the bulk samples provided by Tutor-Saliba indicated that the constituents of the fireproofing materials were consistent with the ingredients indicated in the MSDSs.

CONCLUSIONS AND RECOMMENDATIONS

There appeared to be some confusion at the SFO International wing construction site about who was responsible for what, and when. This opinion is based upon our conversations with the various parties involved in this investigation, and upon a review of the Cal-OSHA citations and other documentation. It is not the purpose of this report to sort out the differing or overlapping responsibilities of: (a) SFO as the owner of the construction project, (b) Tutor-Saliba as the general contractor, and (c) each of the various subcontractors. The purpose of this report is to review the background of the complaint, consider the available information regarding the conditions and exposures that occurred during 1998 and 1999, evaluate the available toxicological and exposure limit information, and suggest appropriate and reasonable guidelines when

dealing with Cafco®, Monokote®, and similar fireproofing materials.

After consideration of: (a) the MSDS’s for the Cafco® and Monokote® fireproofing, (b) the previous company and Cal-OSHA surveys, (c) review of the various documents submitted (e.g., work practice guidelines), and (d) discussions with numerous employees and review of the information forms provided by employees, we conclude that it is likely that dusts resulting from fireproofing materials present more risk to exposed employees that would be expected from substances that truly are inert or nuisance dusts.

Given the uncertainty regarding the potential health effects caused by routine and/or episodic high inhalation and dermal exposure to fireproofing dusts, we recommend that such mixed dusts not be treated as if they were simply inert or a nuisance dust. In the absence of a valid and scientifically defensible industry- or manufacturer-supplied exposure limit, exposures should be highly controlled.

Exposures to each individual worker (e.g., construction worker, regardless of occupation or subcontractor, or airport maintenance employee) should be minimized or eliminated through some effective combination of worker and employer training, work practices, and feasible engineering controls (e.g., wet removal and cleanup, use of dust suppression cleanup materials, vacuum removal at time of removal). If exposures, both full-shift and within-shift peak exposures, are not reliably controlled by the above means, then the employer should provide and require respiratory and other personal protection. Respiratory protection is utilized only when all feasible options have been tried and failed to completely control exposures.

The single-page guidance sheet developed by the SFO, and distributed to the contractor and subcontractors, contained a considerable amount of common-sense guidance regarding work-practices and use of personal protection equipment. Below are similar recommendations in the following areas:

- employee awareness and training
- personal protective equipment
- exposure assessment
- exposure limits
- interpreting exposure survey information
- extended workshifts
- susceptible employees
- maintenance and other activities
- material safety data sheets

Employee Awareness and Training

Documentation and personal accounts suggest that compliance with the guidance sheet developed by SFO (see Appendix A) was irregular. Workers in a variety of trades reported that they were not aware of the guidance sheet, were never provided or informed of the provisions in the MSDSs, nor provided suitable respiratory protection (other than the occasional paper dust mask).

Hazard Communication Employers are obligated to ensure that each employee is made aware of the physical and chemical hazards associated with the job. If a new or unexpected hazard presents itself, even if it is the direct result of other subcontractors doing their work, the employer is obligated to inform the employees of the risks involved. This includes the presentation of hazard information and safety handling procedures as contained in the MSDS of the substance in question. The primary contractor is obligated to provide appropriate information to the subcontractor regarding the activities and hazards associated with nearby and concurrent construction activities.

Training Employers are obligated to ensure that each employee is adequately trained in the safe installation, handling, and removal of fire proofing materials.

Personal Protective Equipment

Respiratory Protection Respiratory protection should be provided for those activities, e.g., installation, removal, and maintenance of fireproofing materials, where engineering and other

controls do not eliminate or substantially reduce exposure to both inhalable and respirable dust. Engineering and work practice controls such as, but not limited to wetting, use of allaying materials, and engineering controls (e.g., high efficiency vacuums), should be tried and evaluated for the different activities and tasks present at a construction site.^b Such workers should be enrolled in a respiratory protection program as described in 1910 CFR 1926.103. OSHA provides a quick guide to the basic elements of a respiratory protection program at their website (<http://www.osha.gov>).

Personal Protective Clothing Appropriate clothing should be required and provided. As a precautionary measure, clothing contaminated with fireproofing dust should be collected and cleaned by an appropriate cleaning service. Dust-contaminated clothing that is worn home contaminates vehicles and exposes family members to workplace hazards (e.g., when shaking out dirty clothes prior to washing).^c

^b29 Code of Federal Regulations 1926.103(d): “In the control of those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, *the primary objective shall be to prevent atmospheric contamination* [emphasis added]. ... When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to the following requirements.”

^cTake-home exposures have been known to occur, and have often resulted in family members developing occupational disease without occupational exposure. reference: NIOSH (National Institute for Occupational Safety and Health): Report to Congress on Workers’ Home Contamination Study Conducted Under The Workers’ Family Protection Act (29 U.S.C. 671a). DHHS (NIOSH) Publication No. 95-123 (1995).

Eye protection and face-shields Goggles, safety glasses with side shields, or face-shields should be used whenever there is a potential for eye and face contact with fireproofing material or dust.

Exposure Assessment

The measurements collected in this case by the contractor and the airport were too few and scattered for us to develop an impression that exposures were routinely controlled to levels well below the limits found in the MSDS's. The airport, contractor, and subcontractors should develop an exposure assessment program that ensures that reliable data are collected. Guidance on how to develop a rational, defensible exposure monitoring program and strategy is readily available; for example see Damiano and Mulhausen (1998) and ASTM (1998, or later). General guidance can be found in OSHA's Appendix B to the formaldehyde standard (OSHA, 2000).

No one strategy or approach is applicable in all circumstances and situations. But some exposure monitoring is necessary for establishing a baseline against which later measurements are compared, for evaluating the contribution of different tasks and activities to overall exposure, and for evaluating any improvements gained from specific engineering controls or work practices. Exposure monitoring is required when selecting the appropriate respirator(s), and for the periodic evaluation of the degree of employee exposure when employees use respirators.

Baseline exposure monitoring Exposure monitoring should be performed for each job/activity and shift combination that comes into contact with fireproofing materials and dust. Guidance from the industrial hygiene profession suggests that at least six to ten measurements, per job/activity and shift combination, are necessary for a baseline exposure assessment (Damiano and Mulhausen, 1998).

Periodic exposure monitoring Periodic exposure monitoring is necessary for determining if the worksite, work practices, or controls have changed, resulting in greater exposures. For stable manufacturing environments, periodic monitoring should be done at least once per year (Damiano and Mulhausen, 1998). For dynamic, rapidly changing work environments, such as construction sites, periodic exposure monitoring should be performed more frequently, perhaps synchronized with major changes in activities, or at least monthly or quarterly. A new baseline should be established whenever the work environment, tasks, jobs, and/or materials change in any substantial manner.

Task-based exposure monitoring Exposure monitoring during specific tasks permits the employer to determine the relative contribution of the task to the overall exposure. For example, knowledge that Task A comprises 10% of the workshift, but contributes 90% of the exposure, would be useful for prioritizing attention to work practice and engineering controls. When respirators are required, task-based exposure monitoring is the only means for determining if the short-term exposures exceed the maximum use concentration for the respirator selected. Direct reading instruments - if calibrated to a particular dust or the results are interpreted conservatively (i.e., with the protection of the employees in mind) - can be used to evaluate both peak exposures and contribution of tasks/activities to overall exposure.

Eye and skin (dermal) exposure assessments Inhalation is not the only route of exposure. Particulates, particularly if they are acidic, basic (alkaline), and/or contain fibrous materials, can be extremely irritating to the eyes and skin. Each job, task, and shift combination should be evaluated - by both observation and employee discussions - to determine the frequency, duration, and extent of such contact. Appropriate clothing and face/eye protection should be required and provided whenever the potential for eye and face contact exists.

Exposure Limits

The legal limits for most of the constituents of fireproofing materials are over thirty years old. We recommend that employers use the more recent NIOSH and ACGIH recommended exposure limits. These are generally lower, reflecting newer information and concern regarding exposures to such materials. For low toxicity dusts that meet the requirements for classification as a PNOR or PNO, we recommend that both the ACGIH PNO TLV's of 10 mg/m³ for inhalable dust and 3 mg/m³ for respirable dust be used to evaluate exposures to the upper airways (nasal, larynx, and tracheo-bronchial regions) and alveolar (gas exchange) regions of the lungs, respectively. When mineral wool or glass fibers are present, we recommend that the ACGIH TLV of 1 fiber per cc for mineral wool (fibrous glass; synthetic vitreous fibers) be used.

Exposure to mixtures of dusts When dealing with mixtures of substances, the recommended practice in industrial hygiene is to assume, in the absence of information to the contrary, that the effects are at least additive. That is, even when the exposure to each component is less than its respective exposure limit, the combined effect can still be detrimental to the respiratory system. We recommend that employers consider the components of fireproofing materials to at least have additive effects.

The ACGIH TLV booklet (ACGIH, 2000) contains a brief discussion regarding how to assess exposures to mixtures. If each component has the same exposure limit, the exposure limit for the mixture is the same as for each component. If components have different exposure limits (e.g., calcium sulfate versus crystalline silica), but are measured in the same units (e.g., milligrams per cubic meter, mg/m³), then the additive formulate approach can be used to calculate a specific exposure limit for the mixture. If the units for the exposure limits are different (e.g., mg/m³ versus 'fibers per cc'), then the 'unity formula' approach discussed by the ACGIH is appropriate. Additional guidance regarding dealing with exposures to mixtures can be found in the following references: Ballantyne (1985), Krystofiak and Schaper (1996), and Craig et al. (1999).

Interpreting Exposure Survey Information

Just as there is no one exposure sampling strategy applicable to all circumstances and situations, there is no one scheme for interpreting exposure measurement data, survey information, worker interviews, and field observations. In the recommendations above we provide general guidance regarding exposure sampling and selection of exposure limits. The American Industrial Hygiene Association monograph on exposure assessment and management (Damiano and Mulhausen, 1998) should be consulted for additional, and more specific, guidance on developing a reasonable and defensible decision logic for evaluating and interpreting exposure data relative to legal or authoritative exposure limits (e.g., OSHA "TWA PEL" or ACGIH "TWA TLVs"). Below are several recommendations for an employer decision logic:

- Compare exposure measurements to the ACGIH exposure limits. Substantial compliance with the ACGIH exposure limits^d virtually ensures compliance with the dated regulatory limits.
- Peak exposures during each shift should infrequently exceed three times the full-shift, TWA exposure limit, and rarely exceed five times the limit. See the guidance provided by the ACGIH regarding within-shift excursions (peak exposures) (ACGIH, 2000).

Extended Workshifts

The OSHA and other exposure limits were intended for application to standard 8-hour workshifts, for 5 days per workweek. When workshifts extend beyond 8 hours per day, or total to more than 40 hours per week, there is reduced time for employees to recover from the cumulative workday and

^dThe ACGIH recommends (Damiano and Mulhausen, 1998) that the employer be highly confident that 95% or more of the full-shift, TWA exposures are less than the TWA exposure limits.

workweek exposures. Because the protection afforded by exposure limits is decreased under such conditions, standard practice in industrial hygiene is to reduce the exposure limit to account for the decreased recovery time. The ACGIH (ACGIH, 2000) provides general guidance and references on reducing exposure limits in such instances. (The OSHA lead standard for construction explicitly requires that the lead PEL be reduced whenever workshifts exceed 8 hours (OSHA, 2000). Additional guidance can be found in Brief and Scala (1975, 1986) and Verma (2000).

Susceptible Employees

All of the exposure limits discussed in this report are premised on the notion that the employee(s) in question are healthy adults, with no preexisting conditions or individual susceptibilities. Because all workforces consist of a cross-section of society, there will always be some fraction of workers who will experience adverse reactions or develop occupational disease at exposure levels that have little effect on others. Factors that increase this fraction include: (a) control of exposures to exposure limit that are dated and inadequately protective, (b) frequent uncontrolled high exposures (peak exposures), and (c) failure to properly evaluate exposures to mixed dusts. Employers should be cautious about exposing employees to inhalation hazards, such as fireproofing dusts, particularly when the MSDS's contain contradictory or incomplete information.

Maintenance and Other Activities

It can be expected that there will be maintenance or other activities where employees are likely to come into physical contact with installed fireproofing material, will be required to remove or repair fireproofing materials, and/or will be exposed to airborne fireproofing dust. Activities that disturb the fireproofing and result in skin and/or inhalation exposure should be strictly controlled. SFO maintenance and other workers should be trained in the proper procedures for removing, disposing, and repairing fireproofing materials. If visible dust is generated - e.g., a cloud of dust that persists for more

than a few seconds - the workers should at a minimum be provided filtering face-piece respirators. Such workers should be trained in the proper use of respirators and enrolled in a respiratory protection program provided by the employer. The procedures presented here, as well as those listed in Appendix A and in the MSDSs, should be adequate for protecting maintenance workers.

Material Safety Data Sheets

It is common for MSDSs to contain incomplete or contradictory information, or to have either overly cautious or inadequately cautious protection recommendations (Kolp et al., 1995; Welch et al., 2000). The employer should contact the supplier or manufacturer whenever there is an indication that the guidance in the MSDS is not adequate or does not apply to a specific or unique situation. For example, an indication that exposures - inhalation, eye, and/or dermal - may constitute a greater problem than suggested by the MSDSs would be the consistent and corroborating worker complaints and visits to occupational health clinics.

Crystalline silica The latest version of the MSDS for Monokote® MK6/HY indicates that the current formulation contains 5% quartz (crystalline silica). The PNOR and PNOC exposure limits require that crystalline silica in the respirable dust be less than 1%. Given this restriction of use, neither the PNOR nor PNOC criteria apply. The MSDS should, therefore, contain guidance on an appropriate exposure limit that provides greater protection than the PNOR or PNOC exposure limits.

SUMMARY

We conclude that it is likely that dusts resulting from fireproofing materials present more risk to exposed employees that would be expected from substances that truly are inert or nuisance dusts. Exposures to each individual worker, construction worker or airport maintenance employee, should be minimized

or eliminated through some effective combination of work practices, worker and employer training, work practices, and feasible engineering controls (e.g., wet removal and cleanup, use of dust suppression cleanup materials, vacuum removal at time of removal). If exposures - both full-shift and within-shift peak exposures - are not reliably controlled by the above means, then the employer should require and provide respiratory, and other personal protection.

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Table 1
Cafco® fireproofing products. All information was taken from the supplied MSDSs
HETA 2000-0134

Cafco® Product	Hazardous Ingredients *	Exposure Limit	Other Information
Blazeshield® II (MSDS dated 9/14/95)	technical white mineral oil	5 mg/m ³ oil mist (OSHA)	(a)
	mineral wool	15 mg/m ³ (OSHA) 10 mg/m ³ (ACGIH)	
Top-Cote (MSDS dated 1/6/99)	<none list>	--	(b)
Fiber-Patch (MSDS dated 9/15/95)	mineral wool	15 mg/m ³ (OSHA) 10 mg/m ³ (ACGIH)	(c)
Deck-Shield I (MSDS dated 9/15/95)	technical white mineral oil	5 mg/m ³ oil mist (OSHA and ACGIH)	(d)
	mineral wool (nuisance particulates)	15 mg/m ³ (OSHA) 5 mg/m ³ (OSHA respirable) 10 mg/m ³ (ACGIH)	
300	nuisance particulates	15 mg/m ³ (OSHA) 5 mg/m ³ (OSHA respirable) 10 mg/m ³ (ACGIH)	(e)

* Percent (%) by weight was not provided in the MSDS's

- (a) chemical family - silicates and calcium sulfate
formula - mineral wool, inorganic binders, and technical white mineral oil
- (b) chemical family - vinyl chloride copolymer
- (c) chemical family - silicates and calcium sulfates
formula- mineral wool and inorganic binders
- (d) chemical family - silicates and calcium sulfates
formula - mineral wool, inorganic binders, and technical white mineral oil
- (e) chemical family - silicates, calcium sulfates, and aluminates
formula - perlite and inorganic binders

Table 2
Monokote® fireproofing products. All information was taken from the supplied MSDSs
HETA 2000-0134

Monokote® Product	Hazardous Ingredients (% by weight)	Exposure Limit	Other Information
Type MK-6/HY (MSDS dated 6./22/98)	calcium sulfate (80%)	15 mg/m ³ (OSHA) 5 mg/m ³ (respirable - OSHA) (a) 10 mg/m ³ (ACGIH)	(b)
	hydrous aluminum silicate (4%)	none established	
	hydrous magnesium aluminum [silicate] (4%)	none established	
	limestone (4%) [calcium carbonate]	15 mg/m ³ (OSHA) 5 mg/m ³ (respirable - OSHA) 10 mg/m ³ (ACGIH)	
	nuisance particulates (0%)	15 mg/m ³ (OSHA) 5 mg/m ³ (respirable - OSHA) 10 mg/m ³ (ACGIH) 3 mg/m ³ (respirable - ACGIH)	
	silica, quartz (0%)	0.1 mg/m ³ (respirable - OSHA) 0.1 mg/m ³ (respirable - ACGIH) 0.05 mg/m ³ (respirable - NIOSH)	
Type MK-6/ED (MSDS dated 4/6/93)	gypsum (80%) (calcium sulfate)	15 mg/m ³ (OSHA) 5 mg/m ³ (respirable - OSHA) (a) 10 mg/m ³ (ACGIH)	(c)
	quartz (<3%)	0.1 mg/m ³ (OSHA) 0.1 mg/m ³ (ACGIH) 0.05 mg/m ³ (NIOSH)	
	calcium carbonate (4% max)	15 mg/m ³ (OSHA) 5 mg/m ³ (respirable - OSHA) 10 mg/m ³ (ACGIH)	
	hydrous aluminum silicate (4% max)	15 mg/m ³ (OSHA) 5 mg/m ³ (respirable - OSHA) 10 mg/m ³ (ACGIH)	
	hydrous magnesium aluminum silicate (% not given)	15 mg/m ³ (OSHA) 5 mg/m ³ (respirable - OSHA) 10 mg/m ³ (ACGIH)	

(a) OSHA PEL for general industry

(b) formula - blend of gypsum, hydrous magnesium, aluminum silicate, styrene polymer, and cellulose

(c) formula - blend of gypsum, clay, styrene polymer, cellulose, and chopped glass filament

Table 3
Evaluation Criteria
HETA 2000-0134

Substance	OSHA PELs * (construction industry)		ACGIH (2000) * Threshold Limit Values (TLVs)			NIOSH * Recommended Exposure Limits (RELs)		
	PEL	type of sample	REL	type of sample	health effect/ target organ	REL	type of sample	health effect/ target organ
calcium sulfate (gypsum)	15 mg/m ³ 5 mg/m ³	total dust respirable dust	10 mg/m ³ (a)	total dust	irritation	10 mg/m ³ 5 mg/m ³	total dust respirable dust	physical irritation
calcium carbonate (limestone)	15 mg/m ³ 5 mg/m ³	total dust respirable dust	10 mg/m ³ (a)	total dust	irritation	10 mg/m ³ 5 mg/m ³	total dust respirable dust	moderate skin irritation, severe eye irritation
mineral wool or fibrous glass (synthetic vitreous fibers)	15 mg/m ³ 5 mg/m ³	total dust respirable dust	1 f/cc **	respirable fibers (b)	irritation (c)	3 f/cc ** (f) 5 mg/m ³	respirable fibers total dust	eye, skin, and respiratory effects
oil mist (white mineral oil)	15 mg/m ³ 5 mg/m ³	total dust respirable dust	5 mg/m ³	total mist (d)	lung	5 mg/m ³ 10 mg/m ³	total mist total mist (short term) (g)	respiratory effects
silica, crystalline	250 mppcf	impinger and particle count	0.05 mg/m ³	respirable dust	pulmonary fibrosis, silicosis	0.05 mg/m ³	respirable dust	chronic lung disease (silicosis)
PNOR (OSHA) PNO (ACGIH) (i)	15 mg/m ³	total dust	10 mg/m ³ 3 mg/m ³ (a)	inhalable dust respirable dust (e)	lung	(h)		

* Unless otherwise indicated, all exposure limits refer to exposures for a typical 8-hour work shift.

** f/cc = fibers per cubic centimeter (or milliliter)

*** Particulates Not Otherwise Regulated

(a) Applicable to dusts containing no asbestos and less than 1% crystalline silica.

(b) Measurement technique should measure respirable fibers greater than 5 µm in length with an aspect (length to width) ratio greater than or equal to 3.

(c) The ACGIH has classified mineral wool as a confirmed animal carcinogen with unknown relevance to humans.

(d) Mist should be sampled by method that does not collect vapor.

(e) For more information see Appendix D of the ACGIH 2000 TLV booklet (ACGIH, 2000).

(f) Measurement technique should measure fibers greater than or equal to 10 µm in length and less than or equal to 3.5 µm in diameter.

(g) Applies to peak exposures as measured over a fifteen minute period.

(i) Particulates Not Otherwise Regulated and Particulate Not Otherwise Classified - inert and nuisance dusts

(h) NIOSH's position is that there is insufficient information to support the OSHA PEL of 15 mg/m³ (total dust) for inert and nuisance dusts (NIOSH, 1997)

Table 4
Composition and pH of Cafco® Blazeshield® II and Cafco® 800
HETA 2000-0134

Material	Composition	pH
Cafco® Blazeshield® II (unused)	glass fibers (mineral wool) - 60% non-fibrous glass - 10% mineral fragments (including quartz* and feldspar**) - 30%	10-11
Cafco® Blazeshield® II (applied)	glass fibers (mineral wool) - 55-60% non-fibrous glass - 10% mineral fragments (predominantly calcite***) - 30%	6-7
Cafco® 800 (hard coat) (unused)	glass fibers (mineral wool) - 50% non-fibrous glass - 10% mineral fragments (predominantly calcite) - 40%	11
Cafco® 800 (hard coat) (applied)	glass fibers (mineral wool) - 50-60% non-fibrous glass - 10% mineral fragments (predominantly gypsum****) - 30%	6

* e.g., silicon dioxide

** e.g., group of minerals consisting of potassium, sodium, or calcium aluminosilicates.

*** e.g., calcium carbonate

**** e.g., hydrated calcium sulfate

Requirements for Safe Handling of Fireproofing Material (Monokote, Cafco)

All workers must receive training/education in the safety procedures associated with fireproofing materials use.

Mixing

- Face shield, dust mask required.

Spraying Monokote, Cafco Blaze Shield

- Safety glasses, dust mask, and protective gloves required.
- Rain gear or water-resistant coveralls recommended.

Spraying Cafco Top Cote

- Organic cartridge respirators or disposable organic mask required. Must be NIOSH approved for this use.
- Splash goggles and vinyl or rubber gloves required.
- Loose fitting long sleeved shirt or coveralls.
- Written respiratory protection program.
- Medical evaluations for capability of wearing respirators.

Spraying Cafco Bond Seal

- Chemical goggles and vinyl or rubber gloves required.
- Safety glasses and respirators required. Respirators must be NIOSH approved for paint fumes.
- Written respiratory program.
- Medical evaluations for capability of wearing respirators.

Removal/Scraping

- Dust mask and safety glasses required.
- Wet down or dampen the surface to be removed.
- Position collection bags to collect falling material.
- Clean up any Monokote spillage on the floor.
- Wear loose fitting long sleeved shirt for skin protection.
- Cloth gloves recommended.

Cleanup

- Dust mask and safety glasses required.
- Wet down or dampen prior to sweeping and collecting.
- Must be done end of operation or end of shift – whichever is sooner.

Area

- Post "Slippery when wet" signs where appropriate.

Personal Hygiene

- If you need to wash after skin contact, wash in cold water.

February 5, 1999

Appendix B

Date

Name

Address

Address

Dear ____:

On January 31, 2000, NIOSH, the National Institute for Occupational Safety and Health, received a confidential request for a Health Hazard Evaluation* to investigate complaints relating to the use and removal of fireproofing materials from wall surfaces and structural steel. The worksite involved is the new San Francisco Airport International Terminal. The airport terminal is currently under construction, and according to the requestor, several construction workers were routinely exposed to various dusts. The requestor indicated that the primary concern was with exposure dusts generated when scrapping fireproofing materials and later when cleaning up, and disposing of the accumulated fireproofing material.

It is our understanding that the dust generating activities occurred during 1998 and 1999, and that current activities do not result in similar dust exposures. Consequently, we are evaluating the available relevant data and information regarding conditions as they existed at the construction site. To date we have obtained and reviewed copies of various material safety data sheets (MSDS), OSHA inspection reports, and several hazard assessment reports conducted by outside investigators.

Your name was given to us as a worker that may have been exposed to dusts originating with the fireproofing materials, while working at the new San Francisco Airport International Terminal during 1998 and/or 1999.

In order for us to better understand what occurred during construction activities in 1998 and 1999, we request that you fill out the attached "information sheet", and return it to us by the 31st of August.

If you have any questions, you can call Paul Hewett at (304) 285 6259 or Karen Kestenberg at (304) 285 5710.

Thank you for your time.

Sincerely,

Paul Hewett Ph.D. Karen Kestenberg RN, MPH

* NIOSH is permitted by the Occupational Safety and Health Act of 1970 to investigate workplaces at the request of management or authorized representatives of workers.

INFORMATION SHEET

Date _____

Name _____ Occupation _____

Home _____ Union (if any) _____

Address _____
(address) _____

Phone _____

Did you work at the San Francisco Airport International Terminal construction site at any time during 1998 and 1999?

____yes ____no

If "No", then please return this form in pre-addressed, stamped envelop provided.

If "Yes", then please answer the following questions.

During the period 1998 and 1999, how many days, weeks, or months did you work at this construction site?
____ days ____ weeks ____ months

Did your job or work assignment require that you remove (scrap off) and/or clean up fireproofing materials?
____yes ____no

What type of contact did you have with fireproofing materials?
____none ____skin only ____inhalation only ____both skin and inhalation

How often did you work with, or around loose fireproofing materials?
____never
____several days per month
____several days per week
____daily

During each of these days, how long were you likely to be contact with fireproofing materials?
____less than 15 minutes per day
____less than one hour per day
____several hours per day
____usually all day

Did your employer (or anyone else) provide you with instructions or training regarding the safe removal, handling, and disposal of fireproofing materials?

___yes ___no

If "yes", please describe the type of training and training materials?

Did you wear a respirator when removing fireproofing materials, or when exposed to dusts during cleanup of fireproofing materials?

___yes ___no

If "yes", what type of respirator did you routinely use?

___disposable___half-mask with cartridges___other (describe)_____

Who provided the respirators?

___you___your employer___other (describe)_____

During this time did you receive any training regarding the proper use, care, and maintenance of your respirator?

___yes ___no

If you received training, please describe: _____

Did you experience any health effects that you feel were caused by inhalation exposure or skin contact with loose fireproofing materials?

___yes ___no

If "yes", please describe: _____

Did you visit the airport clinic (OCIP clinic) with these complaints?

___yes ___no

What was the result of the visit(s) to the OCIP clinic?

Did you see a private physician for these complaints?

___yes ___no

What was the result of the visit(s) to your private physician?

If you visited either the airport clinic (OCIP clinic) or a private physician regarding healths effects related to exposure or contact with fireproofing materials, **we request that you fill out and sign the enclosed medical release form.** This form will authorize us to contact either the airport clinic or your private physician, and request copies of the relevant medical records.

Thank you for your comments. Please return this form in pre-addressed, stamped envelop provided. If you have any questions, please contact either Paul Hewett at (304) 285 6259 or Karen Kestenberg at (304) 285 5710.

Appendix C

Evaluation Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs) (NIOSH, 1992), (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®) (ACGIH, 2000), and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) (OSHA, 2000a, 2000b). Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 95-596, sec. 5.(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

There are no federal exposure limits for "fireproofing" dusts. The fireproofing materials mentioned in the request consisted of various combinations of (a) cementitious materials - calcium sulfate (gypsum) and calcium carbonate (limestone), (b) various clays (e.g., hydrous aluminum silicate, hydrous magnesium aluminum silicate), and (c) fibrous materials (e.g., mineral wool, fibrous glass, or synthetic fibers). One brand contained mineral oil as a major ingredient. The ingredients of the Cafco® fireproofing products are listed in Table 1. The manufacturer is United States Mineral Products Co., a subsidiary of Isolotek International. The ingredients of the Monokote® are listed in Table 2. The manufacturer is W.R. Grace & Company.

The applicable regulatory (federal OSHA) exposure limits are listed in Table 3. Included also are the current ACGIH Threshold Limit Values (ACGIH, 2000)^a and NIOSH's Recommended Exposure Limits.^b Both the

^aThe American Conference of Governmental Industrial Hygienists is a non-government, professional organization that has since 1946 maintained and updated a list of exposure limits to industrial chemical
(continued...)

ACGIH and NIOSH recommended exposure limits for calcium sulfate (gypsum) and calcium carbonate (limestone) are lower than the respective OSHA PELs.

Dusts known to have a low toxic potential were once called “nuisance dusts.” While this terminology remains in use, such mixed dusts are now called Particulates Not Otherwise Regulated (PNORs) by OSHA, and Particulates Not Otherwise Classified (PNOCs) by the American Conference of Governmental Industrial Hygienists (ACGIH). Because the MSDSs refer to many of the components of the fireproofing materials as “nuisance dusts,” we will use this term interchangeably with PNOR and PNOC throughout this report.

Mixtures or single substances without specific exposure limits should not automatically be considered a PNOR or PNOC. Specifically, if it has been demonstrated that all components consist of inert^c or nuisance^d particulates, then from a regulatory viewpoint the general exposure limits for low toxicity particulates can be applied. But if it has not been demonstrated that the components are basically inert, or if evidence exists that there are adverse health effects (e.g., case reports or case clusters), then such a mixture cannot be treated as a PNOR or PNOC, and exposures should be controlled to lower levels.

Federal Exposure Limits

The PELs listed in 29 CFR 1926.55 were created in 1973 when OSHA adopted the 1970 ACGIH TLVs to be the initial set of exposure limits for the construction industry. Consequently, these PELs reflect knowledge regarding occupational health effects and risks existent during the 1960s and earlier. The OSHA PEL is defined as the upper limit for exposure concentrations averaged over each single shift for each employee. Worker exposure is best measured by having the worker(s) selected wear a battery-powered sampling pump and filter collection device for nearly the full-shift. Shorter term measurements may be collected in order to assess the contribution of specific tasks or activities to the overall shift exposure. The shorter term measurements can be combined into a full-shift, time-weighted average (TWA) exposure that is compared to the PEL.^e A work environment in compliance with the OSHA PELs is one where few if any full-shift exposures exceed the PEL.

^a(...continued)
and substances often encountered in the workplace.

^bNIOSH as federal research agency routinely recommends, based upon published studies or its own research, new or modified exposure limits for selected substances. Unlike the OSHA regulatory exposure limits, these exposure limits are not legally enforceable.

^cInert - having little or no ability to cause a toxic effect with surrounding lung tissue, or to exert a toxic effect, through dissolution or translocation, elsewhere in the body.

^dNuisance particulate - any dust having the following characteristics: (a) the pulmonary architecture is not affected, (b) fibrosis is not formed to a significant extent, and (3) any tissue reaction is potentially reversible. (ACGIH; 1971) (Repeated in ACGIH 1992 documentation for PNOC.)

^eIf there are unsampled periods of the day the investigator usually makes an assumption that exposures were either similar to those during sampled periods, or were essentially zero. This decision affects the calculation of the full-shift, time-weighted average exposure and should be indicated in any report of exposures. For compliance samples OSHA inspectors frequently assume zero exposure for unsampled portions of the full-shift, but such a practice for corporate inspectors should not be used without documented justification.

Particulates Not Otherwise Regulated (PNOR)

OSHA's construction industry Permissible Exposure Limit (PEL) for Particulates Not Otherwise Regulated (PNOR) is 15 mg/m³, measured as total dust.^f According to Appendix A of 29CFR1925.55, particulates must be "inert or nuisance dusts" in order to be classified as a PNOR.

Calcium Sulfate, Calcium Carbonate, Mineral Wool, and Oil Mist (White Mineral Oil)

The OSHA limits applicable to the construction industry for calcium sulfate, calcium carbonate, mineral wool, and oil mist (white mineral oil) are all equal to the PNOR limit of 15 mg/m³ for total dust. Each of these substances also has a companion limit of 5 mg/m³ for respirable particulate or mist.

Other Exposure Limits

The above OSHA limits suggest that the substances listed in the MSDSs exhibit a low order of toxic potential. However, these OSHA limits were adopted in 1973 from the 1970 list of ACGIH TLVs, and so are considerably dated. Both NIOSH and the ACGIH have since developed and adopted lower recommended exposure limits for all of the substances in question (see Table 3). These exposure limits reflect advances in knowledge regarding health effects and their relationships to exposure. Consequently, it is our recommendation that the more recent NIOSH and ACGIH limits be used to evaluate exposures.

Particulates Not Otherwise Classified (PNOC); Nuisance Particulates

The ACGIH has two TLVs for PNOCs: 10 mg/m³ for inhalable particulate^g and 3 mg/m³ for respirable particulate.^h These limits apply only to substances for which there is "no evidence of specific toxic effects," no asbestos, and less than 1% crystalline silica (ACGIH, 2000). In the documentation for these TLVs, the ACGIH TLV Committee reviewed the studies on the effects of particulate loading on the clearance mechanisms in the lung. The committee felt that past studies indicate that adverse health effects, such as pulmonary alveolar proteinosisⁱ, are the result of "particulate overload effects." The committee observed that "the clearance

^fIn the general industry standards OSHA specifies a companion PEL of 5 mg/m³, measured as respirable dust. The use of the respirable exposure for nuisance dust is commonly used in modern industrial hygiene practice to assess and minimize exposure to the air exchange (alveolar) regions of the lungs.

^gInhalable particulate" includes the larger, non-respirable particles that tend to deposit in the upper airways (nasal passages, larynx, and tracheo-bronchial system) and the smaller, respirable particles that tend to deposit in the air-exchange regions, or alveoli. In normal, healthy individuals the non-respirable particles tend to be rapidly cleared from lungs and nasal region, and subsequently swallowed. Inhalable particulate is measured using devices that match the collection characteristics for inhalable samples (ACGIH, 2000).

^hRespirable particles tend to remain in the alveoli for longer periods. Respirable particulate is measured using devices that match the international criteria for respirable samplers. The ACGIH recommends a sampling system using a Dorr-Oliver 10mm nylon cyclone and a flowrate of 1.7 liters per minute (ACGIH, 2000).

ⁱPulmonary alveolar proteinosis is a fairly rare lung disorder that can occur upon high exposures to
(continued...)

mechanisms of the lung must be maintained in a functional condition, capable of a normal clearance mechanism” (ACGIH, 1991). In the current TLV booklet (ACGIH, 2000) the TLV Committee emphasizes that PNOC substances are potentially toxic and that one should avoid assuming that PNOC substances are harmless regardless of concentration.

NIOSH has not adopted any recommended exposure limits for either total, inhalable, or respirable nuisance particulates. However, NIOSH has advised OSHA that the documentation is inadequate to support a nuisance dust PEL of 10 mg/m³ (measured as total dust) (NIOSH, 1997) and that health effects are likely to occur (NIOSH, 1992).

Calcium Sulfate and Calcium Carbonate

The current documentation of the ACGIH TLVs for calcium sulfate and calcium carbonate suggests that each substance possesses a low order of toxicity. In order to prevent undue irritation the ACGIH suggests that each full-shift exposure be limited to no more 10 mg/m³. Furthermore, the ACGIH suggests that short-term, peak exposures (i.e., exposure during 15-minute periods) rarely exceed three times the full-shift limit and never exceed five times the limit (ACGIH, 2000).

The NIOSH recommended exposure limits for these substances are identical to those of the ACGIH, but are accompanied by a 5 mg/m³ respirable dust exposure limit. Pulmonary and eye irritation are listed as the primary concerns (NIOSH, 1992, 1997).

Mineral Wool

The ACGIH TLV for mineral wool has changed considerably since 1970. No longer should it be sampled and analyzed as if it were an inert or nuisance dust, but as a respirable fiber (see Table 3 for details). The TLV is now expressed in fibers per cubic centimeter (f/cc). Additionally, the ACGIH has concluded that there is sufficient evidence to assign mineral wool an “A3” classification, meaning that mineral wool is a confirmed animal carcinogen that is unlikely to “cause cancer in humans except under uncommon and unlikely routes or levels of exposure” (ACGIH, 2000).

The NIOSH recommended exposure limit for fibrous glass can be applied to mineral wool (NIOSH, 1997). The NIOSH exposure limit, which was adopted in 1977, was intended to prevent undue irritation to the eyes, skin, and respiratory tract.

Oil Mist (Mineral Oil)

The ACGIH concluded from a review of the literature that significant health effects do not occur at levels above the current TLV of 5 mg/m³. However, oil mists containing additives or containing carcinogenic fractions should be controlled to lower levels.

The NIOSH recommended full-shift and short-term exposure limits for mineral oil mist were intended to prevent undue irritation to the eyes, skin, and respiratory tract, across the entire shift as well as during peak exposures.

ⁱ(...continued)

inorganic dusts. The alveoli, or air exchange sacs of the lung, fill with fluid (surfactant), interfering with the gas-exchange function of the lungs. This condition is often confused with chronic pneumonia, and results in an increased risk of pneumonia.

Comments regarding the OSHA PNOR PEL

The renaming of “nuisance dust” to PNOR/PNOC had to do with the increasing recognition that no dust, particularly mixed dusts, is truly just a nuisance with no physiological effects at all concentrations (Hearl, 1998). It is true that there are a number of particulates and mixed dusts that have been recognized to possess a low order of toxicity when exposures are maintained below the PNOR or PNOC exposure limits, several of which are components of fireproofing materials. However, simply because a particular mixture contains one or more of these low toxicity substances does not automatically qualify the *mixture* to be classified as a PNOR or PNOC. Furthermore, the PNOR or PNOC exposure limits are not the default limits for substances or mixtures having no specific exposure limit, legal or authoritative (e.g., an ACGIH TLV). The PNOR or PNOC exposure limits can only be applied to particulate or mixed dust after it has been demonstrated, by either the manufacturer or the user, in a reliable and scientific manner, that the particulate or mixed dust is essentially inert or simply a low level nuisance (i.e., a low level irritant) at the PNOR or PNOC concentration and below.

The PNOR or PNOC criteria *do not apply* when there is evidence that the mixture may cause more than simple, low level irritation. For example, if a mixture contains either basic (alkaline) or acidic compounds one should suspect that deposited particulate in the nasal/laryngeal region and upper airways may cause severe irritation and reflexive reactions, particularly in individuals with asthma, reactive airways, and/or compromised lung function.^j There are a variety of animal tests that a manufacturer can employ to assess the potential for direct, chemical action and irritation.

The PNOR or PNOC criteria *do not apply* when there is evidence that workers are experiencing unexpected health effects. For example, if there is evidence of an unusual fraction of the exposed individuals complaining of irritation, pulmonary infections^k, or other effects, then it is reasonable to suspect that (a) short-term exposures may be routinely exceeding the ACGIH guidelines for within-shift excursions above the full-shift, or (b) that there are toxic effects. With true PNOR/PNOC substances any effects should be short-term, and not persisting beyond the workshift. However, whenever irritative or significant pulmonary or systemic effects persist well beyond a single shift, and especially weeks or months after exposure, it is likely that the PNOR/PNOC designation is inappropriate.

It may be that the effects of the mixture are indeed minimal and not persistent when the exposure levels are maintained below the OSHA or ACGIH exposure limits. But at higher levels experienced infrequently or episodically the dust handling mechanisms of the lungs (the clearance mechanisms) are simply overwhelmed, permitting dust overload to occur, resulting more severe and persistent effects. Because of this consideration the ACGIH has consistently warned against permitting short-term, excessive exposures *during a shift*^l, even

^jOnce reduced to a fine powder, the combination of rigid respirable, glass-like fibers with chemically reactive, alkaline materials may present more of a hazard than any single component.

^kDust overloading and chemical/mechanical pulmonary irritation are known to increase the likelihood of pulmonary infections.

^lThe ACGIH strongly advises that short-term, high exposures within a shift be limited. Their recommendation is that short-term exposures, typically measured as 15-minute averages, not exceed three times the full-shift TLV for more than 30 minutes total during *each* work-shift and never exceed five times the full-shift TLV. These recommendations are directed toward short-term tasks and activities with the potential to generate excessive exposures.

when the full-shift exposure is within the exposure limit. This warning was included in the ACGIH TLV documentation for calcium sulfate, calcium carbonate, oil mist (mineral), and mineral wool (ACGIH, 1991).^m

In summary, the PNOR and PNOC exposure limits do not automatically apply to any substance or mixture that has no specific limit. The PNOR and PNOC criteria can be applied only to substances or mixtures known to be essentially inert, or having only a *nuisance* potential. If a particular dust is known to produce significant health effects, then it cannot be classified as inert or nuisance, and steps should be taken to reduce or control exposures to levels well below the PNOR or PNOC exposure limits.

^mIt is also worth mentioning that in the introduction of the 1970 TLV booklet, the ACGIH cautions users that the 15 mg/m³ exposure limit for nuisance particulates applies to a “normal workday [i.e., 8-hour shift], and “does not apply to brief exposures at higher concentrations”. Furthermore, it does not apply “to those substances which may cause physiologic impairments at lower concentrations but for which a threshold limit has not yet been adopted” (LaNier, 1984). While this wording was not adopted by OSHA when it adopted the 1970 TLVs, it does give us insight into the limitations of the exposure limit as viewed by the ACGIH. The ACGIH has since substantially lowered its recommended PNOC exposure limits.

Appendix D

Summary of Previous Surveys

OSHA surveys

Over the past two years numerous complaints were registered with the local Cal-OSHA office. A survey was conducted in February, 1998, to look at the “application of fireproofing on the structural steel.” The Cal-OSHA inspector collected exposure data using a direct-reading mini-RAM. The readings were all less than 5 mini-RAM units.^a A “notice of no violation after inspection” was issued to Tutor-Saliba Corporation by the Cal-OSHA office in Foster City.

Another survey was conducted in February, 1999, again to look at problems with fireproofing material dust. A non-serious citation was issued to Amelco Electric SF Inc. for not effectively implementing an injury and illness prevention program, particularly with regards “to its employees exposure to the sprayed-on fireproofing and job site hazards not created by the employer.”

On March 26, 1999, Cal-OSHA sent SFO Associates (the construction manager for the construction of the new international airport wing) a letter indicating that

“previously applied fire proofing materials are being disturbed, creating an environment sufficiently dusty so as to cause employees of various trades to complain of symptoms of upper respiratory irritation, breathing difficulty, other respiratory tract symptoms including, asthma and asthma-like symptoms.”

The letter further alleged that employees are not supplied appropriate respiratory protective equipment. SFO Associates responded saying that the “controlling employer at the airport expansion project” is not the responsibility of SFO, but instead is Tutor-Saliba; that previous sampling had twice shown low levels of mineral wool, and that employees are supplied or required to wear respirators. No survey was conducted.

On July 9, 1999, citations were issued to Pierce Enterprises, a contractor working at the San Francisco International Airport, regarding conditions during inspections that occurred on or between April 28, 1999 and July 8, 1999. Several citations were issued regarding contact and exposure to CAFCO® Blaze Shield II fireproofing. These citations covered failure to have a written Hazard Communication program, failure to train employees about the health hazards associated with fireproofing, and failure to provide hand protection and failure to ensure that suitable clothing was worn when dealing with a fireproofing material where the MSDS warns against skin contact.

There were other inspections by Cal-OSHA. At least two dealt with dust generated when workers were breaking concrete with jack hammers or “scabbler machines”. Citations were issued for failure to use “allaying media” and for failure to monitor exposures.

Company surveys

On April 30 and May 1, 1998, Compliance Consulting Group (on behalf of Isolatek International; manufacturer of Cafco® BlazeShield® II) collected measurements for crystalline silica and mineral wool fibers. The five

^aThe mini-RAM is a survey instrument designed for locating high exposure areas. It does not read directly in mg/m³ units, but instead in mini-RAM units. To convert to mg/m³ one must devise a calibration curve based upon the dust being measured. Otherwise, the measurements are simply suggestive, and are generally used to separate high and low exposure tasks and activities.

silica samples indicated either “trace” or non-detectable silica concentrations. The five fiber samples were all 10% or less of the ACGIH TLV of 1 fiber/cc. However, no descriptive information regarding tasks and general work conditions was provided in the report (source: Cal-OSHA), nor was any information on sample time or sample volume. Based on these few samples the consultants declared that “no job activity had a potential for exposure to respirable crystalline silica” and that “all job activities showed low level exposures to respirable mineral wool fiber.”

On February 5, 1999, the Argonaut Insurance Company collected several respirable dust measurements from an electrician downwind of “floor sweeping,” a millwright who did some sweeping, and an electrical foreman. According to Argonaut, all measurements were “well within safe limits” (i.e., less than the “State of California permissible limit” of 5 mg/m³ for respirable, nuisance dust). Samples for fibers (mineral wool or fiberglass) were also collected. According to Argonaut, “all the results were well within safe limits” (i.e., less than the ACGIH TLV of 1 fiber/cc). According to the requestor they did not measure during a particularly dusty day.

On March 16, 1999, Lumina Technologies collected two air samples and two core samples of the fireproofing. The air samples were analyzed for “detectable odor,” with none detected. One bulk sample was analyzed for its pH, and the other for the presence of volatile organics. The pH was reported at 7.5, which is essentially neutral. No volatile organic compounds were reported. Lumina Technologies noted that “[p]rior tests have indicated high levels of airborne particulate.” The report concluded with the following recommendation:

“high concentrations of fine particulates may pose a health risk to workers. It is advised to perform dust misting twice daily and surface hosedown daily in all construction areas where coating are present. Followup air testing and visual inspection should be carried out within five working days after such program has been initiated.”

On September 13, 1999, the Safety and Health Office of San Francisco International Airport collected air samples for respirable silica and dust while two workers chipped and broke concrete using a pneumatic chipping guns. This sampling was done at the request of the SFO Owner Controlled Insurance Program (OCIP) and Tutor-Saliba. Compressed air was used to clean the area. The two measurements of respirable crystalline silica were at or just above 0.1 mg/m³. Given that the respirable dust was 1 mg/m³ for both workers, it can be assumed that percentage silica in the respirable dust was around 10%. The San Francisco International Airport Safety Officer, who conducted the sampling, listed several recommendations: (a) wet methods should be used, (b) compressed air cleaning should be eliminated immediately, (c) respiratory protection be upgraded to P100 half-masks, and (d) follow-up, full-shift monitoring should be conducted.. These recommendations were comprehensive and presumably were meant to be applied to the employees measured, as well as those doing similar work. A copy of NIOSH’s Alert “Preventing Silicosis and Deaths in Construction Workers” was included with report when sent to OCIP.

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1-800-35-NIOSH (356-4674)
or visit the NIOSH Web site at:
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