

on the desired specifications. One such specification calls for an upright cleaner with power-driven beater bar with brushes, weighing less than 12 pounds, not self-propelled, and with a motor six amperes or greater.

Very few of these experts speak to the issue of central vacuum cleaning systems. These would seem to eliminate some problems, such as reentraining dust or mold spores that escape a collection bag. (For a description of one such system, see related story on Page 6.)

Some of the recommendations, such as the weight requirement, are to ensure that maintenance personnel use the cleaner properly. The assumption is that if the cleaner is too heavy, some workers may tend to do a less thorough job.

Of the three available commercial cleaning methods, two vie for acceptability — wet extraction and dry extraction. A third method, bonnet cleaning, is a hybrid between hard-surface and carpet cleaning, and many maintenance experts recommend against it.

Wet extraction consists of spraying a hot water-detergent solution into the carpet and immediately vacuuming it up. Dry cleaning usually consists of applying a detergent-impregnated absorbent material onto the carpet, brushing it into the pile, and then vacuuming it up.

Both methods depend on proper materials and application for total effectiveness. And while both leave residue, there has been little independent research on the IAQ effects of that residue. One company that specializes in dry extraction, Racine Industries of Racine, Wisconsin, USA, has done research on the effect its product has had on dust mites and has found 1) that the system reduces mites significantly and 2) the residue does not provide food for the remaining mites.

One caution with wet-extraction systems is to allow proper drying time, which, depending on conditions, can range anywhere from several hours to several days. A concern with either method is adequate ventilation and humidity control during and after the cleaning.

While carpets have become the focus of some rather sensational publicity, they are not the only floor coverings that should be of concern to those involved with IAQ. Cutter Information Corp. has produced a report, **Floor Coverings & IAQ**, which discusses the benefits and risks involved with carpets, as well as other popular floor coverings.

For more information or to order the report, contact: Cutter Information Corp., 37 Broadway, Arlington, MA 02174-5539, USA; (617) 648-8700 or (800) 888-8939; Fax: (617) 648-8707 or (800) 888-1816.

## CASE STUDY

*[In each issue IAQU presents a case study on an investigation of indoor air problems in a particular building. The editorial staff relies on information provided by the environmental consultants involved in the investigation. IAQU presents a variety of approaches to investigation and mitigation implemented by consultants with a broad range of experience, philosophies, and expertise. Inclusion of a particular case study in the newsletter does not imply IAQU's endorsement of the investigative procedures, analysis, or mitigation techniques employed in the case. IAQU invites readers to submit comments, suggestions, and questions concerning any case. At the discretion of the editors, correspondence may be presented in a future issue.]*

### Proactive, Holistic Approach Leads to Employee Satisfaction

A large international accounting firm recently consolidated several offices into a regional headquarters in a southern US city. This regional headquarters involves eight floors totaling 187,000 square feet of tenant space in a new high-rise building.

The firm's management hoped that improving its employees' work environment would result in

reduced absenteeism and significant savings from increased worker productivity. Therefore, the firm retained Environmental Design International (EDI) of Marietta, Georgia, USA, as consultants in creating and maintaining an environmentally sound office space.

Creating a healthy, productive, and safe indoor environment involves a holistic approach to the

various elements that affect indoor environmental quality (IEQ) in a building. (Some professionals prefer to extend indoor air quality to a whole range of factors that affect a building's occupants, and therefore refer to this as IEQ.) A holistic approach requires evaluating all areas that impact IEQ, not just reviewing HVAC systems, which is more common.

**Construction Materials and Furnishings**

Construction materials and furnishings, a major source of pollutants, can contain many harmful chemicals that they emit into the indoor environment. In addition, some construction materials and furnishings are more susceptible to microbial infestation than others. Finally, many construction materials and furnishings shed significant amounts of fibers, dust, and airborne particulates that are indoor air contaminants.

Construction materials and furnishings that are conducive to a healthy indoor environment do not necessarily cost more than materials that aren't. During construction, EDI made changes to improve the client's indoor environment by selecting "environmentally friendlier" materials and furnishings.

Construction materials that EDI examined and specified included: insulation, cabinets, particle board, sealing and spackling compounds, adhesives, wall coverings, paints, stains, and varnishes.

Specific construction material selections included latex-base paints, hardwood plywoods, and water-base glues and adhesives. Specific furnishing selections included low-formaldehyde furniture fabrics and continuous-filament carpeting to reduce particle shed.

The results of environmental testing indicate that attention to furnishings and construction material selection greatly improved the space's indoor environmental quality. For comparison, the consultants sampled for several volatile organic compounds (VOCs) in the client's space and concurrently in another tenant's space in the same building.

The sample floor in the other tenant's space is very similar to the client's; appearance, furnishings, and space usage are indistinguishable. In fact, the same contractor constructed both tenant spaces at the same time. Figure 1 shows that VOC concentrations recorded in the other

Figure 1 -- Selected VOC Concentrations

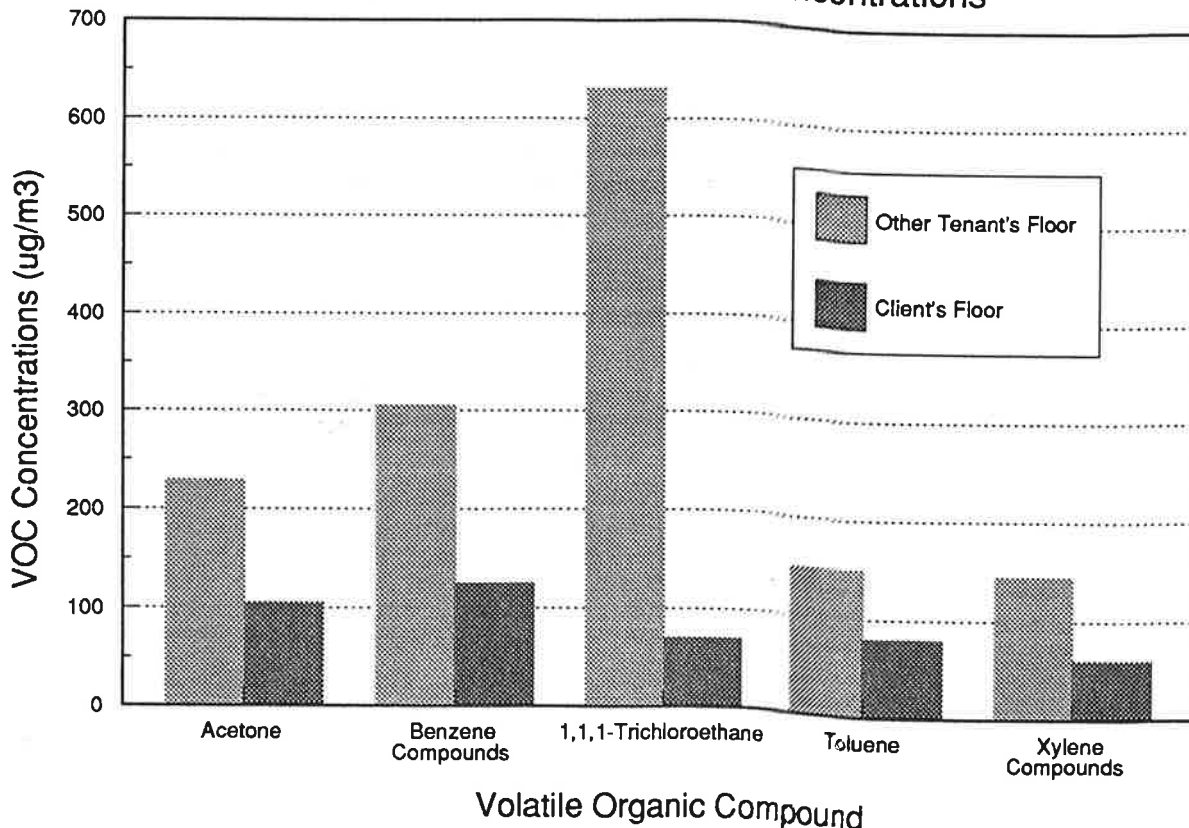
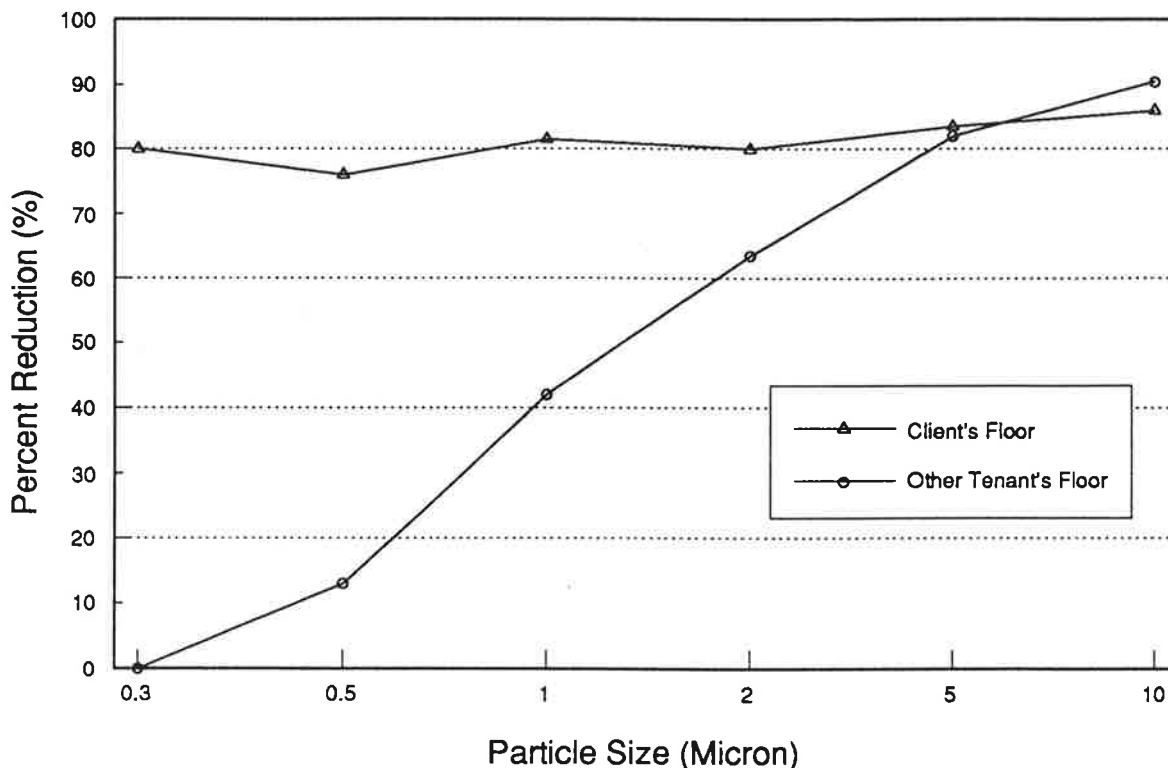


Figure 2 -- Filter Particle Reduction Efficiency



tenant's space were 50% to 75% higher than those recorded in the client's space with IEQ-conscious materials and furnishings.

### Pest Control

Pest control began during construction, before any infestation occurred. Low-toxicity pesticides applied to the interior surfaces of wall cavities were intended to minimize future insect infestation within walls. A mild pesticide was sprayed on all vertical surfaces while the walls were "one sided." The solution was allowed to dry and the second half of the wall was applied. EDI used this technique to minimize vertical migration of potential pests.

The building's pest control contractor practices "integrated pest management." To reduce potentially harmful chemicals, the contractor uses pest traps and baits to monitor the presence of insects and rodents and sprays pesticides only when and where the traps indicate a specific problem. The consulting firm must approve any chemicals used in the space before they are applied. The firm also provides ongoing training about pesticides and indoor environmental quality.

### HVAC System Design and Air Dynamics

The HVAC systems and the associated air dynamics are among the most important contributors to a building's indoor environmental quality. IEQ problems attributed to poor HVAC design are numerous and well documented. Therefore, EDI approached the tenant's HVAC system design from an improved-IEQ perspective.

The base building's outside air system was limited in capacity, and could not deliver outside air at 20 cubic feet per minute (cfm) per occupant as required by the Ventilation Rate Procedure of ASHRAE Standard 62-1989. In addition, the standard relies on perfect mixing between the outside air and the air within the occupied space. However, it is common for a portion of outside air to "short circuit," that is bypass occupants without fully mixing in the occupied zone. Therefore, designers used the Indoor Air Quality Procedure of ASHRAE Standard 62 to improve the quality of the indoor air.

The Indoor Air Quality Procedure achieves acceptable indoor air quality by minimizing the concentration of known contaminants and clean-

ing recirculated air. This approach was incorporated throughout the design process to reduce occupant- and building-generated contaminants within the space.

Special filter racks adapted for the existing air handling units contain four-inch deep, 30% efficient particulate prefilters; activated charcoal gas-phase filters; and 95% efficient particulate filters. All filters and racks were installed with gaskets and edge seals to minimize bypass leakage.

The high-efficiency filters significantly reduced respirable particulates in the space. EDI took airborne particulate samples in the client's space and compared them to samples taken on other floors with conventional filtration. Figure 2 shows the filter particle reduction efficiency in the client's space versus the other space. The client's filters are several times more efficient at removing airborne particles measuring 1.0 micron and less. This is especially important since these smaller particles can easily penetrate the lung's defense mechanisms and cause respiratory complaints. In addition, the high-efficiency filters have a lower lifecycle cost than conventional filters due to their extended change-out schedule.

Other recommendations included:

- A localized exhaust system in the print shop's photographic developing room connected to the base building toilet exhaust riser.
- HVAC equipment locations designed to ensure accessibility and maintainability.
- Fan filtration units containing gaseous and high-efficiency particulate filtration in several high-contaminant areas such as the cafeteria, print shops, copy rooms, and break rooms.

### Environmental Systems Commissioning

One of the crucial steps in creating and maintaining a healthy indoor environment is proper commissioning of the building's environmental systems. Proper commissioning does not replace traditional test-and-balance work, but it is an ongoing process, beginning with the design phase and continuing through construction, acceptance, and building occupancy.

EDI functioned as the commissioning authority for the project to develop and implement the overall commissioning process. During this process it:

- Developed environmental benchmarks with which to evaluate final building performance and acceptance criteria;
- Incorporated tenant revisions and review comments on construction materials, HVAC systems, lighting, etc. into the design and construction process;
- Monitored the construction and test-and-balance procedures to determine compliance with the commissioning plan;
- Determined minimum standards for operation and maintenance manuals, as-built drawings, and other documentation;
- Observed and verified performance acceptance testing for environmental systems, and provided acceptance checklists and documentation specific to each system; and
- Provided direction to implement corrective measures when some systems did not perform satisfactorily.

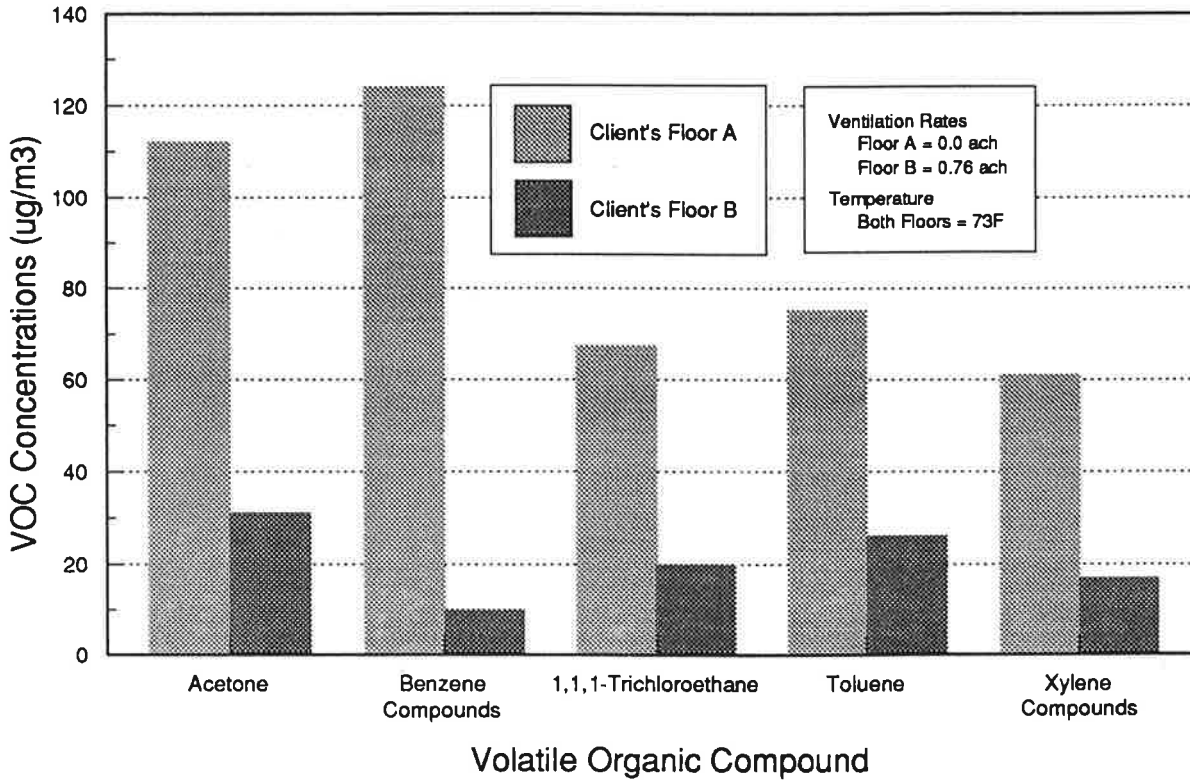
### Contaminant Flush-Out

EDI requested that the air handling units, toilet exhaust, and outside air systems be run continuously to flush out potentially harmful fumes and vapors from construction materials. This flush-out period took place during the last month of construction and the first few weeks of occupancy.

Air sampling indicated a marked reduction in total volatile organic compounds (TVOCs) during the first few weeks of flush-out. As part of system commissioning, the consulting firm discovered that the outside air system serving several floors was malfunctioning and was not delivering outside air to the space. When informed of the malfunction, building operators corrected it.

This situation presented an excellent opportunity to compare the effects of the flush-out process as a way to lower TVOC's in the space. Figure 3 indicates the VOC concentrations for two typical floors. Floor A did not receive adequate flush-out due to the malfunctioning outside air system. Floor B received proper outside air and flush out. The VOC levels on Floor B were 64% to 92% less than Floor A, proving that the flush-out process is a valid means of lowering VOC concentrations in newly constructed projects.

Figure 3 -- Flush Out Comparison



### Construction Filtration

EDI requested that the central air handling units not operate during construction to prevent dust contamination in the units and ductwork. However, the building owner and contractor elected to operate the HVAC system during construction.

In order to protect the client's IEQ investment, consultants required that the contractor install four-inch deep, 30% efficient filters and roll media prefilters on all air handling units during construction. They also required that one-inch thick, 30% efficient filters be installed on all fan-powered induction units during construction. EDI monitored the filters regularly for bypass leakage and overloading. At the end of the construction process, a qualified duct cleaning firm vacuumed the supply and return duct systems.

### IEQ Assessment

A crucial step to maintaining a healthy indoor environment is an IEQ assessment of the space just before occupancy. The initial IEQ assessment included a review of the many factors that

affect the tenant's IEQ and provides the foundation for future IEQ efforts.

For example, moving-related damage to furniture and painted surfaces required touch-up work for several weeks after move-in. This reintroduced construction materials as a potential source of pollutants in the indoor environment. EDI consulted with the client's furniture repair contractor on products and procedures to minimize release of potential chemical irritants. In addition, all touch-up painting was performed after hours and during the flush-out period. Such procedures will never be completely avoidable. However proper communications and training can decrease the possibility of spoiling an otherwise healthy indoor environment.

Other areas of special concern include:

- Mechanical systems' environmental parameters, including actual outside air quantities, ventilation efficiency, system balance, filtration efficiency, and equipment condition.
- Occupancy and space use, to determine any differences or deficiencies between design and actual use.

- General housekeeping practices. Consultants make specific recommendations on an ongoing basis.
- Quantitative sampling for CO<sub>2</sub>, temperature, relative humidity, airborne microbials, VOCs, and airborne particulates, to establish equipment performance and baseline concentrations.

### Maintenance and Janitorial Procedures

EDI evaluated all regular and preventive maintenance procedures, including janitorial cleaning methods, and recommended changes and wrote protocols for all environmental systems to help optimize indoor environmental quality. Important maintenance concerns included:

- Filtration efficiency and change-out frequency;
- Condensate system cleaning;
- Insecticides and other purposeful chemicals used in the building; and
- General maintenance (i.e., responsiveness to leaks and other problems).

EDI also evaluated janitorial procedures and their impact on IEQ, including cleaning chemicals, vacuum cleaner types, overall housekeeping effectiveness, and furniture oils/polish, floor waxes, and polishes.

### Operating Procedures

EDI evaluated base building and tenant building operating procedures and recommended changes and protocols to help optimize indoor environmental quality. This phase included:

- Review of and modifications to the operation of major base building and tenant HVAC systems such as upgraded filters, additional HVAC comfort zones, and "IEQ-friendly" operating procedures;
- Review of HVAC test-and-balance reports to determine current supply air settings and outside air quantities;
- Review of control system procedures to determine current operation of the HVAC system;
- Training of building and tenant operating staff; and
- Appointing an IEQ manager and two assistant IEQ managers within the client's organization. These employees receive intensive, hands-on training regarding environmental systems and procedures within their space.

### Post-Acceptance Commissioning

A crucial step in maintaining a healthy indoor environment is commissioning of the environmental systems after acceptance of the building. Post-acceptance environmental commissioning ensures the effective, ongoing performance of the building's environmental systems. As the facility's use and function change, environmental systems need to be adapted to the changing occupant and use requirements. Post-acceptance includes the following:

- Maintaining a history of the facility and recording changes and their effects on the previously commissioned systems;
- Updating as-built documents as required to reflect modifications of the facility or environmental systems;
- Evaluating the impact of planned alterations to the environmental systems;
- Periodically retesting portions of the environmental systems to measure actual versus design performance;
- Developing and maintaining system complaint reports and procedures; and
- Developing plans for recommissioning of systems should discrepancies occur between predicted and actual performance.

### Proactive Monitoring Program

The final step in maintaining a healthy indoor environment and protecting the tenant's IEQ investment involves routine monitoring. The proactive monitoring program can detect potential IEQ concerns and prevent them from becoming problems. This monitoring will consist of an "IEQ Check-Up," twice a year in the client's space, at the beginning of the cooling season and at the beginning of the heating season. This program includes:

- On-site reviewing and monitoring of mechanical systems, occupancy levels, housekeeping effectiveness, and space usage;
- Routinely updating maintenance, janitorial, and operating protocols;
- Submitting a written summary reporting the general condition of the space and any changes that have occurred since the last observation;
- Providing the client with access to the latest information about IEQ issues; and

- Evaluating the strategic impact of IEQ issues on the client's business.

### Conclusion

Presently, EDI is evaluating whether it fulfilled its ultimate goal of improving employee productivity and reducing absenteeism. Several anecdotal reports from employees indicate a perception of improved indoor air quality and an increase in productivity. While these testimonials are no substitute for statistical data on productivity and absenteeism, they are extremely promising.

EDI also examined absentee records since move-in with the same time period from the previous year. Comparisons show a 6%-10% decrease in absenteeism, per employee, since the client oc-

cupied the new offices. This represents a significant savings to the client.

This experience shows that optimizing a healthy indoor environment is a continuous, all-inclusive process. This process begins with selecting construction materials and designing environmental systems, followed by administering construction, commissioning systems, and monitoring IEQ parameters. This all-inclusive process protects the client's investment in a healthy, productive, and safe indoor environment.

### For More Information

This case was adapted from a report by Joseph A. Milam, PE, of EDI. For more information, contact Milam at EDI, 1000 Johnson Ferry Road, Suite E-150, Marietta, GA 30068, USA; (404) 977-7007, Fax: (404) 977-2217.

## NEWS AND ANALYSIS

### OSHA Seeks Added Comments on Asbestos Exposure Regulations

The US Occupational Safety and Health Administration (OSHA) has reopened the comment period on its proposed revisions to regulations concerning worker exposure to asbestos. OSHA will receive comments, which should be submitted in quadruplicate, until January 4, 1993.

The specific areas in which the agency is seeking comments include:

*Presumed Asbestos-Containing Materials:* At the present time OSHA will presume that materials contain asbestos if they were in the building at the time asbestos was common in such materials. For example, the owner of a building that was constructed between 1920 and 1980 and that contains thermal system insulation surfacing material must presume that this material contains asbestos.

*Adequacy of Building Records:* OSHA wants comments on whether building owners can rely on building records to rebut the presumption of asbestos-containing materials. It also wants to know what would be considered adequate building records.

*Notification:* What kind of notification would adequately inform employees of the presence of asbestos?

*Exposure Data:* The agency wants to know what the exposure would be for maintenance workers

doing tasks in an environment where asbestos-containing materials are present.

*Frequency and Duration of Custodial Activities:* OSHA is looking for comments on the types, frequency, and duration of maintenance or housekeeping tasks performed by custodians, janitors, and other service workers.

*Current Practices:* What practices — respirators, coveralls, or other personal protective equipment — are currently in place to limit worker exposure to asbestos?

*Training Requirements:* OSHA is considering a training requirement and wants to determine the minimum training required by building and custodial personnel.

All submissions should be sent to: Docket Officer, Docket H-033e, Room N2625, OSHA, US Department of Labor, 200 Constitution Avenue NW, Washington, DC 20210, USA. Comments less than 10 pages may be sent by fax to: (202) 523-5046, provided that the original and four copies are mailed to the above address.

For more information, contact: James Foster, Room N3647, Office of Information and Consumer Affairs, OSHA, 200 Constitution Avenue NW, Washington, DC 20210, USA; (202) 523-8151.