Controlling Chemical Exposure
Industrial Hygiene Fact Sheets

Concise guidance on 16 components of
industrial hygiene controls

POISON

New Jersey Department of Health and Senior Services
Division of Epidemiology, Environmental and Occupational Health
Occupational Health Service
PO Box 360
Trenton, NJ 08625-0360
609-984-1863

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James E. McGreevey
Governor

Clifton R. Lacy, M.D.
Commissioner

Written by:
Eileen Senn, MS, CIH
Occupational Health Surveillance Program

James S. Blumenstock
Senior Assistant Commissioner
Public Health Protection and Prevention Programs

Eddy Bresnitz, MD, MS
State Epidemiologist/Assistant Commissioner
Division of Epidemiology, Environmental and Occupational Health

Kathleen O'Leary, MS
Director
Occupational Health Service

David Valiante, MS, CIH
Acting Program Manager
Occupational Health Surveillance Program

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Methods for Controlling Chemical Exposure

Evaluation and control of chemical exposure in the workplace are major components of an effective safety and health program. Workplace controls at the source of chemical release are inherently better than controls at the worker, such as personal protective equipment. This concept is known as the *Hierarchy of Controls*. The box lists control measures in order of most effective to least effective.

CONTROL AT THE SOURCE

Substitution: Many harmful chemicals and processes are currently used as a matter of tradition although less harmful alternatives exist. Substitution is complex and requires research and experimentation. If successful, however, it is the most powerful and desirable control method. More information is given in ***Industrial Hygiene Fact Sheet 2***, **Substitution.**

Mechanize the process: Handling of particularly hazardous chemicals can be done by using mechanical arms or robots to keep workers away from the source of exposure.

Isolate/enclose the process: Isolating the source of exposure can be accomplished through actual physical enclosure, preferably with separate rooms or buildings, closed doors, always with the direction of airflow into the restricted area from other areas, As a further precaution, *regulated areas* can be established with access only to a limited number of essential employees. The amount of time that employees spend in regulated areas should be minimized. A hazardous operation can sometimes be performed during the second or third shifts to reduce the number of workers potentially exposed; this is isolation by time. More information is given in ***Industrial Hygiene Fact Sheet 3***, **Isolation**.

The Hierarchy of Controls - in order of most effective to least effective

CONTROL AT THE SOURCE

- ***Substitute a safer chemical or process***
- ***Mechanize the process***
- ***Isolate/enclose the process***

CONTROL ALONG THE PATH

- ***Local exhaust ventilation***
- ***General ventilation***
- ***Housekeeping***

CONTROL AT THE WORKER

- ***Worker education***
- ***Enclose the worker***
- ***Respirators, gloves, goggles, and chemical protective clothing***
- ***Lunch and locker rooms, lavatories, eye wash, shower***

CONTROL ALONG THE PATH

Local Exhaust Ventilation (LEV): A hood or intake near the point of a chemical release can capture or draw contaminated air from its source before it spreads into the breathing zone of workers involved in the operation using the chemical or workers at nearby operations. Contaminated air is drawn away by fans through ductwork to some type of air cleaner like a baghouse or electrostatic precipitator. More information is given in ***Industrial Hygiene Fact Sheet 4***, **Ventilation.**

General ventilation: General or dilution ventilation involves the introduction of fresh air so that levels of chemicals in the work area are diluted. Levels of chemicals in the air will still be highest at the source. Pockets of high levels of chemicals may exist if the fresh dilution air is not mixed well throughout the work areas. More information is given in ***Industrial Hygiene Fact Sheet 4***, **Ventilation.**

Housekeeping: Good housekeeping involves the removal of chemicals from room and work surfaces. For example, floors, walls, ceilings, doors, stairs, rafters, tables, chairs, machinery, equipment, and tools should be kept free of chemicals so that they do not get into the air or come into contact with employees' skin or food. *Housekeeping using dry wiping or sweeping or the use of compressed air should be eliminated because they often create massive worker exposure.* Wet wiping and mopping using water will raise less dust and result in cleaner surfaces. Special vacuums with high efficiency filters on the exhaust air stream, called HEPA (high efficiency particulate absolute) vacuums, should be used rather than regular vacuums. Regular vacuums allow fine dust to get into the air by passing through collection bags. Prompt spill clean-up by properly trained and equipped employees is necessary to avoid exposures. More information is given in ***Industrial Hygiene Fact Sheets 5 and 6***, **Housekeeping and HEPA Vacuums** and **Spill Clean-up**.

Match Controls to the Form of the Chemical

DUST, FUME, FIBER, MIST

- ***Ventilation***
- ***Housekeeping, HEPA vacuum***
- ***Respirators***
- ***Clean break and lunch rooms***
- ***Clean storage for food, etc.***
- ***Hand-washing facilities***
- ***Gloves***
- ***Chemical Protective Clothing***

VAPOR, GAS

- ***Ventilation***
- ***Respirators***

LIQUID (if vapor also present, see above)

- ***Hand-washing facilities***
- ***Gloves***
- ***Chemical Protective Clothing***

CONTROL AT THE WORKER

Worker education: Everyone who works with chemicals should know the chemical name as well as brand or trade name of each chemical or chemical mixture, their health hazards, and other hazards such as fire or explosion. Employers are required by law to provide this information, along with training in how to use chemicals safely. There should be written operating procedures for all activities involving chemicals, including how to handle spills. More information is given in ***Industrial Hygiene Fact Sheet 1***, **Hazard Communication.**

Enclose the worker: Workers can be located in control booths/rooms as a method of control. One disadvantage of this method is the social isolation of the worker. Worker enclosures should be as roomy and comfortable as possible. They should be provided with heating and air conditioning and provided with clean air from an uncontaminated location. They should be under slight positive pressure to keep out contamination.

Personal Protective Equipment (PPE): Improper use of personal protective equipment is dangerous! OSHA's PPE standard, 1910.132, requires employers to determine the appropriate personal protective equipment for each hazard and to train employees on how and when to use PPE. Training must also be given on the limitations of PPE. OSHA's respirator standard, 1910.134, requires employers to have a respirator program written and implemented if workers use respirators. The cost of properly providing PPE is often underestimated. It may be less expensive to control a hazard at the source than to provide PPE and administer its use properly year after year. For some jobs which are done only rarely, PPE may be appropriate.

Respiratory protective equipment: There are many kinds of masks which cover the mouth and nose to prevent chemicals from being inhaled. Some filter out chemicals. Others provide clean air from a compressor or bottled air. Proper respirator selection requires knowing which chemicals are in the air in what amounts. A combination of filters and cartridges may be required to protect against a mixture of chemicals. All respirators leak to some degree, especially those which operate under *negative pressure*. With these, the wearer must pull air in by breathing through paper filters or cartridges of activated charcoal or other absorbent. Negative pressure respirators should never be used in an oxygen deficient atmosphere. More information is given in ***Industrial Hygiene Fact Sheet 7***, **Respiratory Protective Equipment.**

Match Controls to the Routes of Exposure
INHALATION
- ***Ventilation***
- ***Housekeeping, HEPA vacuums***
- ***Respirators***
- ***Isolation***

INGESTION
- ***Clean break and lunch rooms***
- ***Clean storage for food, etc.***
- ***Hand-washing facilities***

SKIN ABSORPTION
- ***Gloves***
- ***Chemical protective clothing***

INJECTION
- ***Design job to avoid contact***

Gloves: Gloves can provide some protection from chemicals when skin contact cannot be avoided. Gloves must be properly selected, fitted, maintained, and used in order to be effective. No glove can provide complete protection against skin contact with a chemical. There will always be some permeation through the glove and degradation of the glove, increasing over time. Glove vendors are a good source of information on which gloves provide protection against which chemicals. More information is given in ***Industrial Hygiene Fact Sheet 8***, **Gloves.**

Skin washing and barrier cream: Frequent and thorough washing is one of the easiest ways to reduce skin contact with chemicals or ingestion of chemicals. Barrier creams are not as effective as properly selected gloves and chemical protective clothing (CPC). However, a protective cream or lotion for the hands, arms, face, and neck can be used in addition to gloves and CPC. More information is given in ***Industrial Hygiene Fact Sheet 9,*** **Skin Washing and Barrier Creams.**

Chemical protective clothing: Special chemical protective clothing (CPC) such as coveralls, aprons, head covers, shoes, and boots can be used to protect parts of the body potentially exposed to chemicals. Street clothing and shoes should not be worn at work because of the danger of them becoming contaminated and carrying chemicals into cars and homes, exposing others and continuing workers' exposures past working hours. CPC must be properly selected, fitted, maintained, and used in order to be effective. No clothing can provide complete protection against skin contact with a chemical. There will always be some leakage, permeation, and degradation which increase over time. More information is given in ***Industrial Hygiene Fact Sheet 10***, **Chemical Protective Clothing and Footwear.**

Eye and face protection: Splash-proof chemical goggles, face shields, and respirators with full face pieces provide some protection against chemical splashes. Ordinary safety glasses are intended for protection against large flying particles and do not provide protection from chemicals. More information is given in ***Industrial Hygiene Fact Sheet 11***, **Eye and Face Protection**.

Lunch and break room: A clean room for lunch and breaks with a refrigerator, microwave oven, and vending machines will help to encourage employees to avoid eating in work areas where they may ingest or continue to inhale chemicals. A clean storage area should be provided for food, beverages, and cigarettes. Employees should be instructed to HEPA vacuum the outside of their PPE, and wash hands (first with any

gloves on, then ungloved) and face (first with any respirator on, then with it off) prior to eating, drinking, or smoking. Clean shelving should be provide for storage of gloves and respirators while using the room.

Locker and change room: Workers can accidentally take chemicals, particularly dusts, out of the workplace on their shoes, clothing, and other belongings unless measures are taken to prevent this from happening. Vehicles, homes, and other places where the workers go may become contaminated and other people sharing these spaces may become exposed. If chemicals are taken home, children, elders, pets, and others with greater susceptibility to health effects may be exposed. This is known as "take home exposure". Clean storage for street clothing, shoes, and personal belongings should be provided so that they are kept from contact with chemicals. One way to do this is providing two lockers for each worker, one for work items (dirty) and one for personal items (clean). Personal belongings, including wallets and purses, should be kept out of work areas so there is no chance of them becoming contaminated with chemicals. More information is given in ***Industrial Hygiene Fact Sheet 12***, **Locker, Shower, and Change Rooms.**

Lavatories: Clean, convenient lavatories with skin cleaner, towels, and warm water will encourage employees to wash chemicals often from their hands and face. Additional hand-washing facilities in work areas are an extra incentive to wash up often. Where chemicals get on the body or hair, clean showers with warm water should be provided for use before going home. Skin cleaner, shampoo, and towels should be provided with the showers.

Emergency eyewash and shower: An eyewash fountain should be located close to any work area where a chemical might splash into or otherwise enter the eyes. If there is the possibility of skin exposure, an emergency shower or hose should also be provided. This equipment should be tested regularly to make sure that is working. A bottle of water is not satisfactory as an eyewash because it cannot provide 15 minutes of flushing which is the recommended length of time for flushing chemicals from the eyes.

Industrial Hygiene Fact Sheet 1

Hazard Communication

The OSHA Hazard Communication Standard (1910.1200) is different from many other OSHA rules because it covers ***all*** hazardous chemicals. The rule also incorporates a *downstream flow of information* which means that producers of chemicals have the primary responsibility for generating and disseminating information, whereas users of chemicals must obtain the information and transmit it to their own employees. In general, it works like this:

Chemical Manufacturers/Importers

- Determine the health, fire, reaction, and explosion hazards of each product.

Chemical Manufacturers/Importers/Distributors

- Communicate the hazard information and associated protective measures downstream to customers through labels on containers and Material Safety Data Sheets ***(MSDSs).***

Employers

- Identify and list all hazardous chemicals in their workplaces.
- Obtain current ***MSDSs*** and labels for each hazardous chemical.
- Develop a system to ensure that all incoming hazardous materials are labeled**.**
- Review each ***MSDS*** to make sure it is complete. Discard old versions.
- Make sure that ***MSDSs*** are available to workers. (Consider MSDS management software)
- Develop and implement a written hazard communication program.
- Communicate hazard information to workers through labels, ***MSDSs***, and a formal training program.
- Inform workers of protective measures for hazardous chemicals.

DANGER
Contains ASBESTOS Fibers
Avoid Creating DUST
Cancer & Lung Disease Hazard

For more information, see the actual OSHA standard and the following publications:

Chemical Hazard Communication -- OSHA Publication 3084; Free by calling 202-693-1888

Hazard Communication -- A Compliance Kit -- OSHA Publication 3104; Order No. 029-016-00147-6; cost $18.00; Order by calling 202-512-1800

Hazard Communication Guidelines for Compliance
Order No. 029-016-00127-1; cost $1.00; Order by calling 202-512-1800

OSHA Instruction CPL 2-2.38D. Free by calling 202-693-1888 or on the Internet at www.osha.gov

Also, under the New Jersey Worker and Community Right to Know Act, every container at a private employer's facility must bear a label indicating the chemical name and Chemical Abstracts Service (CAS) number of the five most predominant substances in the container. For more information, call RTK at 609-984-2202.

Industrial Hygiene Fact Sheet 2

Substitution

Many harmful chemicals and processes are currently used as a matter of tradition although less harmful alternatives exist. Substitution of less harmful chemicals and processes for particularly hazardous ones has the advantage of completely removing a hazard from a workplace so that the potential for exposure is gone. Substitution is a complex process that requires research and experimentation. If successful, however, substitution is the most powerful and desirable control method.

Some examples of possible substitutions include:

- alkaline degreasing for trichlorethylene and chlorinated, fluorinated hydrocarbons (HCFCs or freons)
- water-based or melting glues for solvent-base glues
- water-based for solvent-based paints and lacquers
- emulsion cleaning (water containing non-chlorinated organic solvent and an alkaline mix of tensides) for perchloroethylene in dry-cleaning
- lead-free for leaded paints and pigments
- cadmium-free pigments for ones containing cadmium
- silica-free abrasive blasting materials for those containing free silica
- vegetable oil mixture for organic solvents in cleaning offset printing presses
- paper wool, perlite, or polystyrene for asbestos and fiberglass insulation
- electronic thermometers for those containing mercury

Sometimes the same chemical can be used in a different form, for example:

- a slurry instead of a dry powder
- a brick of material instead of a dry powder
- a material encapsulated in a dissolvable plastic bag or gelatin capsule
- a waxy material instead of a dry powder

Sometimes a different process with less potential for exposure can be substituted, for example:

- flow coating or dipping instead of spraying
- water-based caustic or abrasive or water blasting for paint-stripping with solvent-based strippers containing methylene chloride or N-methyl pyrrolidone (NMP)
- water blasting instead of abrasive blasting

Functional analysis for substitution

One way to approach substitution is to use functional analysis, a method derived from the product development field, which can help define the problem and find substitutes. In the first step, the basic requirements to be met by the product are determined by asking ***"Why is it used?"***. The second step is characterized by ***brainstorming*** alternative ways to meet the basic requirements. Free and open brainstorming is very important because humans are very good at restricting themselves by rejecting new ideas as too expensive, too troublesome, or not technically suitable. The final step is to assess the alternatives for workability and safety. It is important to compare the chemicals being considered for substitution not only for toxicity but also routes of entry, vapor pressure, flammability, particle size, safe disposal, etc. Don't substitute with a chemical for which toxicity has not been studied at least as well as the chemical

which is being replaced. Lack of toxicity information is a warning sign, not a sign of immunity from problems. It may be difficult to identify the potential disadvantages of a substitution. These may include increased noise, additional cleaning steps, waste disposal difficulties, etc. ***The real question to ask is which chemical's problems will be easiest to control.***

Substitution and pollution prevention

A secondary benefit of substitution can be reduction or elimination of waste and the costs associated with its disposal, regulatory compliance, liability, and environmental impact. It is clear that pollution prevention is far more desirable than pollution treatment, control, and remediation. Free, confidential consultation for industrial pollution prevention is available to industry in New Jersey from:

> ***New Jersey Technical Assistance Program for Industrial Pollution Prevention***
> ***New Jersey Institute of Technology, Advanced Technology Center Building***
> ***323 Martin Luther King, Jr. Blvd.; University Heights***
> ***Newark, New Jersey 07102***
>
> **973-596-5864**

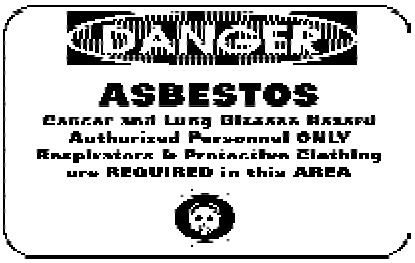
Available services include the following:
1. On-site assessment of processes and procedures;
2. Literature research on existing, successful waste reduction technologies;
3. Referrals to qualified experienced professionals accomplished in process design, modernization, troubleshooting, and engineering;
4. Industry specific case study workshops and presentations to trade associations on waste reduction opportunities;
5. Development of pollution prevention demonstration projects with trade associations and utility authorities.

Industrial Hygiene Fact Sheet 3

Isolation

Enclosed operations -- Isolation of the source of exposure can be accomplished through actual physical enclosure, preferably separate rooms or buildings, and closed doors. The direction of airflow must be into the restricted area from the cleaner areas. ***Therefore, the isolated area must be under negative pressure compared to surrounding areas.*** This is accomplished by exhausting extra air from the isolated area to the outdoors using fans in either general or local exhaust ventilation. Exhaust air must be decontaminated before release to the outdoors. There should be no connections between the isolated area and other areas via the ventilation system, ceiling plenums, pipe chaseways, openings in walls, etc.

Regulated areas -- As a further precaution, *regulated areas* can be established around enclosed operations with access only to a limited number of essential employees. Entrances to regulated areas should be posted informing workers that the areas may be entered only by authorized personnel and the special procedures, such as wearing respirators, that must be followed in the regulated area. A roster of employees entering and leaving the regulated area should be kept. No smoking, eating, drinking, chewing tobacco or gum, or applying cosmetics is permitted in regulated areas. Air locks with interlocked doors add an extra measure of isolation. Computerized card readers and doors with alarms prevent unauthorized entry.



Isolation by time -- The amount of time employees spend in isolated or regulated areas should be minimized. A hazardous operation can sometimes be performed during the second or third shift to reduce the number or workers potentially exposed.

Glove boxes -- Glove boxes are usually small units that have two or more ports in which arm-length rubber gloves are mounted. The worker places her hands in these gloves to perform tasks inside the box. Construction materials vary widely, depending on the intended use. Clear plastic is frequently used because it allows visibility of the work area and is easily cleaned. Glove boxes generally operate under negative pressure so that any air leakage is into the box. Exhaust air must be decontaminated. Because these units have low airflow, scrubbing or absorption of exhaust air can be accomplished with little difficulty.

Enclose workers -- Workers can be protected by enclosure in a special isolated booth or room from which they can observe and control an operation using chemicals. One disadvantage of this method is the social isolation of the worker. Worker enclosures should be as roomy and comfortable as possible. They should be provided with heating and air conditioning and provided with clean air from an uncontaminated location. They should be under positive pressure to keep out contamination.

Industrial Hygiene Fact Sheet 4

Ventilation

Ventilation supplies and moves air through spaces. It is important to distinguish between two types of ventilation -- *general or dilution ventilation* and *local exhaust ventilation* (LEV).

General or Dilution Ventilation

General ventilation reduces the concentration of air contaminants by mixing and diluting the contaminated air with clean, uncontaminated air. Air is supplied or exhausted from an area or building by large fans in walls or ceilings. Sometimes general ventilation is provided by opening doors and windows; this is not a reliable way of providing the amount or direction of flow of air that may be necessary. General ventilation can effectively remove large amounts of hot or humid air or dilute low concentrations of contaminants. General ventilation does not eliminate the exposure. It should not be relied on to reduce chemical exposures unless the amount of contaminant is small and is produced at a constant rate. It can also be considered for use in areas where workers are far away from the source of exposure.

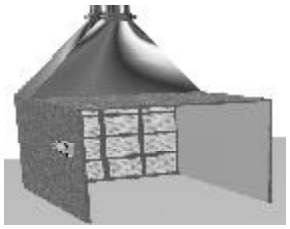
For more information, obtain:

- ***A Basic Guide to Industrial Ventilation, available from the NJDHSS, 609-984-1863***
- ***Industrial Ventilation: A Manual of Recommended Practice, available from the ACGIH, Cincinnati, OH 513-742-2020***

Local Exhaust Ventilation (LEV)

Local exhaust ventilation is the ventilation of choice for controlling air contaminants. LEV captures contaminants at or near the point where they are generated and removes them. LEV systems are usually permanently installed; portable units are also commercially available. LEV has these basic elements:

- ***Hoods*** that capture the contaminants as close as possible to their source.
- ***Ducts*** that transport the contaminants
- ***Air cleaning devices*** that remove the contaminant from the air
- ***Fans*** that move the air through the ventilation system and discharge the exhausted air outside.
- ***Make-up air*** that replaces the exhausted air.



LEV must be properly designed, constructed, operated, and maintained in order to be effective.

How To Check Exhaust Ventilation

Use a smoke tube, burning incense or children's soap bubbles to generate smoke or bubbles to float in the air. Smoke tubes that emit a highly visible smoke are made for this purpose. Notice whether the smoke/bubbles and therefore the air moves into the exhaust hood. One caution is that the light smoke/bubbles will only partially imitate how heavier dusts, such as lead and silica, are removed. An exhaust hood might suck up the smoke/bubbles but not the dust. However, with this in mind, the smoke/bubbles can be valuable even in these cases. Cross drafts, interfering air turbulence, inadequate exhaust, "eddies" and "backwaters" all become very apparent.

Maintenance of Ventilation

Scheduled periodic checks and preventive maintenance of the entire ventilation system by qualified maintenance personnel are essential to good operations but are often neglected. These items should be checked:

Hoods

- Dents, holes, or other damage.

Ducts

- Plugging - tap with a screwdriver - a "thud" indicates the duct is plugged.
- Correct position of adjustable dampers.
- Dents, holes, loose joints, or other damage.
- Some ducts contain fused dampers that close in case of fire. These fuses may melt causing the dampers to close.
- Changes to system which limit airflow, for example, 90 degree bends in ducts.

Motors and Fans

- Belts may be loose or broken.
- Low voltage and undersized fan.
- A fan may be installed backwards.
- A motor may be wired wrong and a fan may be rotating backwards. A centrifugal fan, when running backwards, will **not** reverse the air flow but will pull a lower volume of air.
- Fan blades may be dirty, plugged, rusted, broken.

Air Cleaning Devices

- Filters or other collection devices may be clogged.
- Dents, holes, loose doors, or other damage.

Make-Up Air

- If the amount of clean make-up air brought into the area does not equal the amount of exhaust air, the workplace becomes "starved" for air and negative pressure is created. This will put a strain on the ventilation system causing it to move less air.
- Test for negative pressure by noticing the direction of air movement at windows, doorways, and other openings into the workplace using smoke/bubbles. If air rushes into the workplace, it is "starved" for air and more make-up air must be provided.

Some manufacturers of small-scale, pre-fabricated local exhaust ventilation systems:*

Alsident, Denmark
c/o Lab Safety Supply, Janesville, WI
800-356-0783
www.alsident.com

Nederman, Westland, MI
313-729-3344
www.nederman.com

PACE, Laurel, MD
301-490-9860
www.paceusa.com

** Mention of any product name does not constitute endorsement by the NJDHSS*

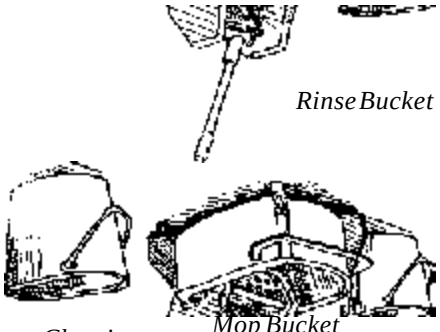
Industrial Hygiene Fact Sheet 5

Housekeeping and HEPA Vacuums

Good housekeeping involves the prompt and complete removal of chemicals from room and work surfaces, including floors, walls, ceilings, doors, stairs, rafters, tables, chairs, machinery, equipment and tools. The purpose of good housekeeping is to prevent chemicals from getting into the air or coming into contact with workers' skin or food. Housekeeping activities can themselves be a significant source of chemical exposure if good practices are not used. ***Housekeeping methods which should be avoided with chemicals are dry sweeping, dry dusting, use of compressed air for cleaning, and use of ordinary (non-HEPA) vacuum cleaners because they often create massive worker exposure.*** Recommended housekeeping methods are described below. What may seem like extraordinary methods are recommended to assure that surfaces are truly chemical-free. Surfaces just looking clean is not enough because chemicals may still be present in amounts capable of causing exposure.

Wet wiping: Wiping should be done using the **three bucket** method. Assemble two buckets with clean water, an empty bucket for dirty excess cleaning solution, and a container of cleaning solution. *To clean* the work surface, pour cleaning solution onto a clean cloth. Wring excess solution into the empty bucket. Wipe the surface with the cloth. Add more cleaning solution to the cloth and continue wiping until all surfaces have been covered. Discard cloths as they become dirty. *To rinse*, dip and wring out a clean cloth in the first rinse bucket. Wipe off the work area. Rinse the cloth in the first bucket again and wring out thoroughly. Rinse the cloth in the second bucket and wring out thoroughly again. Continue wiping in this way until all surfaces have been rinsed. The rinse water in the buckets should be changed periodically, depending on the amount of contamination.

Wet mopping: Mopping should be done using the **three bucket** method. *To clean*, assemble a bucket of cleaning solution, a mop and mop bucket for dirty rinse, and a bucket for clean rinse. Place the mop into the cleaning solution and then wring excess solution into the mop bucket. Mop small sections of the work area until the mop is dry. Slosh the mop in the clean rinse bucket and then wring into the mop bucket. Continue until the entire surface has been cleaned. *To rinse*, follow the same procedure except the bucket of cleaning solution is exchanged for a second rinse bucket. The rinse water in the buckets should be changed periodically, depending on the amount of contamination.



Vacuuming with a HEPA vacuum: Standard vacuums may allow fine dust into the air by allowing it to pass through normal bags and filters. HEPA (High Efficiency Particulate Absolute) vacuums are special vacuums with high efficiency filters on the exhaust air stream. HEPA stands for High Efficiency Particulate Absolute, a filter capable of removing 99.97% of particles down to 0.3 microns. Some HEPA vacuums also have activated charcoal filters on the exhaust air stream; these are designed for mercury and some other volatile chemicals. Some HEPA vacuums are wet/dry. Most models are electric; some are pneumatic. Models come in capacities from 4 to 15 gallons. Most are portable floor models; some units are designed to be carried on the back.

Some manufacturers of HEPA vacuums* are:

Cat Vac, Algonquin, IL
708-658-1444

Hild, Chicago, IL
800-451-2457

Lab Safety Supply, Inc., Janesville, WI
800-356-0783

Minuteman International, Addison, IL
800-323-9420

Nikro, Villa Park, IL
708-530-0558

Nilfisk of America, Malvern, PA
800-645-3475

Pullman-Holt, Tampa, FL
800-237-7582

Tornado ToxVacs by Breuer, Chicago, IL
800-VACUUMS

Care to avoid chemical exposure must be taken when using a HEPA vacuum. Attachment nozzles should be used in a manner that does not cause the chemical to become airborne. Care must be taken especially when removing and replacing the disposable waste bag and HEPA filter; manufacturer's instructions should be followed. HEPA vacuum users should wear appropriate personal protective equipment.

Vacuuming with a central vacuum system: Some workplaces have installed a central vacuum system with ports for attaching cleaning hoses and tools. These are useful when large amount of material which would quickly fill a portable vacuum cleaner must be cleaned up. Central systems are commercially available, however they must be customized for the layout of the particular work-place. Air cleaning devices for the exhaust air should be isolated or placed outdoors. If it will be recirculated into the workplace, the exhaust should be HEPA filtered.

* *Mention of any product does not constitute endorsement by the NJDHSS.*

Industrial Hygiene Fact Sheet 6

Spill Clean-up

The following issues should be addressed in advance in every workplace that uses chemicals, preferably by establishing written spill clean-up procedures:

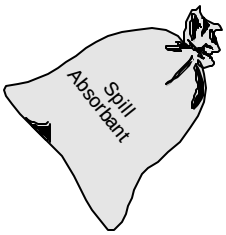
1. ***Lines of authority***. To whom in management spills should be reported. Who is responsible for taking charge of the spill area.

2. ***Site control measures.*** Spill containment and area protection procedures. Limiting the spread of the chemical until clean-up begins. Decontamination of employees if contaminated during the spill.

3. ***Criteria for assessing*** the size and difficulty of cleaning up the spill and deciding whether the spill will be cleaned up by:
   a. employees in the immediate area of the spill
   b. employees on the Hazardous Materials team
   c. an outside contractor

4. ***Step-by-step procedures*** for conducting the clean-up under various probable scenarios of size and difficulty.

5. ***Equipment available*** for use in spill clean-up.



6. ***Training*** of personnel to be involved in the clean-up.

7. ***Personal protective equipment*** to be used during the clean-up.

8. ***Reoccupancy criteria*** for deciding that enough clean-up has been done and the area can be re-occupied.

9. ***Disposal*** procedures for the chemical-contaminated waste.

10. ***Legal requirements*** including compliance with OSHA and PEOSH regulations; compliance with regulations on chemical disposal.

11. ***Medical surveillance*** to be certain that employees performing clean-ups are not getting sick and are medically capable of wearing protective equipment during clean-up activity.

For more information, see How to Prepare for Workplace Emergencies, OSHA Publication 3088. Free by calling 202-693-1888.

Industrial Hygiene Fact Sheet 7

Respiratory Protective Equipment

Respirator Types

Respiratory protective equipment consists of devices that cover the mouth and nose to prevent chemicals in the air from being inhaled. There are two major types:

- **Air-purifying respirators:** particulate masks, cartridge style respirators, gas masks, and Powered Air Purifying Respirators (PAPR). These all filter the workplace air before it is inhaled. PAPRs deserve special mention and recommendation for consideration. They use a battery-powered blower to push the contaminated air through air purifying filters or cartridges and into the facepiece. In this group, only PAPRs supply air at positive pressure, which is a major advantage in minimizing leakage into the facepiece. PAPRs are often more comfortable than negative pressure, air-purifying respirators.

- **Supplied air respirators:** Self Contained Breathing Apparatus (SCBA), airline systems, and Emergency Escape Breathing Apparatus (EEBA). These provide clean air from an air compressor or bottled compressed air. Many of these supply air at positive pressure.

Respirator Limitations

Respirators can provide only limited protection against inhaling chemicals in the air. Even if they are properly selected, fitted, maintained, and used, respirators are a problematic control measure for the following reasons:

- They are not comfortable, especially under hot conditions;
- They limit communication about work issues and enforce social isolation;
- They put extra stress on the heart and lungs;
- They do not prevent skin exposure;
- They can be a source of exposure by inhalation and ingestion if they are contaminated inside the facepiece;
- Those with negative pressure inside the facepiece allow leakage under the facepiece to some degree, allowing inhalation exposure;
- Chemicals may break through the filters of air-purifying respirators;
- Air-purifying respirators only protect against certain chemicals at relatively low levels and offer no protection whatsoever against many chemicals.
- Air-purifying respirators require the user to be clean-shaven.
- Air-purifying respirators cannot be used in oxygen deficient atmospheres.

Fitting respirators

Because everyone's face is different and every respirator manufacturer's facepiece shapes and sizes are different, not every size or model of respirator will fit a given individual. Therefore, the employer must have samples of several styles and sizes from several manufacturers available for fit testing purposes. Each exposed worker must be fit tested to determine which brand and size will give the individual the best face seal. All respirators with tight-fitting facepieces must be fit tested.

There are two types of fit tests:

- ***Qualitative fit tests*** are based on whether a test chemical can be detected by an individual wearing a respirator. The test chemicals used are isoamyl acetate (banana oil), irritant smoke, or saccharin. *Respirator manufacturers can recommend where to purchase inexpensive qualitative fit test kits.*
- ***Quantitative fit tests*** involve placing the respirator wearer in an atmosphere containing an easily analytically detected, relatively non-toxic aerosol. The atmosphere inside the respirator is sampled continuously through a probe to measure how much test chemical leaks into the facepiece. Quantitative tests do not rely on a person's sense of taste or smell, which can vary greatly between individuals, and therefore are much more accurate than qualitative tests. Quantitative tests require expensive equipment and training for the person administering the test, however.

Once a fit test has been done, a mask of the appropriate brand, style and size for that employee should be ordered and assigned ***exclusively*** to that employee. Even though a respirator has been fit tested, daily changes in putting on the respirator, in strap tightness, hair, etc., may affect the fit. Thus employees should be instructed to do one of the following **seal checks** each time a reusable mask is put on. (Such checks can not be done with disposable respirators.) If the check fails, the respirator should be readjusted and perhaps tightened on the face.

- **Negative pressure seal check:** The user closes off the inlets of the cartridges or filters by covering them with the palms or a thin glove, then inhale gently so that the facepiece collapses slightly and holds breath for about 10 seconds. If the facepiece remains slightly collapsed and no inward leakage is detected, the respirator is probably tight enough.
- **Positive pressure seal check:** The user closes off the exhalation valve by covering it with the palm or a finger, then exhales gently so that the facepiece inflates slightly and holds breath for about 10 seconds. If the facepiece remains slightly inflated and no outward leakage is detected, the respirator is probably tight enough. For some respirators, this method requires that the wearer remove the exhalation valve cover which disturbs the respirator. In this case it is better to use the negative pressure fit check.

Comfort

Another consideration should be comfort. While it is important, it must never take priority over protectiveness. A comfortable mask which fails to keep out contaminants gives a false sense of security and presents a health risk to employees. Of course a protective mask which is uncomfortable is unlikely to be worn consistently, and so in the end will not be protective. Both factors must be considered. Again, PAPRs may offer greater comfort than other air-purifying respirators.

Respirator Programs

Respirator use must be part of a comprehensive program established by the employer, for which OSHA requires the following elements to be documented in a written program:

- The basis for selection of a specific type of respiratory protective equipment.
- Provision for medical screening of each employee assigned to wear a respirator to certify if he/she is physically and psychologically able to wear a respirator.
- Provisions for testing for the proper fit for tight-fitting respirators.
- Procedures for proper use of respirators in routine and foreseeable emergency situations.
- Provisions for regularly cleaning and disinfecting.
- Provisions for proper storage.

- Provisions for periodic inspection and repair.
- A periodic evaluation by the administrator of the program to assure its continued functioning and effectiveness.
- An employee training program in which the employee can become familiar with the respiratory protective equipment through hands-on practice and be trained in the proper use and the limitations of the equipment.
- Employee training in the respiratory hazards to which they are potentially exposed.

A single individual should be designated to develop and manage the respirator program. Without a definite chain of supervision, there is no assurance that written procedures will be followed. The manager of the respirator program should ensure that all phases are implemented initially and carry out periodic review and evaluation to ensure their continuing quality.

Protection Factors

The effectiveness of a respirator in providing protection is described by the *protection factor* of the respirator. This is a number assigned by NIOSH or respirator manufacturers which indicates by what factor the air concentration of a contaminant outside the facepiece is reduced by the respirator. A protection factor of 10, for example, indicates that if the airborne concentration of a dust is 12 mg/M^3, that the average fit-tested user will be exposed to ten times less inside the respirator facepiece, or 1.2 mg/M^3.

NIOSH Approval

A major consideration in choosing a respirator appropriate to a particular job is *approval* by NIOSH. Both disposable and reuseable respirators may be NIOSH approved. If a reuseable, cartridge, air purifying respirator is used, the cartridge must be approved for the contaminants present in the workplace. For example, only a *charcoal cartridge* or canister will be approved for organic vapors. Only a *particulate filter* will be approved for dusts, fumes and mists. NIOSH approves particular combinations of facepieces, cartridges, retainer rings and filters. It is important to use approved combinations. Mixing and matching will void NIOSH approvals.

Changing rules

Occupational respiratory protection matters are in a state of flux. OSHA, NIOSH, and other regulatory requirements, respirator categories, and approvals are changing. A new OSHA respirator standard went into effect during 1998. The existing consensus standards are being revised. When purchasing respirators, ensure that they will meet upcoming as well as current requirements.

For more information, see <u>new</u> OSHA standard 1910.134 and the following publication:
Respiratory Protection, OSHA Publication 3079 - Available on the Internet - www.osha.gov - or free by calling OSHA Publications at 202-693-1888.

Respirators are sold primarily through safety equipment distributors. Some major respirator manufacturers are listed below.* They can provide the names of distributors of their products. Many manufacturers also have educational videotapes and publications and can offer technical assistance in dealing with respirator selection, fitting, maintenance, and use.

3M-Racal, St. Paul, MN
800-243-4630
www.3m.com

Alpha Pro-Tech, St. Lake City, UT
801-936-3240
www.alphaprotech.com

Bullard Company, Cynthiana, KY
800-827-0423
www.bullard.com

Aearo Safety Corp., Southbridge, MA
800-225-9038
www.aearo.com

Devilbiss, Maumee, OH
877-849-9564
www.devilbiss.com

National Draeger, Inc., Pittsburgh, PA
800-615-5503
www.draeger.net

Lab Safety Supply, Janesville, WI
800-356-0783
www.labsafety.com

MSA Co., Pittsburgh, PA
888-277-5449
www.msanet.com

Moldex/Metrics, Inc., Culver City, CA
800-421-0668
www.moldex.com

North Safety Products, Cranston, RI
401-943-4400
www.northsafety.com

Scott, Monroe, NC
800-633-3915
www.scottaviation.com

Survivair, Inc., Santa Ana, CA
888-APR-SCBA (888-277-7222)
www.survivair.com

U.S. Safety, Lenexa, KS
800-821-5218
www.ussafety.com

Willson/Dalloz, Reading, PA
800-345-4112
www.cdalloz.com

** Mention of any product does not constitute endorsement by the NJDHSS*

Industrial Hygiene Fact Sheet 8

Gloves

Gloves can provide some protection from chemicals when skin contact cannot be avoided. Gloves must be properly selected, fitted, maintained , and used in order to be effective. There are many types of chemical resistant gloves available on the market. Choosing the correct glove can be difficult because no glove is resistant to all chemicals. Selection for protection against chemical mixtures is especially difficult and may require "double-gloving", the wearing of one type of glove over another type. Even gloves that offer good chemical resistance may protect the hands for only a limited time before chemicals permeate through the glove material. Glove manufacturers can provide breakthrough times for their gloves against common chemicals. The breakthrough time is the elapsed time between initial contact of the chemical on the surface of the glove and the analytical detection of the chemical on the inside of the glove. For mixtures, a glove should be selected on the basis of the chemical contaminant with the shortest breakthrough time. Gloves manufactured by various companies may provide different levels of protection because of manufacturing and quality control differences. Hazard assessment should be done in compliance with the OSHA standard on general requirements for personal protective equipment (29 CFR 1910.132). Selection should be done in compliance with the OSHA standard on hand protection (29 CFR 1910.138) and consider the tasks being performed in relation to the following features:

Glove Composition-- The most common types of chemical resistant gloves are:

Latex --A natural rubber material often made into thin disposable gloves which offer very little chemical resistance. In thicker gauges, latex offers some protection from acids, alkalis, and undiluted ketones and aldehydes. Does not protect against hydrocarbon solvents. High resistance to cuts. **WARNING: Workers who use latex gloves frequently are at risk for developing latex-related contact dermatitis and asthma. If latex gloves are used, select powder-free gloves with reduced protein content.**

Nitrile -- This synthetic rubber offers protection from oils, grease, many solvents, esters, acids, and caustics. It also offers good puncture, cut, and abrasion resistance. Not recommended for ketones and some organic solvents.

Neoprene -- This synthetic rubber offers resistance to a broad range of chemicals, including oils, solvents, acids and caustics. Neoprene remains flexible at low temperature, but offers only limited protection from cuts and snags.

Polyvinyl chloride (PVC) -- A synthetic thermoplastic polymer, PVC offers protection from many acids, caustics, and alcohols. It also offers good protection from abrasion, but some glove styles are susceptible to cuts. Not recommended for ketones and other solvents.

Polyvinyl alcohol (PVA) -- High resistance to aliphatic and aromatic hydrocarbons, chlorinated solvents, esters, and most ketones. Glove will break down in water and light alcohols. Resists cuts and abrasion.

Ethylene vinyl alcohol (EVOH) -- This is one of the most chemical resistant materials available. These flat-film gloves are used as liners inside PVC or nitrile gloves due to their thin structure.

Butyl -- Used against polar organics like acetone. Ineffective against hydrocarbons and chlorinated solvents. Moderate resistance to cuts, snags, puncture, and abrasion.

Viton ® -- Recommended for use with chlorinated and aromatic solvents. Not for use with ketones, esters, and amines. Limited resistance to cuts and snags.

Silver Shield® -- Lightweight, flexible foil laminate stands up to almost any chemical. Often used as an overglove in hazardous materials incidents.
4H -- Patented, plastic, five-layer laminate handles more than 280 chemicals and chemical mixtures including epoxy, organic solvents, acids, bases, paints, degreasing agents, and adhesives. For heavy-duty work are best used under other chemical resistant work gloves. For handling small, delicate items, wear under latex gloves.

Size -- Gloves should fit well. Most gloves come in extra small, small, medium, large, and extra large; some come in numbered sizes. Tight-fitting gloves can cause restricted motion and discomfort while loose-fitting gloves can be hazardous. Sizes may vary among styles and manufacturers.
Thickness -- Thickness of glove material is usually measured in mils (1 mil=0.001" gauge). Lower gauge gloves allow better dexterity and flexibility. Higher gauge gloves give better overall protection, but less flexibility.
Length -- Wrist/forearm length protects hands and wrists; elbow length also protects the forearm for extra splash protection or during immersion; shoulder length protects the whole arm during full arm immersion or glove box applications.
Lining -- Lining inside the glove can absorb perspiration and add temperature protection. Glove liners can also be purchased separately.
Cut, snag, puncture, and abrasion resistance -- These vary widely.
Disposable or reusable -- Disposables are intended for one time use. Gloves that are reused, even after being washed, may offer less protection than when new because chemicals may have begun to breakthrough. For that reason, reusing gloves is risky and gloves should be discarded after the breakthrough time has elapsed.

Some glove manufacturers are listed below. They can provide names of local distributors and technical assistance on glove selection, fitting, maintenance, and use.

Ansell Edmont, Coshocton, OH
800-800-0444
www.ansell-edmont.com

Best, Menlo, GA
800-241-0323
www.bestglove.com

Guardian Glove, Willard, OH
800-243-7379
www.guardian-mfg.com

Lab Safety Supply, Janesville, WI
800-356-0783
www.labsafety.com

North Safety Products, Cranston, RI
888-943-9434
www.northsafety.com

** Mention of any product does not constitute endorsement by the NJDHSS*

Industrial Hygiene Fact Sheet 9

Skin Washing and Barrier Creams

Skin Washing

Skin washing is one of the easiest ways to reduce ingestion and skin absorption of chemicals. In order to prevent accidental ingestion of chemicals, washing should take place, especially before eating, drinking, or smoking. All exposed skin, including hands, arms, face, and neck should be washed frequently and thoroughly during the work day to reduce the time that chemicals are in contact with the skin. Washing facilities should be placed near work areas and be supplied with warm water, skin cleaner, a fingernail brush, and paper towels. In addition, a mirror will help workers to see any visible contamination on their necks and faces. The more convenient and well designed the washing facilities, the more likely they will be used.

Skin cleaners should not dehydrate, abrade, or irritate the skin. They should be pH neutral. Cleaners should be properly selected for removing the chemical(s) in use. Solvents should never be used for cleaning the skin because they defat and damage the skin. Dispensing units are preferable to bar soap which may become contaminated. Where running water is not available, disposable wet wipes such as wet paper towels or baby wipes can be provided. Try to avoid products with sensitizers, like lanolin or limonene.

Barrier Creams

Barrier creams are not as effective as properly selected, fitted, and used gloves and chemical protective clothing (CPC). However, a protective cream or lotion can be used in addition to gloves and CPC. Protective barrier agents should be applied to clean, exposed skin -- usually the hands, arms, face and neck. After contact with the chemical, both the barrier and any chemical should be washed off and the cream reapplied. The barrier should also be removed at lunch and at the end of the workday.

A barrier cream must be properly selected for use against the particular chemical. Some are useful for protecting against solvents while other types protect against water-soluble materials. Barrier cream manufacturers can provide information on the proper selection and use of their products.

Industrial Hygiene Fact Sheet 10

Chemical Protective Clothing and Footwear

Special chemical protective clothing (CPC) such as full-body ensembles, coveralls, shirts, pants, aprons, head covers, can be used to protect parts of the body exposed to chemicals. Cloth work clothing should be worn under CPC rather than street clothing. This work clothing should be laundered by the employer and not taken home by the worker. Street clothing and shoes should not be worn at work because of the danger of them becoming contaminated and carrying chemicals into cars and homes, exposing others and continuing workers' exposure past working hours. Street clothing and shoes also do not provide adequate protection from chemicals.

No clothing can provide complete protection against skin contact with a chemical. There will always be some breakthrough which increases over time. In many cases, seams and closures have shorter breakthrough times and higher permeation rates than the fabric. CPC must be properly selected, fitted, maintained, and used in order to be effective. There are many types of CPC on the market. Choosing the correct CPC can be difficult because no fabric or garment is resistant to all chemicals. Manufacturers and vendors can provide breakthrough times for their CPC against common chemicals. Because of manufacturing and quality control differences, CPC manufactured by various companies may provide different levels of protection. Hazard assessment should be done in compliance with the OSHA standard on general requirements for personal protective equipment (29 CFR 1910.132). Selection should consider the tasks being performed in relation to the following features:

Material --CPC materials can be categorized into three general types:

***Limited-use general protection*:** Provides protection from toxic dusts like lead and asbestos. Includes such patented fabrics as Tyvek® -- spunbonded olefin fibers, and Kleenguard® . Can be worn several times until contaminated, soiled, or damaged.

***Limited-use chemical protection*:** Provides protection from chemical hazards, however, breakthrough times must be considered. Includes Tyvek® /Saranex® 23-P -- chemical resistant film on Tyvek®; Tychem™ 9400 -- multiple films; Kappler CPF™ I, II, III, and IV-- a multi-layer barrier film material laminated to a polypropylene substrate; Chemtuff™, Chemrel™, and Chemrel Max™ -- a flexible laminate bonded to a polymer substrate.

Chemical splash protection: Vinyl offers good basic protection from initial liquid penetration. Durable fabrics coated with PVC, rubber, neoprene, nitrile, and polyurethane each have their own strengths and weaknesses concerning chemical protection. Not intended to protect against regular or prolonged chemical contact.

Size -- CPC should fit well. Most CPC comes in sizes from small to XX Large, or even XXX Large. Some are available in women's dress sizes.

Thickness, weight, breathability, flexibility, wicking ability, and thermal properties -- These all affect comfort and performance.

Cut, snag, puncture, and abrasion resistance -- These vary widely.

Disposable or reusable -- Decontamination and reuse of CPC is a complex and controversial issue. CPC must be cleaned before being removed to allow safe doffing. Actual decontamination represents a subsequent step. Surface contamination may be able to be removed with detergent. It is not clear whether matrix contamination, which occurs when the fabric has been permeated by chemicals, can be effectively removed. Doing so may require the use of solvents and/or heat. No guidelines exist on how clean CPC needs to be before reuse. For all these reasons, reusing CPC is risky.

Chemical resistant footwear

The state of the art for testing footwear for chemical breakthrough is not as far along as for gloves and CPC. Normal safety shoes do not offer adequate chemical protection. A variety of over-the-shoe covers and over-the-sock industrial footwear is commercially available. The latter tend to be made of vinyl, PVC, polyurethane, or blends of these. Over-the-shoe protection is available in many of the fabrics described under CPC above. Selection should be done in compliance with the OSHA standard on general requirements for personal protective equipment (29 CFR 1910.132). Size, thickness, weight, breathability, flexibility, wicking ability, thermal properties, and cut, snag, puncture, and abrasion resistance should all be considered. In addition, other hazards to feet, for example from falling objects or piercing the sole, need to be considered. Therefore, selection should also be done in compliance with the OSHA standard on foot protection (29 CFR 1910.136).

Some manufacturers of chemical protective clothing are listed below. They can provide the names of local distributors and technical assistance on CPC selection, fitting, maintenance, and use.*

DuPont, Wilmington, DE
800-44-TYVEK (800-448-9835)
www.dupontprotectiveapprl.com

Lakeland Industries, Inc., Ronkonkoma, NY
516-981-9700
www.lakeland.com

Kimberly-Clark, Roswell, GA
800-255-6401

Kappler, Gunterville, AL
800-633-2410 (ext. 4242)
www.kappler.com

* *Mention of any product does not constitute endorsement by the NJDHSS*

Industrial Hygiene Fact Sheet 11

Eye and Face Protection

Splash-proof chemical goggles, face-shields, and respirators with full facepieces provide some protection against chemical splashes. Special purpose goggles can provide protection against mists. Ordinary safety glasses are intended for protection against flying objects and do not provide adequate protection from chemicals. An eye hazard assessment should be done in compliance with the OSHA standard on general requirements for personal protective equipment (29 CFR 1910.132). Selection should be done in compliance with the OSHA standard on eye protection (29 CFR 1910.133) and consider the tasks being performed in relation to the following features:

- Compliance with ANSI Z87.1-1989, *American National Standard Practice for Occupational and Educational Eye and Face Protection.*
- Compatibility with respirator use
- Compatibility with the use of prescription lenses
- Field of vision
- Venting -- ventilation should be adequate but well protected from splash entry.
- Comfort and fit

Goggles come in a number of different styles: eyecups, flexible or cushioned. Goggles should be kept in a case when not in use. They should be cleaned after each use and replaced if scratched or if the headband has lost its elasticity.

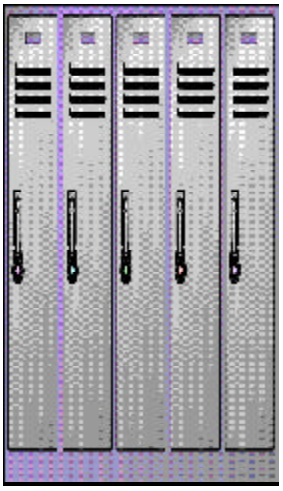
Faceshields are designed to protect the face from splashing liquids or flying objects. They are not meant to provide eye protection. Therefore, proper eye protection must be worn under a faceshield.

Contact Lenses

Blanket recommendations against the use of contact lenses in the workplace were common in the past but are no longer valid. OSHA has published an enforcement procedure authorizing the use of gas permeable and soft contact lenses in all workplaces and with all types of respirators. The American Academy of Ophthalmology and the American College of Occupational and Environmental Medicine now agree that, under the Americans with Disabilities Act, individuals should not be disqualified from performing their essential functions in an industrial environment unless it can be proven that they pose a direct threat to the health and safety of themselves or others. Contact lenses do not offer eye protection, so the required, correctly selected eyewear for the specific hazard must be worn over them.

Industrial Hygiene Fact Sheet 12

Locker, Shower, and Change Rooms



Workers can accidentally take chemicals, particularly dusty materials, out of the workplace on their shoes, clothing, and other belongings unless measures are taken to prevent this from happening. Vehicles, homes, and other places where the workers go may then be contaminated and other people sharing these spaces may be exposed. If chemicals are taken home, children, elders and others with greater susceptibility to health effects may be exposed. To prevent chemicals from leaving the workplace, clean storage for street clothing, shoes, and personal belongings should be provided so that they are kept from contact with chemicals. One way to do this is providing two lockers for each worker, one for work items and one for personal items. Personal belongings, including wallets and purses, should be kept out of work areas and away from work clothing so there is no chance of them becoming contaminated with chemicals.

The layout of locker, shower, and change rooms is important in assuring that the worker is not contaminated with chemicals at several junctures:

- while putting on work clothes, shoes, and PPE (donning)
- while taking off work clothing, shoes, and PPE (doffing)
- after showering

One good arrangement is to have two sections -- a **clean** section and a **dirty** section, with locker, skin washing, and toilet facilities in both and shower facilities in between. The **clean** section has an *outside entrance/exit*, lockers for street clothing and shoes, and a supply of clean uniforms and chemical protective clothing (CPC). Work shoes are kept in the **dirty** section. On arriving at work, the individual enters the **clean** section through the outside exit, removes all street shoes and clothing (ideally including socks and underwear) and puts on a clean uniform and CPC, including gloves and respirators. They walk through the shower room into the **dirty** section, put on their work shoes and proceed to their work area.

At the end of the day, the individual enters the **dirty** section and removes gross contamination from CPC by HEPA vacuuming; gloved hands are washed. All clothing and CPC are removed, leaving on the respirator. More heavily contaminated items, for example boots and gloves, should be removed first. Dirty CPC and uniforms are deposited in the trash and laundry, respectively. Work shoes are kept in lockers in the **dirty** section. The individual proceeds into the showers where the respirator is removed *after* the face and outside of the respirator are washed and the hair wetted. Respirators are deposited in a container in the shower area. The individual then proceeds to the **clean** area in a towel, puts on their street clothing and shoes, and exits to the outside.

Showers should be clean, with skin cleaner, shampoo, towels, and warm water.

Industrial Hygiene Fact Sheet 13

Air Sampling

The goals of air sampling can include:

- Identify where ventilation and engineering controls are needed.
- Compare chemical exposures before and after controls are installed.
- Assess how well ventilation controls are working.
- Assess the potential for worker exposure by inhalation of a chemical.
- Determine if worker exposures to chemicals are within exposure limits.

The limitations of air sampling include:

- A complete picture of potential worker exposure may not be provided.
- Exposure by ingestion and skin absorption cannot be measured.
- Exposure under all working conditions may not be provided.

Who can perform air sampling?

Air sampling is best designed by an individual with industrial hygiene training who understands the difficulties of selecting a workable sampling strategy and equipment. A company employee can be trained to collect the air samples once the sampling strategy and equipment have been well planned. The industrial hygienist can be from within your company -- perhaps from corporate headquarters -- from OSHA consultation, from your workers' compensation insurance carrier, or a private consulting company. The industrial hygienist will need the cooperation of workplace management to answer the following questions which affect sampling decisions.

- ***Which workers*** *should be selected for sampling?* The workers with the worst exposures in each job category should be selected.
- ***Where*** *should sampling devices be placed?* **Personal samples** should be taken in the worker's "breathing zone", by attaching the sampling device to a worker's collar. **Area samples** should be taken at and around the suspected sources of exposure.
- ***When*** *should samples be taken?* Samples should be taken on each shift, the week-end, and during maintenance or turnarounds, whenever the worst exposures are anticipated.
- ***How long*** *should the samples be taken for?* If exposures don't change much during the day, then full-shift sampling of up to 10 hours is appropriate. If there are peak exposures, then short-term samples during the peaks should be taken in addition to the full-shift sampling.
- ***How many*** *samples are needed?* The more samples are taken, the more the results are likely to be representative of actual exposures. As a rule of thumb, 10% to 50% of similarly exposed workers should be sampled. *Every* worker with a unique exposure should be sampled.
- ***What information*** *should be recorded during sampling?* The workers wearing sampling devices should be observed during sampling. All the tasks they perform which could give rise to exposure should be described along with the time at which they were performed. Ventilation conditions, temperature, humidity, barometric pressure, wind conditions, as well as personal protective equipment in use should also be noted.
- ***How soon*** *will results be available?* With **direct reading** instruments or devices, results are immediately available. Other methods require sending samples to a laboratory for analysis and results may take days or weeks to be received.

Air Sampling Equipment

There are many kinds of air sampling equipment. Most require calibration before and after use to be sure they are operating properly. Types include:

- **Piston or bellows hand pump used with color-changing gas/vapor detector tubes.** These are easy to use, relatively inexpensive, give short-term, direct reading area sampling results but are inaccurate plus or minus 25% or more.

- **Free-diffusion dosimeter badges** allow a gas or vapor to diffuse into a collection device without the need for a pump. These badges are relatively inexpensive and require no calibration. Most give full-shift results. Some are direct reading; others must be sent to a laboratory for analysis which is fairly expensive. Accuracy varies.

- **Battery-powered pumps used with sample collection devices** like filters, glass tubes containing charcoal, or other solid or liquid absorbent. The pump is connected to the collection device by a flexible hose. The pump is worn on the worker's belt and the sampling device is attached to the worker's collar. These can be used to collect either short-term or full-shift samples. Most of these collection devices must be sent to a laboratory for analysis. Accuracy varies.

- **Portable meters** for specific chemicals or types of chemicals which contain a battery-operated pump and provide direct-reading area monitoring. These include aerosol meters which measure particulate concentrations; and Flame Ionization Detector (FID) meters, Photo Ionization Detector (PID) meters, Infrared Absorption (IR) meters, and portable Gas Chromatographs (GC) which measure gas and vapor concentrations. Such meters tend to be expensive and relatively difficult to use. They must be zeroed then calibrated prior to each use with a known concentration of the chemical to be sampled and periodically returned to the manufacturer for "factory" calibration. Accuracy varies.

- **Fixed monitoring systems** for specific chemicals are used to collect and analyze grab samples. Samples are drawn sequentially from a series of pick-up points in the workplace. These are located where there is the potential for chemical release. The samples are carried through tubing to a centrally located analytical instrument of one of the types described above under portable meters. Results are regularly reviewed to check that controls are working and to detect slowly developing leaks. High results such as from a sudden, large leak are used to activate audible and/or visible alarms and other control measures.

Sampling and Analytical Methods

Sampling and analytical methods published by NIOSH or OSHA should be used when laboratory analysis is needed. Samples should be sent to a laboratory which is successfully participating in the AIHA Laboratory Accreditation Program, which incorporates the AIHA/NIOSH Proficiency Analytical Testing (PAT) Program. A list of such laboratories is published every April and September in the American Industrial Hygiene Association (AIHA) Journal and can be obtained by calling AIHA at 703-849-8888.

Worker Notification

All workers whose exposure has been monitored either directly or indirectly, by the sampling of a "similarly exposed" individual, should be informed of the results and a copy of the results placed in their medical or personnel file. Whenever a worker's exposure has been found to exceed an exposure limit, he or she should be individually notified of the result and the corrective action being taken to reduce exposures. This notification should be done within a few days of receipt of the sampling results and is most effective if done in writing as well as verbally.

Calculating Air Sampling Results

The industrial hygienist who designed the sampling strategy should be consulted concerning whether any calculations must be made on the sampling data, for example, time-weighted average exposures, additive exposures of several chemicals, or exposures for unusual work shifts.

Reporting Air Sampling Results

It is very important that air sampling results be presented with all the information about where, how, when, etc. the samples were taken so that the results can be correctly and fully understood.

Interpreting Air Sampling Results

Sampling results can be compared to a number of different criteria for evaluation:

- Previous results at the same workplace.
- Previous results at other comparable workplaces.
- Current results at other locations within the workplace.
- Exposure limits, if any.

If control measures are effective and well-maintained, one should expect to see exposure levels stable over time and as low as similar workplaces with good controls.

Exposure Limits

Exposure limits have been set for about 700 chemicals; they have not been set for many thousands of other chemicals. Lack of an exposure limit does not mean a chemical is harmless or non-toxic. There are many gaps in science's knowledge of chemical toxicity and routes of exposure.

Air sampling results are compared against exposure limits to evaluate how much improvement in controls is needed. Some of the exposure limits apply to the average exposure over a whole work day of 7 to 10 hours. Other exposure limits apply to short term exposures of 15 to 30 minutes. Some chemicals have a notation indicating that they may be absorbed through the skin as well as inhaled.

Many exposure limits are not completely safe because they are based on incomplete scientific information. The OSHA limits consider economic and technical feasibility as well as health effects. If you assess exposures and controls and make improvements as this document recommends, you will be lowering exposures and have a better chance of being in compliance with exposure limits.

There are a number of different sources for exposure limits for chemicals:

- **NIOSH Recommended Exposure Limits (RELSs).**
- **ACGIH Threshold Limit Values (TLVs) and Short Term Exposure Limits (STELs)**
- **OSHA Permissible Exposure Limits (PELs).** ***These are enforceable by OSHA***.

A consolidated source of information on exposure limits is the *NIOSH Pocket Guide to Chemical Hazards*. The pocket guide lists exposure limits and other key information on 677 chemicals. To order, call NIOSH at 1-800-356-4674.

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Wipe Sampling

Wipe sampling is an important and evolving industrial hygiene tool which allows surface contamination to be evaluated to assess the potential for worker exposure by skin absorption and/or ingestion of a chemical. Such wipe samples complement visual observation and review of procedures and increase the level of information available to evaluate the effectiveness of various control programs such as personal protective equipment (PPE), PPE decontamination, worker decontamination, housekeeping programs, the migration of contaminants out of isolated areas into clean areas, and take-home contamination. The results can be used to document that control programs are effective, or alternatively, that they are not working as expected and need modification. Sampling for contamination on the inner surface of PPE is an effective way to test its adequacy in preventing dermal exposure.

In planning wipe sampling, be clear about your goals. The areas to be wiped vary somewhat by what you are trying to find out.

To assess the potential for ingestion of a chemical and to assess housekeeping, wipe sample on skin or other surfaces which contact food, beverage, gum, cigarettes, etc.. These may include lunchroom tables, the interior of refrigerators, the interior of lockers, the spouts of drinking fountains, and the drop slots of vending machines. Also wipe sample on the inside of respirators after use and respirator storage containers.

To assess the potential for skin absorption of a chemical and to assess housekeeping, wipe sample on workplace surfaces with which workers come into frequent contact. These may include machinery, tools, switches, and work tables and chairs. Also wipe sample on the *inside* of PPE, such as gloves, coveralls, and boots. The *outside* of shoes and boots can also be tested to see if they have the potential to contaminate the hands of a worker who is putting them on or taking them off.

To assess the effectiveness of PPE and PPE decontamination, wipe sample on the *inside* of PPE after it has been worn and the *outside* after decontamination. The inner surfaces of gloves, and the inside of sleeves or collar of PPE are relatively easy to reach.

To assess worker decontamination, wipe sample workers' skin when they have washed up to eat lunch or leave work. Direct skin sampling should not be done for substances that are irritants, cause dermatitis of contact sensitization, are easily absorbed by the skin, or are corrosive because the pressure of sampling may increase exposure. Instead, sample surfaces that might contact the skin. Alternatively, rinse the skin with water and analyze the rinse water.

To assess housekeeping, wipe sample on floors and work surfaces.

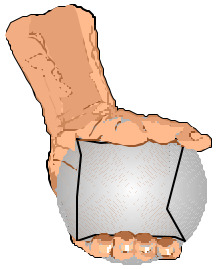
To assess the migration of a contaminant out of an isolated areas into a clean area, wipe sample on floors and work surfaces just outside the isolated area and then at distances further and further from it.

To assess the potential for take-home exposure of a chemical, wipe sample personal items such as pocketbooks, wallets, street clothing and shoes. Also wipe sample the inside of personally owned vehicles. If necessary, people's homes may be sampled. Obviously, great care is required to do such sampling in a non-blaming, respectful manner.

In all cases assess background levels -- Some samples should be collected on clean skin and surfaces in areas of the workplace which are believed to be uncontaminated such as offices or conference rooms, or production areas which don't use the chemical in question. Results from these will be useful for comparison with the actual samples.

Wipe Sampling Methods

For standard wipe sampling, a glass fiber filter, paper filter, smear tab, gauze pad, or baby wipe are generally used for sample collection. The media can be wet with distilled water or other solvent to improve collection. Through a template with an opening of known size (100 cm^2 is standard) the surface to be sampled is "wiped" with the media, using maximum pressure and moving in concentric squares from the outside to the inside of the sampling area. The filter is then folded with the exposed side in, placed in a sampling vial, and sent to the laboratory for analysis. A fresh pair of clean, disposable, non-powdered gloves are worn for each sample.



Interpreting Sample Results

Wipe sample results should be converted to standard units; either mg/m^2 or $g/100\ cm^2$ are common. It may be helpful to arrange the results from the lowest to the highest result so that differences can be compared. The results of background samples will provide some basis for showing how clean things could be while the highest samples will define the worst case scenario for the workplace.

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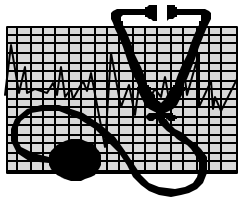
Medical Exams and Tests

Background

When employees are potentially exposed to chemicals, it is often beneficial to monitor their health to determine if any exposures have proven harmful. For the chemicals listed in the boxes, medical exams and tests for exposed workers are required by OSHA. A medical program should be designed to detect adverse effects of exposure as early as possible, at a stage when serious permanent effects are still preventable. Some health effects, however, take many years to develop; testing for these effects before the latency period has passed will not be expected to find disease. For other health effects, for example, lung cancer, there is no test which finds the disease soon enough to allow prevention. Yet the tests should still be performed because early treatment may increase survival time.



Choosing a Physician

The medical program should be designed by and carried out under the direction of a physician knowledgeable in occupational medicine. See end of this Fact Sheet for information on obtaining a list of ***Physicians in New Jersey Specializing in Occupational and Environmental Illness***. Board certification in occupational medicine is an important physician qualification.

Timing of Medical Exams and Tests

Job-related medical exams and tests should be given at these points in times:

- ***Upon hiring, before placement in exposure*** to establish a baseline for future health monitoring. Takes place before a worker begins a job with potential exposure to a chemical.
- ***Periodically during exposure*** to compare findings to the baseline and other previous findings. Takes place at regular intervals, for example, once a year.
- ***Upon assignment of a respirator*** to ensure that the worker is fit enough for the extra strain a respirator places on the heart, lungs, etc.
- ***Upon termination of exposure*** to evaluate findings when exposure or employment ends for any reason.
- ***When the latency period required for the disease to develop has passed*** to see if effects which develop over a long period of time, for example, cancer, have developed.

Chemicals with Comprehensive OSHA Standards and Medical Testing Requirements 1910.1001 to 1910.1052

- ***Acrylonitrile (.1045)***
- ***Arsenic (inorganic) (.1018)***
- ***Asbestos (.1001)***
- ***Benzene (.1028)***
- ***Cadmium (.1027)***
- ***Coke oven emissions (.1029)***
- ***Cotton dust (.1043)***
- ***1,2-Dibromo-3-chloropropane (DBCP) (.1044)***
- ***Ethylene oxide (.1047)***
- ***Formaldehyde (.1048)***
- ***Lead (.1025)***
- ***Methylene Chloride (.1052)***
- ***Vinyl chloride (.1017)***

Typical Medical Exam

A typical medical examination contains the following elements. The exam should be tailored to detect the effects of specific chemicals.

- ***Employment History*** to identify any previous exposure to chemicals or other health hazards.
- ***Medical History*** with emphasis on the target organs for acute and chronic health effects associated with the chemicals to which the worker is exposed.

- ***Physical Exam*** to appraise the functioning of the target organs.
- ***Sign and Symptom Questions*** to elicit the earliest signs of health damage from the chemical(s).

Types of Medical Tests

There are basically two types of job-related medical tests:

- ***Tests for Disease*** look for evidence that an individual has already developed an occupational disease, for example, chest x-rays, lung function spirometry, blood tests for kidney and liver function.
- ***Tests for Toxic Substances*** look for chemicals in the body which indicate exposure has taken place, for example blood tests for lead, urine tests for mercury, exhaled breath tests for solvents.

The tests should be tailored to detect the health effects or presence of specific chemicals. General medical screenings "to see if anything is wrong" should be avoided.

Information to Provide to the Physician

Before designing and carrying out the medical program, the physician should be given the following documents by management for review:

- ***Job titles and description of job duties*** for the employees in the medical program. These should be very detailed.
- ***Description of chemical exposures*** for the employees in the medical programs, such as a list of chemicals used, Material Safety Data Sheets, routes of exposure, and exposure levels, if known.
- ***Description of control measures*** for the employees in the medical program.
- ***OSHA Standards***, if any, for chemicals to which the employee is exposed.

Handling of Medical Information/Confidentiality

Results of medical exams and tests must be kept in separate, locked medical files. No medical-related information should be placed in an employee's personnel file. Results of exams and test should be conveyed in detail to the worker by the physician. Otherwise, results are *confidential* and may be shared with others by the physician only as needed. Supervisors, managers, and safety personnel may be told **only** of identified work restrictions, needed accommodations, possible emergency treatment, and special evacuation procedures. If a physician identifies any medical conditions unrelated to the job, this information should be provided to the employee only, not the employer.

OSHA Carcinogens For Which No Exposure is Permitted and Medical Testing Requirements, 1910.1003 to 1910.1016

- ***2-Acetylaminofluorene (.1014)***
- ***4-Aminodiphenyl (.1011)***
- ***Benzidine (.1010)***
- ***bis-Chloromethyl ether (.1008)***
- ***3,3' Dichlorobenzidine (.1007)***
- ***4-Dimethylaminoazobenzene (.1015)***
- ***Ethyleneimine (.1012)***
- ***Methyl chloromethyl ether (.1006)***
- ***alpha-Naphthylamine (.1004)***
- ***beta-Naphthylamine (.1009)***
- ***4-Nitrobiphenyl (.1003)***
- ***N-Nitrosodimethylamine (.1016)***
- ***beta-Propiolactone (.1013)***

Laboratory Analysis

Urine or blood samples should be submitted to a laboratory which is proficient in the specific analysis. Not all clinical laboratories are proficient in specialized analyses for chemicals. For blood lead, OSHA compiles a list of laboratories which they approve. At present, the most reliable indication of proficiency for other chemicals is successful participation in the interlaboratory comparison programs for specific chemicals sponsored by the College of Physicians (CAP) or the Quebec Toxicology Center. Questions on a lab's proficiency should be directed to a laboratory's quality control department.

Interpreting Lab Test Results

Results of lab tests should first be compared with what the level would be in an unexposed individual, then the level associated with early health effects, then the levels associated with more and more serious health effects. ***Biological Exposure Indices (BEIs)*** are reference values set by the ACGIH which represent the level expected in the test from an individual who has been exposed to chemicals to the same extent as a worker with inhalation exposure to the ACGIH TLV exposure limits. For lead and cadmium, OSHA has set levels of test results which trigger actions such as checking that control measures are working, more frequent medical exams and tests, and removal of the worker from exposure to the chemical.

Medical Removal from Exposure

If abnormal medical exams and/or tests are found, the occupational physician may recommend medical removal from exposure. The OSHA lead and cadmium standards specify blood and urine test levels which trigger such removal. The employee should retain wages, seniority, and other benefits during the medical removal. Return to exposure should only be at the physician's recommendation.

The Importance of Evaluating Group Results

The results of medical exams and tests should be evaluated on a group basis as well as individually. This is important because chemical exposure might cause only mild increase in symptoms in each individual which, when seen in the aggregate, might provide an important clue that exposure is having adverse health effects.

Recordkeeping

In general, employers are required by OSHA to keep all medical records for the duration of the employee's employment plus 30 years.

The Americans With Disabilities Act (ADA)

Under ADA, medical exams and tests may not be used to screen out or terminate people with medical disabilities, including those which are job-related. Rather, the employer is expected to accommodate the disability to the extent reasonably possible, consistent with business necessity, as long as the person can perform the essential functions of the job.

For more information, see the medical surveillance portions of the OSHA standards for the chemicals listed in the boxes, and the following:

- ***Physicians in New Jersey Specializing in Occupational and Environmental Illness***-- free by calling the New Jersey Department of Health and Senior Services, 609-984-1863.

- ***Association of Occupational and Environmental Clinics (AOEC)*** -- a network of clinics affiliated with medical schools throughout the United States specializing in evaluating workers exposed to chemicals and other Occupational and environmental hazards. For the name and address of the nearest clinic, call 202-347-4976.

- ***ACGIH Biological Exposure Indices (BEIs)*** -- order by calling 513-742-2020.

- ***The ADA and Injured Workers*** -- free by calling the ILR Program on Employment and Disability, Cornell University, 607-255-2906, fax 607-255-2763.

- ***ADA Technical Assistance Center*** -- 1-800-949-4232.

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Access to Medical and Monitoring Data

In 1980, OSHA issued a standard (1910.20) requiring employers to provide employees with information to assist in the management of their own health and safety. The standard permits employees or their designated representatives (union, lawyer, etc.) direct access to their personal exposure and medical records that are maintained by the employer. Access means the right and opportunity to examine and copy records. Access must be provided in a reasonable manner and place. If access cannot be provided within 15 days after the request, the employer must state the reason for the delay and the earliest date when records will be made available. The employer may give the employee copies of the requested records, give the employee the records and the use of a photocopier, or lend the employee his/her records for copying off the premises.

Employers must maintain records for a number of years specified by OSHA, usually 30 years after the last date of employment of the employee involved. Under this standard, OSHA representatives have access to exposure and medical records of all employees.

Exposure Records

Exposure records may include any of the following, including studies done in-house or by consultants:

- Industrial hygiene sampling data from personal, area, grab, wipe, or other forms of sampling for chemicals, noise, radiation, heat, cold, microorganisms, or other hazard;
- Material Safety Data Sheets or any other record which reveals the identity of a toxic substance or harmful physical agent.

If an employee does not have exposure records, the employer must provide records of other employees with job duties which are similar to those of the employee. Access to these records does not require consent of the other employees.

Medical Records

Medical records may include any of the following, including both records generated by a company health provider and those contracted out:

- Medical histories and questionnaires;
- Results of laboratory tests and results of medical exams;
- Results of tests on blood, urine, breath, hair, fingernails, etc for toxic chemicals;
- Medical opinions, diagnoses, and recommendations;
- Worker medical complaints.

Access to the medical records of another employee may be provided only with the written consent of that employee.

For more information, see the actual standard and the following publication: *Access to Medical and Exposure Records* -- OSHA Publication 3110. Free by calling 202-693-1888.