B. Personal Hygiene Habits and Practices

Personal hygienic practices in the laboratory are directed, in most part, toward the prevention of occupationally acquired physical injury or disease. To a less obvious extent, they can raise the quality of the laboratory work by reducing the possibilities for contamination of experimental materials. The reasons for many of the recommended precautions and practices are obvious, but, in some instances, amplification will permit a better review of the applicability to anyone specific laboratory. Consequently, what might be forbidden in one laboratory might be only discouraged in another and be permissible in a third. Nevertheless, adherence to safe practices that become habitual, even when seemingly not essential, provides a margin of safety in situations where the hazard is unrecognized. The history of occupational injury is replete with examples of hazards unrecognized until too late. The following guidelines, recommendations, and comments are presented with this in mind:

- Food, candy, gum, and beverages for human consumption should be stored and consumed only outside the laboratory.

- Foot operated drinking fountains should be the sole source of water for drinking by human occupants of the laboratory (1).* These should be located in the corridor, not the laboratory. The water line that serves the laboratory faucets should be separated from the water line to the drinking fountain by appropriate devices that prevent backflow.

- Smoking is not permitted in the laboratory or animal quarters. Cigarettes, pipes, and tobacco should be kept only in clean areas designated for smoking (2,4,5).

- Shaving and brushing of teeth should not be permitted in the laboratory. Razors, toothbrushes, toiletry supplies, and cosmetics are permissible in clean change rooms or other clean areas, but should never be used until after showering or thorough washing of the face and hands.

- A beard may be undesirable in the laboratory in the presence of actual or potential airborne contamination because it retains particulate contamination more persistently than clean-shaven skin. A clean-shaven face is essential to the adequate fit of a face mask or respirator when the work requires respiratory protection (1,2,3).

*The references for this section appear on page 45.

- Keeping hands away from mouth, nose, eyes, face, and hair should become habit. This may prevent self inoculation (1, 2).

- For product protection, persons with long hair should wear a clean hair net or head cover. This has long been a requirement in hospital operating rooms and in the manufacture of biological pharmaceutical products. A head cover also will protect the hair from fluid splashes, from swinging into Bunsen flames and petri dishes, and will reduce facial contamination caused by frequent rearrangement of the hair to move if off the face (4).

- Long flowing hair and loose flapping clothing are dangerous in the presence of open flame or moving machinery. Rings, wrist watches, and other jewelry also are physical hazards during the operation of some types of machines (2,4).

- Personal items, such as coats, hats, storm rubbers or overshoes, umbrellas, purses, etc., should not be kept in the laboratory (6).

- Books and journals returnable to the institutional library should be used only in the clean areas as much as possible. Under no circumstances should books or journals on loan from institutional libraries be taken into a P4 facility (1,2).

- Personal cloth handkerchiefs should not be used in the laboratory. Cleansing tissue should be available in laboratories and change rooms.

- Hand washing, should be done promptly after removing protective gloves. Tests show it is not unusual for microbial or chemical contamination to be present despite use of gloves, due to unrecognized small holes, abrasions, tears, entry at the wrist, or solvent penetration through the gloves.

- Hands should be washed after removing soiled protective clothing, before leaving the laboratory area, before eating, before smoking, and throughout the day at intervals dictated by the nature of the work. Jewelry should not be worn in the laboratory as it will interfere with the hand washing, procedure. If worn, it could become contaminated and cause the contamination to be brought to the home (2,4,6,7).

- A disinfectant wash or dip may be desirable in some cases, but its use must not be carried to the point of causing roughening, desiccation or sensitization of the skin.

- Work should not be done with biohazardous materials by anyone with a fresh or healing cut, abrasion, a lesion of the skin or any open wound, including that resulting from a tooth extraction (6,7).

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C. Protective Clothing and Equipment

Protective clothing and equipment are used to protect the laboratory worker from contact with infectious, toxic and corrosive agents, excessive heat, fire, and other physical hazards. Also, suitable clothing and equipment can help protect the experiment itself from contamination. The extent and kinds of clothing and equipment to be selected for any particular activity are dependent upon the research operations and the levels of potential hazard associated with them. While clothing and personnel safety equipment are of importance in an overall biological safety program, they are to be used with the understanding that they serve as a secondary line of defense. Biological Safety Cabinets accompanied by good laboratory techniques and procedures are the primary barriers against potential exposure to hazardous materials.

Certain types of laboratory clothing and protective equipment are safer, more practical, and provide greater comfort than others. Comfort, however, must not be the overriding factor in the final selection of an item required for protection. Once proper protective clothing and equipment are selected, it is the task of the supervisor to provide training in their use and to assure that employees properly use and maintain them.

The applications of these various items of protective clothing and equipment in the conduct of recombinant DNA research are summarized in the table on the following page.

SUMMARY OF MINIMUM REQUIREMENTS REGARDING LABORATORY ISSUED PROTECTIVE CLOTHING AND EQUIPMENT FOR RECOMBINANT DNA RESEARCH

Physical Containment Level	Protection Required				
	Hand	Head	Body	Foot	Respiratory
P1			The use of laboratory gowns, coats or uniforms is at the discretion of the laboratory supervisor		
P2			The use of laboratory gowns, coats or uniforms is required. Laboratory clothing shall not be worn to the lunch-room or outside the building in which the laboratory is located.		
P3	Gloves shall be worn when handling materials requiring P3 containment. They shall be removed aseptically Immediately after use and decontaminated.		Laboratory clothing that protects street clothing (i. e., long-sleeve, solid-front or wrap-around gowns, no-button or slip-over jackets, etc.) shall be worn in the laboratory. Front button laboratory coats are unsuitable. Laboratory clothing shall not be worn outside the laboratory and shall be decontaminated before it is sent to the laundry.		Respiratory protection is required for emergency procedures
P4	Gloves shall be worn when conducting procedures requiring P4 containment	Headcover is required. Headcover is not to be worn outside the work area	Complete laboratory clothing, including undergarments, pants and shirts, or jumpsuits, shall be provided and worn in the P4 facility, laboratory clothing shall not be worn outside the P4 facility.	Laboratory-issued shoes are required These are not to be worn outside the work area	Respiratory protection is required for emergency procedures
For P4 suit room conditions, all personnel are required to wear one-piece positive pressure suits					

The specifics of protective clothing and equipment are included in the following discussions; however, a broader treatment of the overall field can be found in the Accident Prevention Manual for Industrial Operations, Chapter 19, "Personal Protective Equipment." prepared by the National Safety Council, pages 465-527, 7th edition, dated 1974.

1. Laboratory Clothing

Laboratory clothing can serve to protect the wearer, the experiment, and the environment against contamination. The user must wear the garments in the manner intended to assure the benefits of the protection they can provide. If proper precautions are not taken, clothing may carry microbiological contamination outside the laboratory and into other work areas, cafeterias, or the home. Microorganisms can remain viable on cotton and wool fabrics and can be disseminated from these fabrics.

The National Institutes of Health Recombinant DNA Guidelines include requirements for the use of protective clothing and equipment at the P2, P3 and P4 physical containment levels. For Pl containment, the use of laboratory clothing is left to the discretion of the project supervisor. However, if good microbiological practices are to be applied to protecting the integrity of the experiment, the general and effective use of laboratory c)othing should be encouraged.

Local clothing requirements above the minimum required by the Guidelines will vary from one institution to another. Many institutions recommend that animal handlers and technical operations personnel be provided a complete clean clothing change on a daily basis. While a full-length and fully fastened laboratory coat worn over street clothing may be acceptable in some cases, laboratories have found that, for reasons of comfort, mobility and enhanced protection, one or two-piece laboratory suits, solid front gowns, and wraparound smocks are preferable. Long sleeved garments are best for protection of the arms and to minimize shedding of contaminating microorganisms from them. For the same reasons, consideration should be given to the need for a head covering (cap or head hood) and a snug fitting collar at the neck. The garments usually have close-fitting closures: knitted cuffs, snaps, drawstrings or elastic circlets. Drawstrings for men's pantwaist closures and adjustable snap type waist closures clothing are shown in the illustrations later in the Section.

Clothing inventory planning should provide for the needs of visitors

and of maintenance and security personnel. For some Pl, P2 and P3 facilities, scientists who visit on a short-term basis may find long-sleeved wraparound disposable smocks to be versatile in that they give good protection over street clothes and accommodate a range of sizes. Other laboratories use disposable jumpsuits. These types also are used for the short visits that maintenance staff and security guards make for routine visits in off-duty hours to check that equipment is performing satisfactorily. When extensive maintenance work is involved, the personnel may require sturdier, reusable garments.

Laboratory issued clothing should not be worn outside the facility or to the library, cafeteria, or other places accessible to the public. For P3 and P4 facilities, the use of specially colored laboratory clothing is recommended as part of control practices on the movements of personnel, the sterilization and laundering practices, and the disposal of these garments.

Both reusable and disposable laboratory clothing are available from supply houses. Reusable clothing, although initially more expensive, has , the potential of longer life. It should be of a quality capable of withstanding various and repeated decontamination and laundry treatments. Disposable clothing does not have this attribute; however, it has its place in those situations where visitor$ to the laboratory must be issued clothing, and also in those situations where decontamination facilities, such as autoclaves or ethylene oxide sterilizers, are too distant or not readily available. When there is the potential for contamination of the laboratory clothing with hazardous chemicals, the use of disposable articles allows for degradation by incineration.

Reusable laboratory clothing is made principally of cotton and polyester and combinations thereof. Nylon also is used, but is not recommended for clothing that must be autoclaved. Some of the factors that must be considered in the selection of appropriate laboratory garments are comfort, impenetrability, stitching, appearance, type and effectiveness of closures~ shrinkage (not to exceed 1%), antistatic properties, style, color, and ability to withstand repeated autoclaving at 250˚F. A fabric composed of 65% polyester, 34% cotton and 1% stainless steel metal fibers

(antistatic) has been widely used. Consideration also must be given to the weight of the material used. Heavier fabrics may be required, for rough service or work done in cooler atmospheres, as in the case of animal handlers.

ILLUSTRATIONS OF :

FULLY BUTTONED LABORATORY COAT

WRAPAROUND SMOCK

SOLID FRONT GOWN

ONE PIECE LABORATORY SUIT

TWO PIECE LABORATORY SUIT

HEAVY DUTYCOVERALL

Disposable laboratory clothing, normally, can be obtained from the same companies that supply the reusable garments. Although manufacturers claim that rapidly rising labor costs for decontaminating and laundering make purchase of disposable clothing attractive in contrast to the reusable type, it is up to the individual organization utilizing the clothing to determine which is economical for the intended use. In actual practice, some laboratories report that durable quality reusable clothing is less expensive.

Two of the popular materials used in the manufacture of disposable garments are made, in one case, from a synthetic polyethylene fiber and, in the second, from cellulose fibers. The synthetic fiber is woven and the cross fibers are then bonded by heat under pressure. The material so formed has high strength (wet or dry) and presents a good barrier (wet or dry) to movement of particles through it while retaining reasonable breathability for comfort. Its strength permits several days' use of garments under conditions of reasonable activity and wear. The cellulose materials are formed by layering the fibers and bonding the layer to a scrim of nylon mesh. Normally absorbent, this material can be obtained in treated, fluid repellent form. The porosity of this material assures that it breathes. For any of these fabrics, inquiry should be made of the supplier or manufacturer as to their resistance to solvents and solutions of various salts at different pH's in relation to their intended use. Polyethylene generally provides resistance to abroad spectrum of solvents, cellulose fibers less so dependent, in part, upon the surface treatment they are given. Consideration should be given to special needs for self-extinguishing fabrics.

All reusable clothing worn in Pl and P2 facilities can be discarded into a closed container and laundered in the conventional manner if it is not overtly contaminated. Reusable clothing that is from a P3 or P4 facility should be placed in a closed container and subsequently sterilized before laundering. Any clothing, including that from a Pl facility, that may have been overly contaminated should be wetted down with a disinfectant and autoclaved immediately. All disposable clothing worn in a Pl facility should be discarded

into a closed container with the other noncontaminated laboratory materials and discarded. Disposable clothing that has been used P2, P3, or P4 facility should be placed in a closed container and subsequently autoclaved prior to discarding. Again, if it has been overtly contaminated it should be wetted down with a disinfectant and autoclaved immediately

ILLUSTRATIONS OF

SIMPLE CAP

BOUFFANT CAP

HOODED CAP

2. Gloves, Shoes and Aprons

Gloves, shoes and aprons are important items of safety equipment . Gloves must be comfortable and of sufficient length to prevent ex of the wrists and forearms. Depending on the intended use, the composition and design of a glove may be required to provide dexterity, strength, low permeability, resistance to penetration by sharp objects, and protection against heat and cold. Quality assurance is an important as in glove manufacture, and numerous laboratories have experienced difficulty in obtaining leakproof rubber gloves. Protective footwear is required where there exists the possibility of injury to the feet with protective guards or steel toes and capable of resisting penetration of corrosive or hot liquids are available from several safety sup A change to work shoes is beneficial in laboratories handling microbiological materials. This serves to reduce the amount and type of contamin introduced by street shoes and minimizes the possibility of bringing home microbiological contamination from the laboratory. Aprons are worn in conjunction with a laboratory coat or suit to minimize penetration of a liquid spill or solid particles through the garment to the body surface. They are particularly useful in laboratories handling chemicals. The also are needed in animal handling facilities where washdowns are routinely carried out and in laboratory dishwashing operations where materials handled in the presence of steam and hot water. Best protection is by a solvent resistant, long apron.

a. Gloves

No one glove can be expected to be satisfactory for all applications. Gloves may be fabricated of cloth, leather, natural and synthetic (neoprene) rubbers, and plastics. New formulations synthetic rubbers and plastics continue to be developed as research makes varied and changing demands on the protective capabilities of gloves. Changing applications lead to improved capabilities of low permeability, greater strength, flexibility, tactile sense and control. Even with the

modest laboratory, the requirements to wear gloves may be such that no less than four or five kinds of protective gloves need to be stocked and used.

The type of glove selected is dependent upon the specific activity. For example, delicate work requires the use of thin walled gloves. Heat resistant gloves and mittens are an absolute necessity in biomedical laboratories for such operations as handling hot glassware or dry ice. Leather gauntlet gloves are frequently used when handling certain animals, such as monkeys. For some glove styles, the leather is metal reinforced to increase protection against animal bites. Other gauntlet type gloves are needed to protect hands and arms in washroom operations and in working with hazardous chemicals.

Gloves should be worn when working with materials requiring P3 and P4 containment and with toxic substances, and as protection against harmful solvents, acids and caustics. If a glove is to provide protection, it must be of a composition that limits penetration and possesses sufficient strength to maintain the integrity of the barrier under stresses to which, the glove is subjected. The data in the table provide some indication of the overall performance characteristics of different glove materials. To achieve tactile sense and control, and sometimes for economic reasons, strength may be compromised by reducing the wall thickness (weight) of gloves. Disposable gloves of rubber and plastic may have wall thicknesses on the order of 1.25 to 6.0 mils. Surgical type gloves principally range from 8 to 10 mils. For work in Class III cabinets, arm-length gloves of neoprene in thicknesses of 15 to 30 mils have been found to be satisfactory. Heavy-duty industrial gloves are 16 to 40 mils thick. Tearing is frequently experienced with the lighter-weight gloves. Some disposable gloves present problems of fit. Surgical gloves of about 9 mils thickness, sized and shaped for the hand, are normally used when tactile sensitivity is required. Canvas, leather, or heat resistant gloves should be worn over rubber gloves when handling animal cages or other sharp-edged of hot equipment to prevent tears in the gloves and to protect the skin.

The wearing and final disposal of gloves call for thought and care. Operations in open front safety cabinets should be preplanned

A CHEMICAL RESISTANCE CHART that uses a nearly invisible font!

so that, once gowned, gloved, seated and with hands and arms in the cabinet, the operator does not have to withdraw from the cabinet until the work has been completed.

Gloves should overwrap the cuff and lower sleeve of the laboratory garment. For further protection of the sleeve, a long glove or a simple disposable plastic arm shield can be used. Armshields can be cut from a roll of polyvinyl chloride or polyethylene; they can be secured at the wrist by the glove. If gloves become overtly contaminated when working in a cabinet, they should be removed and discarded in a waste container in the cabinet with disinfectant sufficient to cover the gloves. New gloves should be available so that work can continue. If the work period is long, it is wi se to wipe the gloved hands with disinfectant from time to time. Arm-length gloves secured to fixed port openings are a requirement in Class III safety cabinets and dry boxes. For this, gloves made of neoprene in thicknesses of 15 to 30 mils have been found to be satisfactory. However, they must De inspected for pinhole leaks as received from the manufacturer and at routine intervals of use. Some manufacturers will give assurance that their gloves have been tested by resistance to high voltage for evidence that they are free of thin areas and pinholes. After intervals of service, and after sterilization of the cabinet system, the gloves, while still attached to the cabinets, should be examined for leaks using the soap bubble test following the certification procedures for Class III cabinet Systems (III, B, 6).

Decontamination practices for gloves depend upon circumstances. Many activities require that gloves be sterile before use. Surgical , procedures on experimental animals require the use of sterile gloves. Many laboratories involved in this kind of program will routinely sterilize all gloves before use. Ethylene oxide or formaldehyde gas sterilization can be used for this purpose. Following treatment, the gloves should be thoroughly aerated in flowing filtered air at 2^{lo}C or higher for a minimum of 24 hours to prevent skin burns and irritation from residual disinfectants.

ILLUSTRATIONS OF VARIOUS KINDS OF GLOVES .

SAFETY CABINET

ANIMAL HANDLER (WITH METAL REINFORCEMENTS)

SURGEONS

GAUNTLET

DISPOSABLE

GRIP

The same procedure can be used for gloves of heavy canvas, leather, or coated material, and for heat-resistant gloves. Heavy-weight reusable rubber and plastic gloves should be placed in a disinfectant solution following use. After thorough contact of proper duration, they can be washed, rinsed, dried, and stored for reuse. The lightweight disposable gloves and the medium weight (9 mil) surgical gloves, after use, should be discarded into a covered contaminated waste container for eventual autoclaving.

b. Shoes

Laboratory issued, steel toed safety shoes or protective boots should be worn by animal handlers and any workers handling heavy items or corrosive chemicals, whether this occurs in an infectious disease research area or in any other laboratory area. Cage racks, cages, dishwashing trays, and gas cylinders are examples of heavy items commonly handled in laboratory activities that require foot protection. Painful accidents and lost time absences can result from foot injuries. The complete clothing change required for P4 facilities includes a change to Laboratory issued shoes. "Clean room" activities may require special issue shoes to protect the experiment and sensitive equipment.

All safety or special issue shoes and boots used in controlled access areas should be identified so that they can be segregated from other special issue safety shoes used for work in other areas. Special markings, such as painted toes, can be used to identify shoes worn in biohazard areas. If this is done in a light background color, then numbers or initials can be painted on the background color to identify the wearers. It will be necessary to keep on hand extra shoes in some range of sizes for use by the maintenance staff and visitors.

In the event of overt contamination; the shoes should be decontamination by ethylene oxide or formaldehyde gas should be done on a regularly scheduled routine. Exposing shoes on an ultraviolet (UV) rack or wiping them with a suitable liquid disinfectant such as 8% formalin,

2% iodophor, or 2% phenolic compounds may also be used for decontamination of footwear. However, where there is a known or suspect release of biological material, ethylene oxide or formaldehyde gas treatment is recommended as the most dependable means of decontamination. Whenever a liquid or gaseous disinfectant is used, it is necessary to remove all traces of it following application, to avoid allergic skin reactions to possible burns.

c. Aprons

The penetration of hazardous liquids or particulates to, or through, laboratory clothing can be minimized by the utilization of a solvent resistant, long apron. Plastic or rubber aprons worn over the laboratory garment will provide additional protection. Aprons also are required where equipment is handled in the presence of steam and hot water. Full-length aprons and trousers with cuffs worn outside of shoes and boot tops are recommended.

3. Face and Eye Protection

Protection of the face and eyes is of prime importance in laboratories. Frequently there is the possibility of impact of foreign material, both liquid and solid, on the head, face, and eyes or on contact lenses. A vast array of face shields, head hoods, protective goggles, and lenses is available from safety supply houses. The selection is dependent upon materials of construction, fit, comfort, compatibility with the disinfectant used, and overall facial area of protection required.

a. Face Protection

Face protection against impact and splash can be obtained through the use of face shields and hoods. They serve' to protect the face and neck from flying particles and sprays of hazardous materials; however, they do not provide basic eye protection against impacting objects.

Shields should be of such design that they cover the entire face, permit tipping back to clear the face, if desired, and are easily removable in the event of an accident. Hoods are hot to wear unless they are obtained with air lines to supply a cooling flow of air.

b. Eye Protection

Protection to the eyes is an extremely important matter. Microbiologists and virologists may use chemicals that can cause blindness if splattered into the eye. For example, concentrated quaternary disinfectants splashed in the eye in the course of preparing use dilutions can cause blindness. Personnel must be cautioned as to this danger and given instruction in use of personal protection for eyes, face and hands. In addition, infection can occur through the conjunctiva of the eyes if a pathogenic microorganism is splattered into the eye.

The supervisor has the responsibility of determining that an eye hazard exists, palacarding the area as an "Eye-Hazard Area," determining the type of protection required, and ensuring that the appropriate eye protection equipment is available and worn by the employees. For further

ILLUSTRATIONS

FACE SHIELD

FACE PROTECTION

GOGGLES AND SPECTACLES

EYE PROTECTION

Laboratory Safety Monograph 1/2/79

information, consult American National Standards Institute Publication Z87.1-1968, Practice for Occupational and Educational Eye and Face Protection.

Utilization of a few simple common laboratory practices may avoid accidents that result in blindness. Supplies of caustic chemicals should be stored in the smallest size container compatible with daily need at the workbench. In the event of breakage or spill, this will minimize the hazard. Laboratory personnel handling chemicals that may be explosive, corrosive or caustic, or handling cryogenic materials, should be required to wear eye protection.

Personnel who normally wear corrective lenses and work in an area requiring eye protection must wear goggles or spectacles depending on the job assignment. The protective lenses of spectacles should provide optical correction. Goggles should fit over corrective spectacles without disturbing the adjustment of the spectacles or causing leakage, or incorporate corrective lenses mounted behind the protective goggles.

A basic rule to follow is that if an eye hazard exists for a particular operation or experiment, the soundest safety policy would be to require that eye or face protection, or both, be worn at all times by all persons entering or working in the laboratory. Safety glasses with metal or plastic frame spectacles, impact resistant lenses, and side shields generally are adequate in most situations. Prescription safety lenses fabricated from ground and polished clear glass, or from plastics that may provide longer service life, are frequently required for laboratory personnel. The glass lenses are specially fabricated and heat treated so that they are resistant to impact. However, in those laboratories in which chemicals are used that may cause injury to the eye, it is necessary to use goggles, face shield, or perhaps a combination of them.

If eye protection is deemed necessary in a laboratory, then an emergency' eyewash station should be available.

Contact lenses do not provide protection to the eyes. Foreign material present on the surface of the eye may become trapped in the

capillary space between the contact lenses and the cornea. Inert, but sharp, particles, caustic chemicals, irritating vapors, and infectious agents in this space cannot be washed off the surface of the cornea. If the material that gets into the eye is painful, it becomes extremely difficult to remove the contact lens because of the muscle spasms that may develop. In accordance with the position adopted by the National Society for the Prevention of Blindness, it is recommended that contact lenses not be worn around chemicals, fumes, and other hazardous materials and dust particles. The only exception is if a visual problem exists that is corrected only by contact lenses as certified by the employee's physician or optometrist. Where contact lenses are worn, eye protection, such as tightfitting goggles, must be worn. The eye protective device used with the contact lenses must meet or exceed all the requirements of the American National Standards Institute as specified in Practice for Occupational and Educational Eye and Face Protection, Z87.1-1968.

4. Respiratory Protective Equipment

In recombinant DNA research, respiratory protection is required for emergency procedures and for work in a P4 facility suit area.

There are many kinds of respiratory protective devices from which to choose. They vary in design, application, and protective capability. They can be placed into three categories: air purifying, supplied air, and self-contained breathing apparatus.

a. Air purifying Respiratory Devices

These may contain both a mechanical filter and a chemical cartridge. The mechanical filter provides protection against biological aerosols. Mechanical filters consist of fibrous material that will remove the particles from air as it passes through the medium; however, they do not protect against harmful gases and vapors.

The chemical cartridge protects against specific gases and vapors present in the atmosphere not in excess of 0.1% by volume. Several types of cartridges are available from safety supply organizations. The type to be used for a particular operation is dependent upon the chemical protection required.

If the air-purifying devices are manufactured as "half-face masks," they protect only against entry through the nose and mouth. A "fullface protective mask" is a more sophisticated Air purifying device, that provides protection to the major portion of the face, eyes, and respiratory tract. It is more efficient in filtering out biological contaminants and ,removing gases and vapors.

Hospital or contagion type masks are less efficient forms of air purifying devices. Today, most of these masks are of the disposable type. Unfortunately, they do not permit a very good face seal. In addition, some exhibit low filtration efficiency.

The effectiveness of all air purifying devices is dependent upon such factors as the resistance they present to breathing, their comfort when worn for long periods, and the effectiveness of the filter

material in removing particulates of a given size, the peripheral seal of the device, their design, and durability. This category of mask requires an efficient filtering medium and is dependent upon a good peripheral seal because without it the inhaled air will bypass the filter element and provide poor or no protection. A clean-shaven face is required if a mask or respirator is to provide a good face seal.

b. Supplied-Air Respiratory Devices

(1) Air line Respirators

This device supplies air from a remote filtered source by pipe and hose line to a half- or full-face mask respirator. Air line respirators have been found most useful where maximum respiratory protec- tion is required and where leakage through a filter or peripheral seal cannot be tolerated. The system does have the limitation that if the air supply fails the person using the respirator must leave the area immediately because the central system has a limited reserve air supply tank normally established at a 30-minute reserve. Another disadvantage is that the air supply hose limits the user to a certain fixed range from the air supply.

There are three broad categories of air line respirators: constant flow, demand flow, and pressure demand. Constant flow respirators are generally used under conditions of an ample air supply as supplied by compressors. Demand-type respirators are normally used where compressed air cylinders are available; however, for a laboratory engaged in hazardous activities, this type system is not suitable because of inward leakage caused by negative pressure during inhalation. The pressure-demand air line respirator provides a positive pressure during both inhalation and exhalation, and does not use as much air as the constant flow units.

(2) Air-Supplied Hoods

Air-supplied hoods, or complete suits, that obtain their source of air from an external filtered compressed air source have been used for those operations where it is impractical, or impossible, to isolate the product or hazardous operation in a protective cabinet or

other type enclosure. The air supplied hoods would be used for those situations in which only a respiratory hazard is involved.

(3) Self-contained Apparatus

This apparatus operates independently of the surrounding atmosphere, since the mask comes with its own air supply. There are three basic types of self-contained breathing apparatus: oxygen cylinder rebreathing, demand, and self generating. Normally, they may be used for only very short time periods, 15 to 30 minutes, because of the limited air supply available; however, the system is applicable when leakage through the filter or peripheral seal cannot be tolerated. Self-contained systems are not used to any great extent in laboratories, except in case of emergencies. For those installations desiring to have a self-contained apparatus on hand in the event of an emergency, contact several of the reputable safety supply concerns and discuss with their technical personnel the various features of these devices before making a final selection.

c. Selecting a Respiratory Protective Device

The selection of what respiratory protective device to use should be made with knowledge of the conditions of the research activities and the risk situation involved. Selection should be made jointly by the principal investigator and safety officer. It should be emphasized that the degree of protection required must be thoroughly investigated; and, once determined, the respiratory equipment selected must be inspected and properly fitted. The reputable safety supply houses can provide data as to mask performance based on tests they have conducted or that they know have been performed by research institutions or government agencies referred to previously.

It cannot be overemphasized that there must be a good peripheral seal between the face and the mask. Such conditions as beard growth, temple pieces of eyeglasses, and the absence of one or both dentures all contribute to mask leakage. Full face masks with prescription lenses

that do not interfere with the mask are available commercially, if required. When assigning a respirator to an individual, especially the half face respirator, one size or type will not fit all subjects, and it is necessary to have two or more types and sizes of half face masks available for fitting and use purposes. Determination that the proper tension exists on the respirator headband is also important, because it has been shown that a direct relationship exists between strap tightness and seal. Once the proper mask has been assigned to an individual, the next step is to ascertain that the wearer properly dons and adjusts the mask. Too frequently, adequate peripheral seal is not obtained because a mask is worn improperly.

d. Mask Decontamination

The newer type contagion or hospital type masks are of the disposable category. If masks of this type have been worn in a contaminated area, autoclaving is recommended prior to discard. Where personnel have been working in an area that has resulted in overt contamination of the reusable respiratory protective equipment, ethylene oxide (ETO) must be used to assure complete penetration of the decontaminant. The facepiece, however, must be aerated 24 hours following decontamination because, if there is insufficient aeration, chemical burns can be inflicted on the user. This decontamination process will have an adverse effect on any charcoal filter element, and, therefore, any cartridge or canister that contains this adsorbent as a component of the overall mask should be replaced following sterilization. Autoclaving should not be used, as it has a deleterious effect on some of the compounds used to seal the filter material to the edge of the canister or cartridge.

Personnel using respiratory protection devices should wipe down their equipment with a chemical disinfectant at the end of the day's activity. Several disinfectant may be used. A damp that has been soaked in the disinfectant and the excess squeezed out should be used for the wipe down process of the facepiece. A hypochlorite solution (500 ppm)

with a wetting agent, or alcohol 85%, would be satisfactory. In any wipe down process, it is extremely important to reach all crevices. Following the wipe down procedure, the protective equipment should be thoroughly rinsed with clean, warm water and then exposed to free flowing air at least 30 minutes before reuse. Valves, head straps, and other parts should be checked. Replace them with new parts, if defective. Insert new filters, cartridges, or canisters, if required; ascertain that the seal is tight. Place in plastic bag or container for storage.

When applied frequently to equipment, several of the available disinfectants will cause corrosion of metal surfaces and require that parts of a mask be replaced from time to time.

For those situations in which personal hygiene is the only consideration, all rubber or plastic face masks and respirators should be scrubbed with a liquid detergent solution ard decontaminated. Suitable disinfectants are the quaternary ammonium compounds (200 ppm in water with less than 500 ppm total hardness). Wipe off the decontaminated respiratory device with warm water to remove any residual quaternary compound remaining so as to avoid any possible dermatitis.

Following this decontamination procedure, half face masks can be stored in plastic bags until required again. Fullface masks or other types of respirators should be stored in cartons or carrying cases specifically fabricated for the protective equipment.

ILLUSTRATIONS

FULL MASK FACEPIECE

HALF MASK FACEPIECE

AIR SUPPLIED HEAD HOOD

Laboratory Safety Monograph 1/2/79

5. Positive Pressure Suits

One-piece positive pressure ventilated suits are required to be worn in all designated suit areas within P4 facilities.

Positive pressure suits are usually fabricated of heavy vinyl material. To provide the wearer with protection in the event the air supply is accidentally disconnected, a biological filter should be installed at the quick disconnect at the suit. This will provide the wearer protection to permit egress from the restricted zone.

Although they have been under development for several years, and many are in use in industry, there still are problems associated with their use, Personnel have found them to be cumbersome, some heat up rapidly in warm weather (especially the complete suits) unless conditioned air and a good air distribution system are provided within the protective garment, and many can be easily torn by sharp edges. Personnel with a good positive attitude adapt well to their use.

It is desirable to provide conditioned air and to include an air distribution system within the suit to permit the user to carry on activities in a comfortable environment, One air conditioning device utilizes a vortex tube that introduces either warm or cooled air, After use in a contaminated area, suits must be decontaminated by a through washdown , with a liquid disinfectant. A 2% solution of peracetic acid is suitable and effective but :requires special handling and equipment because it is, quite corrosive and has an irritating odor.

ILLUSTRATION

ONE PIECE POSITIVE PRESSURE VENTILATED SUIT

Laboratory Safety Monograph 1/2/79