MICHIGAN'S occupational health

VOL. 4, NO. 2 MICHIGAN DEPARTMENT OF HEALTH Albert E. Heustis, M.D., Commissioner WINTER, 1958

Respirators—Selection, Use and Care

Man's first recorded attempt to protect himself from a disagreeable atmosphere dates back to the early Christian era. At this time cloth was wrapped around the head and across the nose and mouth of workers in an attempt to filter dust from the air. The result was the beginning of a series of devices which are known today as respirators. The greatest advancement in respirator design and effectiveness has been made in the past thirty years primarily due to the efforts of the U.S. Bureau of Mines.

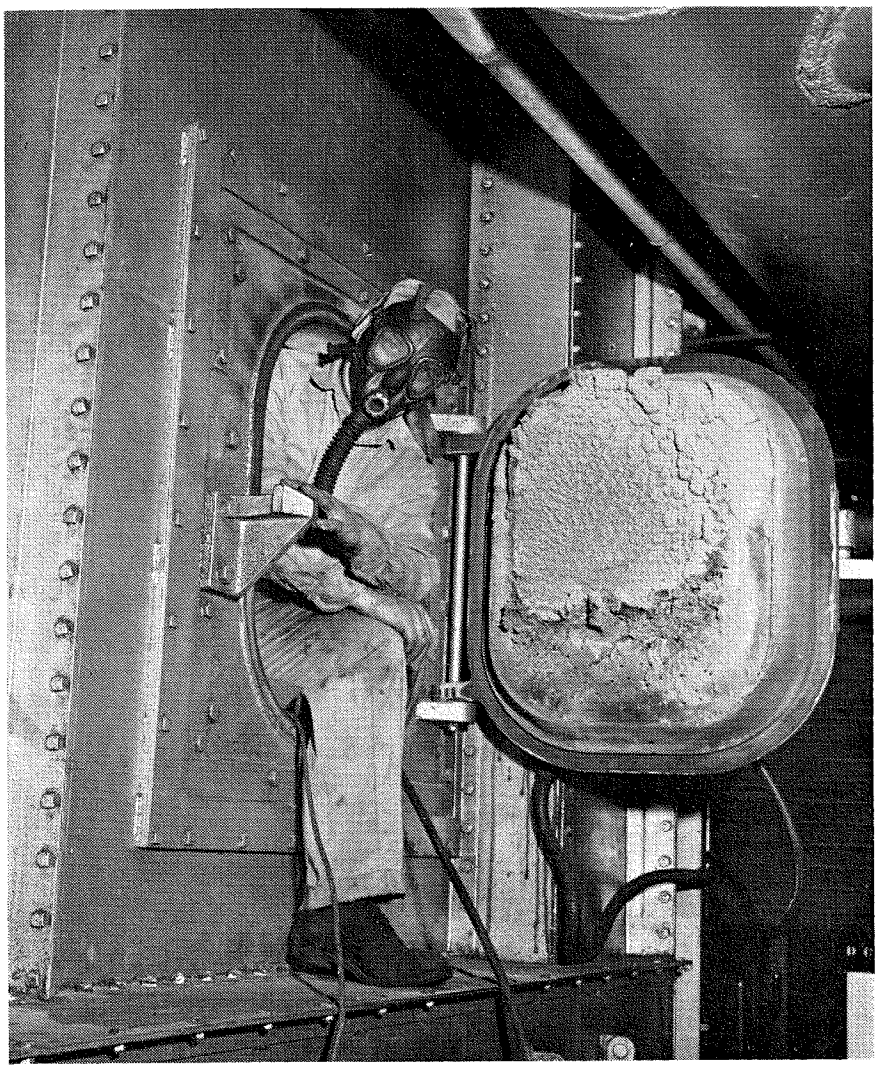

Figure 1. Worker in supplied air respirator, Type A, about to enter power plant boiler. He will be supplied with air in this oxygen deficient atmosphere by means of a blower connected to the air line which can be seen at right, near his leg. Only respirators which make provision for air or oxygen can be used in atmospheres which are short of oxygen.

TWO GENERAL GROUPS

The term "respirator" or "respiratory protective equipment" refers to a large and varied group of devices which are worn on the face or over the head of an individual. They are designed to reduce or eliminate the amount of contaminant in the inhaled air. Basically, respirators are simple devices which can be divided into two general groups, depending on the mechanism by which they protect the wearer. One group of respirators functions by filtering out some or all of the contaminant from the inhaled air. They act as barriers between the lung and the surrounding air filtering out contaminants in a manner similar to the way a home furnace filter traps dust. This group can be further classified depending on the type of barrier offered and the degree of protection necessary. These barriers include mechanical filters to remove organic and inorganic dusts, and adsorbers such as activated carbon for removing organic vapors and fumes.

The other group of respirators separates the respiratory system of the wearer from the contaminated air by supplying him with an artificial atmosphere. Such devices as air line hoods and oxygen containers fall into this category. Many respirators in this group have had wide use in underwater work where the application is similar to many industrial situations, that is, to provide a controlled atmosphere for the worker in a foreign environment. This group may be further divided into three general types: res-

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Figure 2. Maintenance men about to enter building to turn off carbon dioxide fire extinguishing equipment. Men are wearing self-contained oxygen breathing apparatus because the carbon dioxide replaced the air in the building. Source of air is the tanks on the backs of the men.

pirators containing a canister which employs an oxygen producing chemical such as potassium tetroxide, which converts exhaled carbon dioxide to oxygen; respirators which use a tank supply of air or oxygen, and respirators which require a remote air supply via pipes or hose from an air pump.

LIMITATIONS

Respirators have their limitations and are not a substitute for effective ventilation or process controls. "It used to be said that respirators were simply a lazy excuse for avoiding dust control. We quite agree that they should serve merely as a second line of defense, but there are plenty of jobs in which they can and should be used, not as a substitute for dust control but as a necessary adjunct."[1] Respirator devices in themselves are so designed that high efficiency is obtained for only one type of use. An example that has been used many times explains that chicken wire is 100 per cent efficient against chickens, but not against flies.

Figure 3. Worker wearing self-contained oxygen breathing apparatus which generates oxygen through reaction of carbon dioxide with chemical in canister. Before worker enters carbon dioxide saturated atmosphere to turn off automatic fire protection system, he will inflate breathing apparatus.

Other factors which present difficulties in the application of respirators are comfort and reliability. Many individuals dislike the feeling of any device which tends to restrict breathing. Even if breathing is not impeded, the psychological barrier is ever present. Respirators of necessity are designed for universal fit. A common complaint is "show me this average or universal man!" For effective operation a respirator must fit firmly on the wearer to prevent leaks into the face piece. Some individuals, because of physical factors such as a long face or a large chin, find it difficult or impossible to obtain a satisfactory fit.

The reliability of any respirator device is dependent on proper selection and maintenance. Improper selection and/or poor maintenance will result in little or no protection and will give rise to a feeling of false security. It is not sufficient simply to buy some respirators and thereafter let nature take its course.

Added to the problems of selection, comfort, fit, and maintenance are physical factors of the job which may limit respirator use. Full vision on the job may be required and any device which protrudes over the lower portion of the face may create a serious safety hazard. Air line or air supplied respirators because of physical size and weight may become limited in their use in confined spaces such as small manholes or hatch entries. Respirators are at best only a second line of defense and should only be considered when no other engineering means will provide adequate protection for the worker. Then selection must be based on all factors affecting the conditions of use.

SELECTION

To insure that reliable respiratory protection devices are available for industry, the United States Bureau of Mines has established a testing section and a schedule of minimum requirements for respirator equipment. The first type of device for which an approval schedule was prepared was the self-contained breathing apparatus. This testing service was started around 1920 and since that time approximately 150 devices have been tested and assigned approval numbers. A complete listing of all respirators which are currently sold in this country is shown in Table I. The Division of Occupational Health recommends that only equipment which has been tested and approved by the Bureau of Mines be used in any respirator program.

Proper respirator selection depends on specific knowledge of the hazard or hazards that may be encountered on the job. It is important to understand that there are many different kinds of respirators, each designed according to the contaminant which they are supposed to protect against. Not only are respirators designed for use in gases different from those designed for dusts or fumes, but there is also a difference depending upon the specific type of dust or gas in which a respirator is designed for use.

To assist in proper selection the Bureau of Mines has established a numbering or coding system. In this system, the first two numbers of the

[1]Drinker and Hatch. *Industrial Dust* (second edition). New York: McGraw-Hill.

approval apply to a particular type of respirator and the corresponding test schedule: 13 indicates self-contained oxygen breathing apparatus, 14 for gas masks, 19 for air supplied hoods and respirators, 21 for dust and fume respirators, and 23 for organic cartridge respirators. Each schedule or number grouping is further subdivided by type of contaminant and limitations of use within each subgrouping. The second two numbers of the approval simply apply to the device as tested and indicate the order and relative time in which approval was granted. For example, BM 2301 was the first organic vapor cartridge respirator that was tested and approved. BM 2302 was the second so tested and so forth.

USE DETERMINES CHOICE

In addition to a specific knowledge of the hazard it is essential to know the exact nature and procedure under which the device will be used. For example, let us assume that a chemical company has a process in which it is necessary to perform routine maintenance and cleaning both inside and outside of a storage tank. The problem is to select a respirator device which will adequately protect the wearer under all job conditions.

The first questions to be answered are: What are the contents of the tank? How and by what means are the tanks cleaned? Is painting necessary? Will welding be required? Is relining such as with lead a part of normal maintenance? Is ventilation in the form of blowers used in performing the operation? Large tanks by their nature are confined spaces and any worker entering such an enclosure can be expected to encounter an oxygen deficient atmosphere along with possible contaminants.

Therefore, for proper protection, a respirator of the 1300 or 1900 series must be selected. The final choice will depend on the availability of an air compressor and the necessity of full physical movement and vision as required by job demands.

Again, let us assume the same set of conditions except that the tanks are very small and can be cleaned and repaired from the outside and that adequate ventilation cannot be provided. Some respiratory protection is necessary, but what type? Let us further assume that the tank contains an organic solvent such as trichlorethylene. It is obvious that the first respirator selected will do a satisfactory job in the second situation, however, other types may also provide the protection necessary. Since oxygen deficiency is not a problem, a respirator of the 1400 or 2300 series may give adequate protection. Final selection will depend on the greatest amount of trichlorethylene vapors that could be encountered.

Another situation frequently encountered in industry is a hazard caused by spills of organic liquid materials. The final choice of respirator will depend on the greatest amount of vapor that could be expected in the event of a spill and the time required in the area to perform effective control measures. Such factors as vapor pressure, toxicity, room temperature, reaction with other materials and flammability are properties of the contaminant material that must be considered. Some organic solvents, because of their vapor pressure, present few or no hazards under cold room conditions (–20°F.). Should a spill occur, the solvent could be cleaned up without respirator protection. On the other hand, a spill of the same solvent in a warm room (110°F.) might create a very serious hazard to health and therefore require respirator protection.

Proper selection of a respirator must be based on all factors concerned with the contaminant and the nature

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Figure 4. One of the reasons respirators are not a substitute for adequate ventilation is illustrated by the worker in the background who is getting no protection from respirator hung around neck. Good exhaust ventilation would have made respirator unnecessary and would have given worker the protection Division engineer in foreground found necessary.

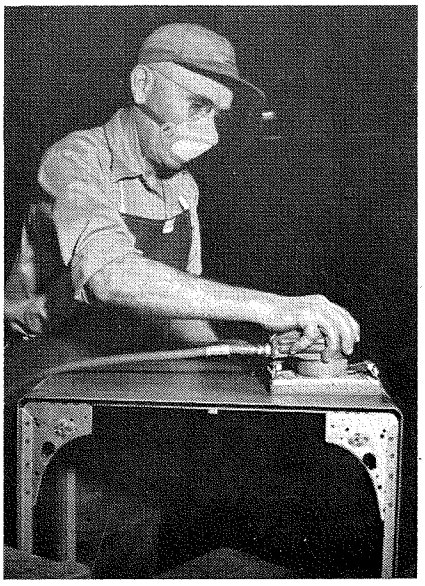

Figure 5. Typical non-approved mask being used to protect worker from breathing non-toxic dust. This mask is of no value for toxic dusts, gases or vapors.

RESPIRATORS, continued

of the job in order to afford the best protection and comfort to the worker.

USE

Issuance of respirators to individual workers should be controlled to insure that the important points considered in their selection are understood by the wearer. The importance of this can never be over estimated. The larger the plant, sometimes the greater is the need for such control. Each worker should be taught how to wear his respirator. He should know how to obtain proper fit and how to check for leaks both in the valves and around the facepiece. A simple test that can be made is to block the inlet at the filter or cartridge and try to inhale. If inhalation is prevented there are no leaks. Both inlet and outlet valves can be checked in a similar manner. Under dusty conditions, fit and leaks may be tested easily by looking for dust inside the respirator or on the face of the worker.

MAINTENANCE

Periodic cleaning and repair of respirators is essential in order to maintain their original effectiveness. These operations should be centralized and subject to rigid control. Cleaning and repair should not be left up to the individual wearer. When used routinely, respirators should be cleaned daily. This affords opportunity to repair worn out or damaged parts and to replace filters and chemical cartridges. When not in use, all respirators should be stored in a clean place. Unless a daily cleaning and maintenance program is carried on, workers will usually allow their respirators to deteriorate and become unsanitary and ineffective. (The Fall, 1958 issue reported a case of poisoning from insecticide caused when a mask became clogged with tobacco particles.) The psychological effect of such a program will directly influence the effectiveness of the entire respirator program.

After collecting respirators at a central cleaning and servicing point the filters and chemical cartridges should be removed. The respirator itself should then be thoroughly cleaned with soap and water. Solvents should never be used since most solvents will attack the various rubber parts and completely ruin the mechanism.

Following cleaning the facepiece should be sanitized and air dried. The mask can be sanitized by dipping it into a standard germicide solution for a few minutes and allowing it to dry. Many germicide solutions are available for sanitizing from either respirator manufacturers or industrial soap distributors. The solutions commonly used are either carbolic acid, or chlorine and iodine salts dissolved in water. Frequent sanitizing is necessary. For example, if a worker has a cold or other respiratory disease re-exposure can occur each time the mask is worn unless it has been sanitized.

Following cleaning and sanitizing, the respirator should be inspected thoroughly. Filters and chemical cartridges should be replaced when needed. How frequently will depend upon the concentration of the contaminant and length of time in use. Since the cost of these replacements is small, some companies have found it worthwhile to replace them daily regardless of use. An effective respirator maintenance program will increase greatly the voluntary use and life expectancy of the equipment, thereby giving the industrial concern full value from its investment in the worker and his protection. —W.M.C.

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U.S. Department of Labor. *Safety Subjects.* Bulletin No. 67, revised 1956.

Bureau of Mines *Schedules:* 13, 14, 19, 21, and 23.

Respirator Catalogs from American Optical Company, Willson Products, and Mine Safety Appliance Company.

Figure 6. Melting lead and brass alloy. Worker could protect himself by wearing proper respirator. Toxic fumes are apparent during this pouring operation, but more important, were being discharged into the working area all during the melting of the bearing alloy.

Figure 7. Far more satisfactory than equipping workers with respirators is the exhaust hood installed to control the same operation as depicted in Fig. 6. The ventilating unit, designed and installed according to Division recommendations eliminates the health hazard from toxic fumes.