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PLAINTIFF'S EXHIBIT

CEL-1610

GENERAL SESSIONS

1950 National Safety Congress

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Volume 1
Transactions
1950 National Safety Congress

NATIONAL SAFETY COUNCIL
425 No. Michigan Avenue • Chicago 11, Ill.

PLAINTIFF'S EXHIBIT
NSC-119

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offer him supplementary materials such as mail enclosures, prospect lists, etc., so that he can conduct whatever type of campaign is within his resources. We urge that the section membership chairman get every member of the section interested in working on some one particular prospect with a view to doubling the membership.

I would like to close on what I believe is a note of urgency. There are today tremendous pressures for increased occupational safety efforts. The day is approaching when the public will not tolerate unnecessary work accidents. The ideal way to do the safety job is the voluntary way through industrial management. However, if industrial management should be remiss in its discharge of its moral and legal obligations, it becomes increasingly clear that there will be strong pressures for governmental regulation. Such regulations will, if they come to pass, be binding upon both those companies which have done a good job and the companies which have not. Such regulations, will, inherently, prove to be restrictions upon the freedom of action and method of approach to a company's safety problems. That is inescapable. Therefore, it is far better that industrial management take up its proper responsibilities for leadership and develop better and better occupational safety efforts.

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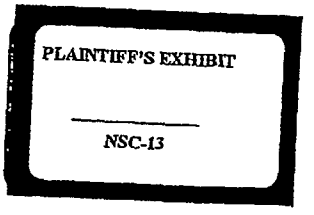
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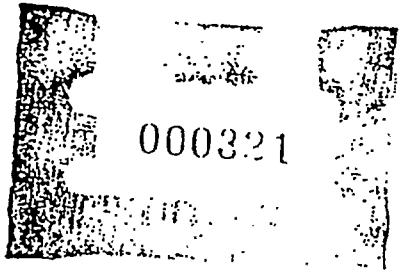
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000313



Industrial Hygiene

Industrial Dusts—What Every Supervisor Should Know

By L. E. HAMLIN, M.D.
Medical Dir., American Brake Shoe Company, Chicago, Ill.

Most manufacturing procedures are capable of generating varying amounts of dust which may be visible, invisible, dangerous or inert. It is therefore important that these substances be properly classified in order to protect the health of employees and provide safe environments in which they may carry on their daily occupations.

Obviously the supervisor should have some knowledge of industrial dusts since the responsibility for enforcing measures instituted for their control usually falls upon his shoulders. Unless he has a good idea of the actual risks confronting him, he will be at a disadvantage in securing cooperation from those under his direction. Ability to answer questions concerning plant hazards in a convincing manner is a very important factor in any dust control program, and if the supervisor cannot explain the necessity of avoiding exposure to toxic materials the worker under his charge is very unlikely to pay attention to it.

On the other hand, a brief explanation that carries the ring of sincerity and truth can frequently correct unnecessary misunderstanding. For example, a capable young employee was worried about contracting silicosis because he worked in a plant where at times there appeared to be considerable dust in the atmosphere. He did not know that this dust was free from silica or other harmful ingredient, but his foreman did.

Knowledge of his own department enabled the supervisor to convince the workman that not only was the dust inert but also plans were under way for the installation of new ventilating equipment which would remove the particles that were already present. The man was satisfied and the company was able to retain the services of a good employee.

What then are some of the fundamental things a supervisor should know about industrial dusts? Dust is formed by reducing earthy materials to small size. Processes like grinding, crushing, blasting, and drilling produce dust particles of sizes from the submicroscopic to the visible.

Fumes are formed from combustion, sublimation and condensation. Those from burning or melting lead or zinc are typical examples. The size of the particles is generally below one micron. (A micron is 1/25,000th of an inch.)

Smoke is usually of organic origin from such things as burning tobacco, wood, oil or coal. The particle size is usually below a half micron.

Mists or fogs are formed by condensation of water vapor and the particle or droplet size varies widely.

The most important item to the supervisor is the realization that he may be dealing with a dust which can produce bodily harm. His first consideration should be "How is the man himself affected? Is the dust present in sufficient amounts in the air to be a source of danger? Does it exist in the pure state or is it mixed with other dusts? What is the actual count of particles per cubic foot of air, and what percentage of these is of respirable size (below 10 microns and especially those below three microns? How long does it take to develop occupational disease of the lungs from exposure to dust?"

All this may appear to be outside the scope of the supervisor's activities since after all his job is concerned primarily with production. However, most industries place the responsibility for carrying out safety measures on the foreman and it is apparent that his department will suffer if these are not properly enforced. Safety therefore includes precautions against occupational disease as well as accidents so that some knowledge of methods for controlling exposure from dangerous dusts, toxic fumes or other

armful materials is a proper part of the pervisor's armament.

It is not advocated that his duties be so panded as to encroach upon the field of e industrial hygienist but it is reasonable d logical to suggest that he equip himself ith the essential details concerning occuational risks in the department he manges. This information can be readily tained from his company medical dertment or through other agencies such as e Division of Public Health of state and deral governments. These bureaus welme inquiry of this type and their services e usually available without charge.

Much confusion and misunderstanding ists about the capacity of various dusts ising from occupational procedures to use physical disability. Exaggerated reorts and misrepresentation by individuals familiar with their specific properties ve incriminated certain materials known be quite inactive and absolved others oven to possess harmful qualities. Expeence accumulated through years of intenve study and research indicates that the eat majority of industrial dusts have tle effect on health other than their isance value and contribution toward poor ousekeeping.

However, the fact that they are unlikely cause occupational desease should not used as an excuse to do nothing about em. A good working environment demands at they be removed in spite of their incuous characteristics and the smart supersor will do all he can to accomplish their mination.

The wide assortment of dusts met with industry makes their classification into armful" and "inert" categories difficult. hose arising from organic sources such animal and vegetable products as a rule not cause serious harm but are capable producing local irritation like dermatitis skin rashes, dental conditions, and inammation of the eyes and the mucous memane lining of the upper air passages.

The majority of harmful dusts encountered manufacturing processes are inorganic in aracter. The specific effect on health rics. Chromium, cadmium, arsenic, and eir compounds produce local irritation as the organic dusts but they can also cause neral intoxication if present in sufficient nounts. The dusts or fumes derived from the heavy metals like lead, mercury, and manganese can be highly toxic and poisoning from these substances has been recognized for many years.

Recently serious and even fatal illness has been found to occur from exposure to beryllium and some of its compounds while another occupational condition known as "Shaver's Disease" has produced severe damage to the lungs of workers exposed to fumes arising from the fusing of bauxite, the chief ore of aluminum, in the manufacture of artificial abrasives.

Generally speaking, the particle size which is most dangerous is in the range of one-half to three microns in diameter. Particles larger than these seldom reach the alveoli or terminal air saces of the lungs since they are filtered out by the "cilia" or natural protective mechanism of the nose. throat, and large bronchi. There is also good evidence that particles below one-half micron in size may be retained in the lungs in sufficient quantities to result in disease. This means that the visible dust in a working place may not be as dangerous as the particles which are not seen by the naked eye.

Industrial hygienists emphasize this and also point out that although the amount of visible dust in the atmosphere in the vicinity of a certain job appears great, it does not necessarily mean that the workman is inhaling significant quantities of harmful particles. The exposure may be intermittent and of brief duration, or the air at the breathing level of the employee may be sufficiently clear that no undue risk is involved.

With the exception of beryllium and bauxite few of the aforementioned dusts cause damage to lung tissue and, as explained previously, not every person so exposed does develop occupational disease.

At the present time it is generally agreed that the most important sources of industrial disease of the lungs are free or uncombined silica and asbestos. Silica or silicon dioxide which makes up approximately 60 per cent of the rocks and minerals of the earth's crust, is the specific cause of the ailment affecting the lungs of workers in dusty trades, known as silicosis.

It is very important to recognize the fact that this widely known condition cannot be acquired from any material other than free silica and also that it happens only when particles smaller than ten microns in size of this mineral have been inhaled over long periods of time, such as from two to 25 years with an average of ten years. The term "free silica" usually means quartz of which there are many varieties. There are also other forms of free silica.

The scarring or fibrosis of the lungs which results from the action of uncombined silica casts characteristic nodular shadows in the chest roentgenograms of those affected. Frequently this is the only way the disease can be detected as it causes no symptoms in the early, uncomplicated stage.

Other dusts may produce x-ray patterns which are difficult to differentiate from silicosis and some unrelated illnesses may resemble it closely. The x-ray picture observed after the inhalation of iron oxide particles among some welders and grinders shows densities which are all too often mistaken for those seen in silicosis. Since this condition (siderosis) is harmless, the implications of such misdiagnosis are obvious.

Unfamiliarity with industrial diseases of the lungs by those charged with evaluating them properly has resulted in employees becoming needlessly alarmed, forsaking their jobs and forfeiting seniority while industry has lost good workmen and production. It has [illegible] paid unjust claims for disability. In [illegible] situation of this sort the supervisor [illegible] along with the rest since his department is bound to be affected by these conditions.

To attempt to tell the supervisor all he should know about the extensive subject of industrial dusts is an impossible assignment. Suffice it to say that the more he learns about them through his own volition, the better his qualifications for his job will be. Through such enterprise he will enter a new field of endeavor and discover a fascinating experience which will pay dividends both to himself and his company.

The complexity of problems which confront the director of any department in today's exacting requirements presents a formidable challenge to his resources, and this, along with the working man's reasonable insistence on a better place to work, demonstrates that a knowledge of industrial hygiene may well be a most important factor in the efficient discharge of his duties.

The best treatment of any disease associated with industry is not to let it happen in the first place. The problem is for engineers rather than physicians, but, regardless of the one on whom the burden falls, the final outcome depends upon the interest and efficiency of the man who manages a department.

Occupational Dermatitis; Teamwork in Engineering and Medical Control

By WALTER F. SCHOLTZ

Supvr., Industrial Hygiene, Allis-Chalmers Mfg. Co., West Allis, Wis.

We have accepted the challenge that occupational dermatitis presents to industrial medicine, and accordingly it can be stated that with proper care and intensive educational programs, occupational dermatitis can be checked and great savings effected.

Through the institution and maintenance of control measures workmen can be protected against dermatitis producing oils, chemicals, etc. The ideal control measures will protect workmen all along the line—from the manufacturing of the basic materials to the completed fabricated part.

Modern industry today is becoming so cognizant of the benefits of good preventive measures that they are not only relying on the worker alone, but are seeking the teamwork of everyone concerned.

Since the proof of the pudding is in the eating, I would like to state what has been done through a concentrated program of occupational dermatitis control and prevention which started in 1943 at the West Allis works of our company. This concentrated program has resulted in a 74 per cent decrease and a reduction from 10.3 to 2.7 in the number of cases per million manhours of exposure.

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ACCIDENT PREVENTION

Manual

• SECOND EDITION

national safety council

FOR
INDUSTRIAL
OPERATIONS



PLAINTIFF'S EXHIBIT
NSC-59

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ACCIDENT PREVENTION

MANUAL for INDUSTRIAL OPERATIONS

This book was written by the staff of the National Safety Council, with the close collaboration of the Industrial Conference of the Council, particularly of its Manual Committee, under the chairmanship of William S. Smith, Director of Safety, Ford Motor Company. Appreciation is due the many consultants, especially the Executive Committees of the Council's Industrial Sections, who reviewed material pertinent to their own fields and whose advice contributed so much to the authority of the final result.

ENGINEERS of the Industrial Department of the Council prepared the major portion of the book. G. G. Grieve wrote Section 1, PERMANENT STRUCTURE AND PLANT LAYOUT; Robert L. Moore and George MacDonald Section 2, MAINTENANCE. Mr. MacDonald also wrote Section 15, ELECTRICAL HAZARDS.

William N. Davis prepared the three Sections, BOILERS, PRESSURE VESSELS AND REFRIGERATING EQUIPMENT; Arthur S. Kelly Sections 6 to 10, inclusive, on guarding machinery.

Lester W. Dutton wrote Sections 11 and 12 on materials handling; A. M. Baltzer, Section 13, HAND AND PORTABLE POWER TOOLS.

Floyd E. Frazier and Mr. Davis collaborated in the preparation of Section 14 on welding. Glenn F. Griffin and Mr. Frazier worked together on SAFETY ORGANIZATION AND TRAINING, Section 24.

Roy G. Benson is the author of the three sections on flammable liquids and fire, and of Section 26, THE SAFETY MAN'S RESOURCES.

E. P. Marconi prepared Section 19, PERSONAL PROTECTIVE EQUIPMENT; Floyd A. Van Atta Sections 21 through 23, INDUSTRIAL POISONS, MEDICAL SERVICES, and INDUSTRIAL HEALTH ENGINEERING.

H. Gene Miller, Director of the Statistical Division, is the author of the section on accident records; The Motor Transportation Bureau prepared Section 20, MOTOR TRANSPORTATION. Mrs. Mildred Grant of the National Safety Council Library did the alphabetical index.

Kent W. Francis, Editor, Industrial Department, supervised the organizing, editing and production of the book. He was assisted by Mrs. Russell Perry, Editor, and by Elizabeth Valovic, Administrative Assistant.

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TABLE 21-F
CONVEYING VELOCITIES FOR INDUSTRIAL DUSTS

DUST				VELOCITIES—TEST			RECOMMENDED TRANSPORT VELOCITIES					
Description	Method of Production	Density	Median Size in.	Bounce	Roll	Clean	Alden[1]	Bull.[2] 217	Brandt[3] Table K	Brandt[3] Table 11	Witheridge[4]	Auth. Results
Aluminum chips	Grinding	2.72	.0132	3800	3000	2200	4000	4000	3500–4500	5000	4500	4000
Asbestos	Saw	2.20	.0138	1800	1560	1500					3000	2000
Casein	Lathe & sanding	1.27	.0070	1370	1210	1270	3000					1600
Catalin	Lathe & sanding			1820	1250	1610	3000					2000
Foundry, nonferrous	Wheelabrator	3.02	.0046	2800	2340	1650	3500		4000	5000	3500	3100
Foundry, ferrous	Tumblers	2.52	.0092	1570	1430	1300	3500		4000	5000	3500–4000	1800
Grain	Blast cabinet	1.41		2500	2400	1950	2000	2000		3000	2000	2800
Lead oxide	Mixer	8.26	.00058			3050						3400
Leather—shavings	Edge trimmer	1.34	.054	1880	1640	2380	3000			4000	3000	2700
Leather—sanding	Sanding	1.32	.021	1330	1270	1120	3000			4000	3000	1500
Limestone, coarse	Drilling	2.83	.0057	2410	1750	1530					3500	2700
Limestone, fine	Drilling	2.78	.0028	1420	1420	1720					3500	1600
Litho powder		1.94	.0048	610		1270						1400
Litho bronze		4.44	.0082	1570	1350	1620						1800
Metal (alum. & bronze)	Grinding	6.34	.0039	2730	2600	1560	3000	2200	3500–4500	4000	3000	3100
Rosin	Hog		.020	3900	3900	1890						4000
Rubber	Grinding	1.14	.060	2000	1390	1800	2000	2000		3000	2000	2200
Starch		1.27	.0025	1300		2300						2600
Steel shot blasting	Blast cabinet	6.85	.0038	2500	2420	1900	3500		4500	4000		2800
Steel shot blasting	Blast cabinet	4.61	.0172	1500	1320	2180	3500		4500	4000		2400
Vinyl	Grinding	1.82	.0064	2020	1880	1390	3000					2300
Wood flour	Sanding		.012	1560	1390	1390	1500		3500		2000	1800
Wood hog dust	Hog		.023	3750	3300	1900	3500				3500	4000
Wood sawdust, heavy	Tumbling barrel		.055	2950	2220	1620	3000	2000	3500	4000	3000	3300
Wood sawdust, light	Table saw			2400	1730	2000	2000	2000	3500	3000	2000	2700
Wood shavings, hard wood	Planer			2150	2000	1770	3000	3000	3500	4000	3500	2400
Wood shavings, soft wood	Matcher			1590	1450	1550	3000	3000	3500	4000	3500	1800
Wood composition, chips	Hog	1.18	0.54	3900	3050	1560	3500					4000

[1] *Design of Industrial Exhaust Systems,* John L. Alden, Industrial Press, 1939.
[2] *The Determination and Control of Industrial Dust;* Public Health Bull. 217, J. J. Bloomfield & J. M. DallaValle, 1938.
[3] *Industrial Health Engineering,* Allen D. Brandt, John Wiley & Sons, Inc., 1947.
[4] *Air Sanitation and Industrial Ventilation,* W. N. Witheridge, 1945.

much more common. Effects of antimony resemble those of arsenic primarily in the dermatitis, which may start as an inflammation of the hair follicles and progress through pus formation and sloughing to leave a contracted scar.

Arsenic, in the form of arsenic trioxide, is traditionally the most important of the poisonous materials used for criminal purposes. It is a profoundly irritating material which produces inflammation of the stomach and intestines, destroys the hemoglobin, and causes nervous collapse. However, cases of severe industrial poisoning are rare.

Men who handle the solid compounds of arsenic may suffer from a husky voice and cough, perforation of the nasal septum, ulceration of the skin, loss of hair and nails, warts and sometimes skin cancers which tend to follow a slow and not very malignant course. These troubles are all severe nuisances, but they are practically never fatal and seldom disabling.

Arsine. Severe and acute industrial poisonings with arsenic are likely to be the result of inhalation of *arsine,* produced accidentally when hydrogen has been generated in the presence of a material which contains arsenic. This gas has been reported in the acid cleaning of filter plates, in the handling of wet dross from a light metals plant, in the cleaning of tank cars which have held sulfuric and hydrochloric acids, in the cleaning of pipes with an acid contaminated with arsenic, in the precipitation of cadmium with metallic zinc, and in other circumstances as well.

Arsine rapidly destroys the red cells. After it has been inhaled, the first signs are those of lack of oxygen. After some time the body begins to excrete the damaged red cells which appear as a dark or bloody urine. The kidneys may then become too clogged to operate at all.

The possibility of arsine formation should always be considered when there is hydrogen formation around the active metals or around ores of the heavy metals, since arsenic is widely distributed in small amounts and only a trace of it is required to produce enough arsine to be troublesome.

Asbestos is a hydrated magnesium silicate found in the minerals chrysotile, amianthus, actinolite and tremolite. Practically all the commercial asbestos is either chrysotile or amianthus, and about 90 per cent of that used in this country is chrysotile. It is used almost exclusively for heat insulation or for textiles which must resist high temperature, such as heat resistant clothing and brake linings.

Inhalation of excessive quantities of asbestos fiber can produce a fibrosis in the lungs similar to that found in silicosis but somewhat milder and usually not so rapidly progressive. Like silicosis, the condition develops slowly and advances slowly and is equally resistant to treatment.

Prevention is essentially dust control. A maximum dust concentration of 5 million particles per cubic foot has been suggested, precisely as for pure free silica.

Barium. The soluble salts of barium are toxic when ingested, as well as highly caustic on the skin. There seems to be little toxic hazard in the inhalation of the dust of the less soluble salts.

Barium is a heavy metal, and the dust of the insoluble salts will collect in the lungs and give rise to the condition known as baritosis. Its nodular appearance on X-ray film may be mistaken for that of silicosis. Men showing the sign of baritosis are apparently not disabled or inconvenienced in any way.

Benzene is a colorless, flammable, volatile liquid with a rather pleasant aromatic odor. Its fire hazard is between that of ethyl alcohol and that of ether. *The greatest hazard is that of chronic poisoning by inhalation of comparatively small amounts over a long period of time. It is one of the two or three most dangerous organic solvents in commercial use.*

The action is primarily on the blood-forming organs, producing severe anemia, bleeding under the skin, and great reduction in the ability of the blood to clot.

The extent of chronic exposure to benzene may be determined qualitatively by measurement of the ratio of organic to inorganic sulfates in the blood. The most convenient measurement of damage is given by a blood count.

People who may be exposed to benzene vapor should have blood counts at regular intervals. Consistent change in the blood count should be closely investigated. Particularly significant changes are diminution in the total numbers of red cells, platelets or white cells.

TABLE OF CHEMICAL HAZARDS—*Continued*

Substance	Flash point ° F.	Explosive limits % by volume		Auto-ignition temperature ° F.	Probable safe concentration for 8-hr. exposure	Usual mode of entrance to body	Signs and symptoms of poisoning
		Lower	Upper				
antimony (salts)	metal and sulfides flammable				0.1 mg/cu.m.[27]	inhalation of dust, ingestion	*Acute:* vomiting, colic, diarrhea, irritation of mouth and throat. *Chronic:* indigestion, loss of weight and appetite, sometimes severe dermatitis.
arsenic	...	...	...	...	0.15 mg/cu.m.[6]	inhalation of dust, ingestion and direct action on skin and mucous membrane	Irritation of skin, loss of hair and nails, perforation of nasal septum, hoarse voice, cough, neuralgic pains, diarrhea.
arsine	...	...	...	...	1 p.p.m.[8] 0.05 p.p.m.[27]	inhalation	Headache, nausea, vomiting, chills and shivering, jaundice, dark or bloody urine.
asbestos	nonflammable				5 million particles per cubic foot[7]	inhalation	*Chronic:* shortness of breath, asbestos corns.
barium (compounds)	peroxide, chlorate, and nitrate produce violent combustion in flammable materials				0.5 mg/cu.m.[27]	inhalation or ingestion of soluble salts, direct action on skin	Severe dermatitis from the caustic salts, vomiting, dyspnea, abdominal pain, cyanosis, paralysis.
benzene (benzol)	12	1.5	8	1000	100 p.p.m.[8] 50 p.p.m.[27]	inhalation	*Chronic:* weakness, fatigue, bleeding from the gums and nose, headache, dizziness. *Acute:* inebriation, convulsions, and loss of consciousness.
beryllium	...	...	...	...	2 micrograms/cu.m.[33]	inhalation	
bromine	...	...	...	...	1 p.p.m.[8]	inhalation direct attack on skin and mucous membranes	Irritation of eyes and respiratory tract, irritation and corrosion of skin, probable lung irritation in acute cases.

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Industrial Hygiene in the Petroleum Industry

By A. C. PABST
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Industrial hygiene is a field that is closely interwoven with industrial safety. In fact, it can be regarded as a medical engineering phase of safety.

Unfortunately, many people do not know what industrial hygiene is and the functions of an industrial hygienist. The reason for this is that industrial hygiene is a comparatively new science and practically unknown twenty years ago.

Today there are only about 800 industrial hygienists in the United States, and a large number of this group are not in industry, but working for the federal government or state departments. Usually, people hearing the word "hygiene" recall they had a hygiene course in high school which dealt with personal habits such as bathing, cleaning the fingernails, teeth, and so forth and immediately jump to the conclusion that an industrial hygienist in industry must be interested in keeping employees clean.

In my initial visit to many refineries, it seemed that the first place I was taken was to locker rooms to inspect shower and lavatory facilities. In some degree, industrial hygienists are interested in the employee's cleanliness, but only so far as it is necessary to protect his health. We are more interested in keeping an employee's lungs, skin, and other organs clean and free from hazardous gases, liquids, and other harmful substances.

Hygiene is defined as that branch of medical science that relates to preservation of health. Therefore, industrial hygiene may be defined as the science of prevention and control of occupational illness. It resolves itself into the problem of finding factors or conditions in work places that may cause or contribute to the illness or serious discomfort of employees, and of devising methods and means of eliminating or controlling such conditions. Another term that may best describe industrial hygiene might be industrial medical engineering.

The industrial hygienist has done much toward bringing medicine and safety engineering into close cooperation partly because his interests overlap these two fields.

The typical industrial hygienist usually started out as a chemist or chemical engineer who became interested and studied toxicological effects of chemicals on man. Consequently, he has a good background of chemistry and engineering combined with some medical knowledge—a sort of one-third doctor, one-third engineer and one-third chemist. His objectives are protection and improvement of health and safety of workers in industrial environments from all manner of harmful exposures related to occupation.

Industrial hygienists and safety engineers have pretty much the same objectives and should be regarded as members of the same team. Actually, the functions of each are sometimes so inter-related it is not possible to draw a clear line of separation between the two fields, nor is it necessary to do so for if a man's health is endangered by working conditions it is an important part of his safety picture. In many industries, safety and industrial hygiene are combined in the same department.

In the petroleum industry, however, industrial hygienists are usually attached to the medical department and work as closely as possible with the safety department for the protection of the employees. There is good reason why, the petroleum industrial hygienists must lean heavily upon the safety department. In the petroleum industry the concept of industrial hygiene is relatively new as compared to the chemical and other industries, consequently, the number of petroleum industrial hygienists is exceedingly small.

On the other hand, safety departments are well established, well acquainted with and close to every day problems of the petroleum industry. They have considerably more coverage and manpower.

To illustrate, the American Petroleum Institute's roster of safety and fire protection personnel list some 1,200 names, probably not all, in this occupation. Contrasted to this, to the best of my knowledge, there are at present only 17 industrial hygienists

working for petroleum companies—an industry ratio of approximately 70 safety men to one industrial hygienist. Most of the major oil companies now have at least one industrial hygienist and anywhere from 50 to 100 safety men so you can see it is very necessary for us to work with and through our safety people.

Basically, the practices of industrial hygiene in the petroleum industry is the same as in any other industry and it can be boiled down to four general principles:

1. A knowledge of the toxicology of chemicals and materials.

2. A review of all chemicals or materials used and how handled and tabulation of toxic or potentially hazardous substances.

3. Measurement of worker exposure to hazardous substances.

4. If required, recommendation and installation of adequate control measures and evaluation of the effectiveness of such corrective steps.

Toxicology of Chemicals

In regard to the toxicology of chemicals, it is usually difficult to adequately define a hazardous material because practically anything can be safe or harmful depending upon how it is used or where it is used.

For example, air and water are not regarded as harmful, but both are quite deadly under certain conditions—air if injected into the blood stream and water if introduced into the lungs.

In the same manner, the use of carbon tetrachloride in a process having properly designed ventilation would not be hazardous, while the use of carbon tetrachloride for mopping floors would be quite dangerous. Most safety people are aware that carbon tetrachloride is a hazardous chemical because there has been considerable publicity regarding its toxicological effects, and in some cases, restrictive labeling requirements have been passed, for example, in New York City. Many other chemicals used in the petroleum industry have inherent toxic qualities of the same magnitude, yet are not so well known.

In regard to toxicology, there are three ways in which a substance can cause adverse effects upon man:

1. It can be ingested or swallowed.

2. It can be harmful by direct contact with the skin or parts of the body.

3. It can be inhaled as a gas, vapor, mist or dust.

Ingestion

Fortunately, petroleum materials are not commonly or intentionally taken internally and therefore, trouble from this is rather rare in a refinery, although it does occasionally occur unknowingly. I recall watching a worker who had been complaining of stomach trouble, whose duties involved the compounding of litharge or lead oxide in a doctor solution. This man proceeded to empty bags of litharge into an outdoor mixing tank and because of the dust and mists generated he correctly wore a respirator. Of course, his hands were covered with lead oxide, and to my amazement, the first thing he did when he came down off the catwalk was to take an orange out of his lunch box which he started to peel and eat—probably one of the most effective ways to get lead poisoning.

Unfortunately, when petroleum products get into the hands of customers ingestion is more frequent, usually by small children whose parents carelessly leave products within easy reach. You know that every year there are fatalities reported from children drinking kerosene. We have had hurry calls from doctors involving children drinking such products as penetrating oil and fly sprays.

Some times adults are even worse as there are many cases of anti-freeze poisoning, drinking of brake fluid and one I recall of our radiator flush which contains muriatic acid and chlorinated hydrocarbon. However, this product is fully labeled including poison warning with the skull and cross bones.

It should be emphasized that hardly a substance exists that is not capable of producing effects on the human body if taken in sufficient amounts or under the wrong circumstances. Even common table salt if used in sufficient quantities is toxic. It is reported that many years ago the Chinese used table salt as a means of committing suicide. Every chemical substance, therefore, has a non toxic dose for man and a toxic dose for man. This can be well illustrated by the following slide on a widely used commodity:

Effect of Alcohol Level in Blood*

Ounces of Whiskey Consumed in 1 Hr. or less	Percent Alcohol in Blood	Behavior
¼	0.01	Normal.
1	0.02	Feeling of warmth pleasant social behavior.
2 - 3	0.05	Judgment blunted. Boastful, impulsive. Officially still sober.
5 - 6	0.1	Fumbling, staggering gait, clumsiness, slurred speech.
8	0.15	Officially drunk. Responses and motor coordination strongly affected.
10	0.2	Helpless, nausea.
16	0.3	Stupor.
24	0.4 - 0.5	Coma.
30	0.6 - 0.7	Paralysis of the respiratory center — Death.

*Pfizer Spectrum, JAMA, March 27, 1954

Skin and Body Contact

Approximately 60 per cent of all complaints received by our department are concerned with dermatitis and skin irritations resulting from contact with petroleum materials.

By far, the majority of these complaints are from customers so this is a subject that is very important in the marketing of petroleum products.

Cases among our employees or in our refineries are few when compared with those among industrial users of petroleum products, and it is believed that the reason for this is due mainly to the degree or extent of contact.

In the petroleum industry skin contact is not generally experienced to the extent that it is—for example, in the metal working industries where a daily eight hour skin contact with cutting oils often takes place.

It is definitely established that skin is not an impermeable barrier to chemical substances, and it is increasingly important as a route of absorption for many materials. Action of chemicals on skin may be local resulting in dermatitis. Examples we are familiar with are kerosene, cutting oils, and so forth, or a chemical may be absorbed through the skin and cause damage to blood or internal parts of the body.

Lead tetraethyl as an illustration does not affect the skin or cause dermatitis but can penetrate the skin and cause internal poisoning.

Regarding external or local skin effects, chemicals may be classified either as primary irritants or sensitizing agents.

A primary irritant is a chemical that may cause dermatitis in individuals frequently after only one contact. They may have a strong chemical action, such as acids, alkalis, amines, and so forth or they may have a weak chemical action but require prolonged contact to cause dermatitis. Most petroleum hydrocarbons are primary irritants but are classed in the latter category in that prolonged or extensive contact is usually required to cause skin irritation.

Sensitizing agents, on the other hand, are chemicals that are innocuous to most skins but capable of producing dermatitis in a few susceptible individuals following repeated contacts over a long period of time. Sensitization may require weeks, months or even years of contact with the material before dermatitis develops.

The petroleum industry is now handling large quantities of chemical additives and inhibitors, many of which are strong primary irritants and very active chemical compounds. By nature, inhibitors usually have to be very potent chemicals because, while they are used in very low concentrations, they exert a powerful influence on the characteristics or performance of the product, and many of the inhibitors are just as potent towards man.

One very active class of inhibitors are the amines and substituted amines, and we are particularly concerned about them because they are very damaging to the eyes, and a splash can readily result in blindness. The amines are usually strong smelling caustic liquids, insoluble in water, hence difficult to remove by washing. They can cause severe eye burns and necrosis of eye tissue. In addition, most amines are readily absorbed through the skin; and even low quantities may cause internal damage and death.

The following will show the effect on skin of one such amine-dimethyl phenylene diamine:

Amount	Skin Area	Effect
0.001cc	1 sq. cm.	Heat — redness — rash
0.005cc	1 sq. cm.	Blister formation
4.0cc	12 sq. in.	Death

Employees should be fully alerted as to hazards of such materials and should be educated to the use of protective goggles, gloves and aprons when handling such products, an activity within the scope of the safety engineer.

The foregoing applies to concentrated or undiluted inhibitors. Finished petroleum

products should and usually do contain such a small quantity, and the inhibitor is so diluted as to result in practically no more harm in the finished product than there would be from the straight mineral oil itself.

Industrial dermatitis cases some times result in bizarre and erroneous conclusions as to their cause even by those who should know better.

I recall a case of a young man who worked in a gasoline station and developed a severe dermatitis. He went to a physician who made patch tests on him and found he had a sensitivity to special gasoline but no reaction to regular gasoline. Apparently, the physician had heard special gasoline contains a lot of lead because the case was diagnosed as resulting from an excess of lead tetraethyl in the special gasoline. We thought this strange because while we all know that lead tetraethyl is a violent poison and can be absorbed through the skin, it is not a primary skin irritant and has never been known to cause dermatitis. A review of records of gasoline shipments into the particular area showed the regular gasoline actually contained the same or some times more lead than the special gasoline, clearly proving that lead tetraethyl was not to blame, but that some other material was responsible.

Inhalation

Of the three avenues by which chemicals can be taken into the body, inhalation probably has received by far the most study and investigation because it is the most important consideration in industrial health.

The vast amount of research on the inhalation of materials has resulted in publication of very useful data on safe human exposure levels known as Threshold Limit Values or Maximum Allowable Concentrations.

This is a list of several hundred commonly encountered chemicals, solvents, dusts, and so-forth, the toxicology of which has been carefully studied by medical research and industrial experience.

The list is compiled annually by the American Conference of Governmental Industrial Hygienists and is published by the American Medical Association. It tabulates the maximum amount of the various materials workers can safely be exposed to for an eight hour working day without injury to health.

A few of the materials commonly encountered in the petroleum industry are listed below:

Gases and Vapors

Substance	PPM
Benzene (benzol)	35
Carbon dioxide	5000
Carbon monoxide	100
Carbon tetrachloride	25
Gasoline	500
Hydrogen sulfide	20
Naphtha (petroleum)	500
Octane	500
Sulfur dioxide	10

Toxic Dusts, Fumes, and Mists

Substance	Mg. Per Cu. M
Iron oxide fume	15
Lead	0.15
Sulfuric acid	1

Mineral Dusts

Substance	MPPCF
Asbestos	5
Dust (nuisance, no free silica)	50
Silica	
high (above 50% free SiO_2)	5
medium (5 to 50% free SiO_2)	20
low (below 5% free SiO_2)	50

These values are based on the best available information from industrial experience, from experimental studies, and, when possible, from a combination of the two. They are not fixed values but are reviewed annually by the Committee on Threshold Limits for changes, revisions, or additions as further information becomes available.

Threshold Limits should be used as guides in control of health hazards and should not be regarded as fine lines between safe and dangerous concentrations. They represent conditions only within which it is felt that workers may be repeatedly exposed, day after day, without their health being adversely affected. It is felt, at the present time, that workers should not be exposed to a working environment containing any of these substances in excess of the value indicated.

I cannot over emphasize the importance of the Threshold Limit Values and believe that every safety man should be familiar with them and have copies of the complete table, because they have been incorporated in states' codes and have the force of law in many states, and therefore, must be complied with. So far some nineteen states have written Threshold Limit Values into their laws and often management is not aware of such requirements but would be in a vulnerable position if trouble resulted from excessive exposure to any of the materials. Usually it is up to safety people and indus-

trial hygienists to alert management to the existence of these codes and to institute measures for measurement of air contaminants so as to insure compliance.

Even a common material like gasoline has a maximum safe level which is 500 parts per million. The results of exposure to concentrations greater than 500 ppm is shown by the following:

Gasoline Exposure

Symptoms: Headache, irritation of eyes and throat, dizziness, nausea, loss of consciousness, death.

	Parts Per Million	%
Maximum Allowable concentration for prolonged exposure	500	0.05
Slight symptoms after several hours	1000	0.1
Maximum concentration tolerable for 1 hr.	5000	0.5
Dangerous for short exposure	15000	1.5
Fatal for short exposure	25000	2.5
Lower explosive limit	14000	1.4

Product Labeling

One very important function of the industrial hygienist in the petroleum industry is precautionary labeling of product. This is receiving more and more emphasis as state after state passes labeling regulations. The most recent is the state of New York where the Council on Public Health passed on February 26, 1954 labeling regulations which became effective August 24, 1954 as Chapter IX-A of the New York State Sanitary Code. These labeling regulations have the force and effect of law and require precautionary labeling on any product which entails a hazard in a reasonably anticipated use.

A hazard is defined as—"the risk of injury or illness which may be encountered during or as a result of any reasonably anticipated type of handling or use of a substance, or during its specified use, if any, by reason of the toxicity of the substance through ingestion, inhalation or absorption through the skin, or due to its corrosiveness or irritating properties, or because of its flammability or explosiveness."

Similar labeling regulations already exist in California, Illinois, Oregon, and the Territory of Hawaii and are in the making in New Jersey, New Hampshire, Ohio and Rhode Island. More can be expected. Fortunately, most state regulations are guided by recommendations of the Manufacturing Chemists' Association, Inc. and with some few exceptions, conformity in one state results in conformity in other states.

It is recognized that as a rule labeling regulations of many products are advisable and result in safer handling of the material by customers, but it requires extensive work, knowledge of product and toxicological information to determine what products must be labeled and how they should be labeled. In our company's operations, we use somewhat over 2,000 basic chemicals or raw materials and manufacture some 3,500 finished products which must be reviewed individually in regard to the above.

To illustrate, the following are just a few of the hazardous materials that are encountered in petroleum refinery operations or that might be compounded into finished products:

Materials Encountered in Petroleum Refinery Operations

Respiratory Irritants	Toxic Materials	Skin Irritants
Acrolein	Aniline, liquid	Acids — all kinds
Acetaldehyde	Aniline, dyes	Amines
Aluminum Chloride	Benzol (Benzene)	Benzol (Benzene)
Ammonia	Cadmium	Caustics
Asbestos	Carbon Monoxide	Chromium Salts
Ditertiary butyl para cresol	Chlorinated hydrocarbons	Coal-tar Compounds
Dusts, physiologically inert, general	Chrome compounds	Cobalt, metal and compounds
Dusts, attapulgus clay	Cobalt, metal	Dyes
Dusts, bauxite	Hydrogen sulfide	Inhibitors
Dusts, catalyst	Inhibitors	Nickel salts
Formaldehyde	Lead, metal & fumes	Oils, general
Fluorides	Lead, oxide, litharge	Oils, high boiling from Cat & Steam Cracking
Furfural	Lead, tetraethyl	Oils, insoluble cutting
Inhibitors	Lead, soaps	Phenol
Lime	Manganese	Pitch
Nitrogen oxides	Mercury	Solvents
Ozone	Methanol	Ultra Violet Radiation
Silica	Radioactive materials, general	Wax, untreated
Smoke	Toluol (Toluene)	
Sulfur dioxide	Xylol (Xylene)	
Fine Oil	Zinc	
Welding fumes		

The petroleum industry has made remarkable progress in development of new and better products and in improving processing operations. Accompanying this progress has been new problems of toxicology and health engineering which must be studied and investigated with the same zeal as other types of research.

The advent of catalytic cracking resulted in production and handling of aromatic hydrocarbons, and of importance to us, health problems long associated with the coal-tar industry.

The use of new chemical catalysts, inhibitors, and other chemical compounds involve health problems that chemical industries have faced for years.

To illustrate this trend we need only look at the modern gasolines, fuel oils and motor oils. Years ago motor oils were practically 100 per cent petroleum in nature with little, if any, additives; today they contain up to 15 to 20 per cent of chemicals, additives and inhibitors, and this trend will continue because there is no question that additives are necessary and contribute much to improve performance characteristics.

Every step in this direction, however, does pose new problems of health and safety among our plant personnel and our customers. Because the petroleum industry is becoming more and more involved in the handling of all kinds of chemicals having various degrees of physiological effects upon man, I would like to quote the following concerning chemicals from a publication issued by Du Pont's *Haskell Laboratory of Toxicology:*

"It Takes All Sorts"

"Chemicals, like people, can be mild, fractious and often exasperating. Like people, chemicals are of many types and dispositions. Most are uncomplaining, law-abiding citizens who present no special problems. Some are unstable and unpredictable. Some are out-and-out neurotics, requiring a sharp and observant discipline. Others, harmless by themselves, may be influenced by bad company. Still others are troublemakers in solitary, but docile and helpful in tandem. Some are just plain bad actors."

It is my firm opinion that good industrial hygiene in the petroleum industry is dependent upon combined skills of many and requires earnest cooperation of industrial physicians, industrial nurses, toxicologists, chemists, safety men and industrial hygienists working together as a team. We all have a very important part in the picture.

Safe Handling of Insecticides

By F. R. WILLSEY
Farm Safety Specialist, Purdue University, Lafayette, Ind.

Insecticides are *supposed* to kill! Of course, they are supposed to kill only insects but the fact that they are intended to kill anything at all should be enough to cause us to be alert.

In one sense this problem of "Safe Handling of Insecticides" isn't a new problem at all. For years, we've had insecticides that could and occasionally did kill humans. We have also had some that were less dangerous. On the other hand, in a few short years we've changed from a few old standbys to over 5,000 products involving about 70 chemicals.

Why all this change?

1. Apparently people don't like to eat worms as well as they did. At least public opinion seems to demand higher quality products now that people realize such products can be produced.

2. And the government doesn't think people should eat so many insects. That's indicated by the fact that we have more laws and regulations governing quality of products, labeling of insecticides, spray residue, and so forth.

3. Insects travel more. They hitch-hike rides on the very latest transportation facilities. As a result they get more places and get there quicker than they could a few years ago.

4. New chemicals, plus research, makes new insecticides possible. In fact with each

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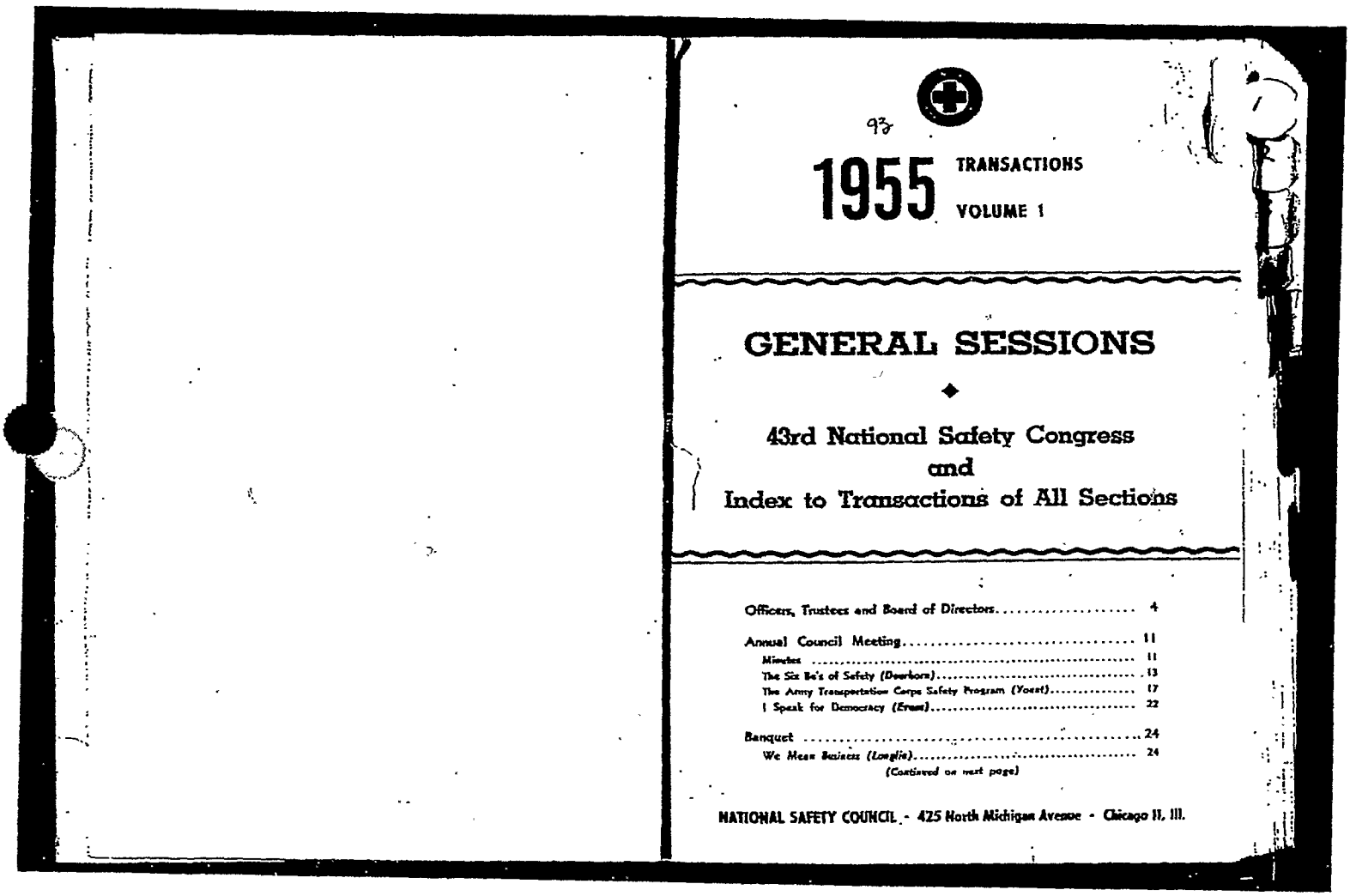
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urine. The kidneys may then become too clogged to operate at all.

The possibility of arsine formation should always be considered when there is hydrogen formation around the active metals or around ores of the heavy metals, since arsenic is widely distributed in small amounts and only a trace of it is required to produce enough arsine to be troublesome.

One of the more common sources of arsine incidents in recent years has been the handling of dross from the aluminum refining of metals.* Probably the most significant observation about these cases, aside from the fact that the moisture in the atmosphere is enough to form arsine, is the fact that the people involved in them have not been aware of the garlic-like odor which is supposed to be a warning of the presence of arsine.

The extremely high acute toxicity is reflected in the threshold concentration of 0.05 ppm. Arsine, in very small amounts, is also capable of producing a chronic type of poisoning, but it is more typically a source of acute episodes.

Asbestos is a hydrated magnesium silicate found in the minerals chrysotile, amianthus, actinolite and tremolite. Practically all the commercial asbestos is either chrysotile or amianthus, and about 90 per cent of that used in this country is chrysotile. It is used almost exclusively for heat insulation or for textiles which must resist high temperature, such as heat-resistant clothing and brake linings.

Inhalation of excessive quantities of asbestos fiber can produce a fibrosis in the lungs similar to that found in silicosis but somewhat milder and usually not so rapidly progressive. Like silicosis, the condition develops slowly and advances slowly and is equally resistant to treatment.

Prevention is essentially dust control. A maximum dust concentration of 5 million particles per cubic foot has been suggested, precisely as for pure free silica.

Barium, in the form of its soluble salts, is both toxic on ingestion and inhalation and highly caustic when applied to the skin. The carbonate and sulfide are sufficiently soluble to be toxic, although not very caustic. The sulfate, which is used as a contrast medium in X-ray work, is too insoluble to show any toxicity, and soluble sulfates are specific antidotes for ingested barium salts.

Since these salts produce violent stimulation of all muscle, upon ingestion they produce severe disturbances of the digestive system. After absorption, the barium salts produce an increase of blood pressure by constriction of the arterial muscle, a slow heart beat by an action similar to that of digitalis on the heart, and first excitation and then paralysis of the central nervous system. In spite of the high inherent toxicity, there are few cases of industrial poisoning with barium.

Barium is a heavy metal, and the dust of the insoluble salts will collect in the lungs and give rise to the condition known as baritosis. Its nodular appearance on X-ray film may be mistaken for that of silicosis. Men showing the sign of baritosis are apparently not disabled or inconvenienced in any way.

Benzene is a colorless, flammable, volatile liquid with a rather pleasant aromatic odor. Its fire hazard is between that of ethyl alcohol and that of ether. *The greatest hazard is that of chronic poisoning by inhalation of comparatively small amounts over a long period of time. It is one of the two or three most dangerous organic solvents in commercial use.*

The action is primarily on the blood-forming organs, producing severe anemia, bleeding under the skin, and great reduction in the ability of the blood to clot.

The extent of chronic exposure to benzene may be determined qualitatively by measurement of the ratio of organic to inorganic sulfates in the urine. The most convenient measurement of damage is given by a blood count.

People who may be exposed to benzene vapor should have blood counts at regular intervals. Consistent change in the blood count should be closely investigated. Particularly significant changes are diminution in the total numbers of red cells, platelets, or white cells.

Headaches, dizziness, fatigue, loss of appetite, irritability, nervousness, nosebleed, and other signs of abnormalities of the blood may or may not be present in chronic poisoning.

*"Arsine. Poisoning, Epidemiologic Studies of an Outbreak Following Exposure to Gases from Metallic Dross," Louis W. Spolyar, R. N. Harger, *Archives of Industrial Hygiene and Occupational Medicine*, 8:419–436 (1950).

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NATIONAL SAFETY COUNCIL
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manhole. This tag is placed by production personnel and a check is made by plant guards before the car leaves plant property.

Someone asked whether there was a constant monitoring device for HCN gas. It was suggested that Mine Safety Appliance Company be contacted as it has a portable device.

Someone else asked how metallic sodium waste could be properly disposed of. It was suggested that if no other reasonable method were known, it might be a good idea to get in touch with the A.E.C. for recommendations.

Some discussion was had relative to pressure-relieving devices. If a rupture disc is in the same line with pressure-relief valve, should the rupture plate be before or after the valve? One company stated they had a rupture disc in front of every relief valve. The rupture disc is set for about 15 per cent lower than the relief-valve device.

In discussing these valves, the frequency of relief-valve inspection was questioned. Some plants inspect them once a year, others as often as once a month. One statement was made that in their experience 50 per cent of the spring-loaded relief valves were found out of adjustment after a year.

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friendly attitude must be maintained. The best way to get a detailed history is not to "talk down" to the patient.

In the case of physical examinations as pre-employment, periodic or special, the nurse may obtain the history. The findings of the physical examination may be recorded by the physician himself or transmitted to the nurse to complete the record. A common error in the recording of the physical examination is to insert only the positive findings. Experience indicates that no space should be left blank, since in the event of a claim, it is important that the portions of the body examined as disputes should have negative as well as positive findings recorded.

The records of these examinations play an important role in preventive medical practices in industry.

Records are also important in the supervision of the correction of physical defects found in examinations. Finally, accurate medical records of examinations enable the physician to make intelligent recommendations for safe work assignments.

The impact of compensation laws which made accidents a prime responsibility of management was perhaps the stimulus to maintain adequate medical records. Accurate records became essential for the keeping of data necessary for the filing of claims. When the emphasis shifted to the prevention of accidental injury and industrial safety programs were organized, it became evident that the analysis of accident records was fundamental to the success of the program.

A careful and detailed account of the accident causing the injury will not only make a strong record in the case but will materially assist in the diagnosis of the injury and serve as a guide in recommendations for treatment.

Accurate records should be kept of all treatments. If injuries are infrequent, a small day book may be sufficient, if kept systematically. Entries should include these details:

1. Date and time of injury.
2. Date and time injury was reported for treatment.
3. Name and address of injured.
4. Where and how injury was received.
5. Names, addresses, telephone numbers of witnesses.
6. Nature of injury.
7. Kind of treatment given and by whom.
8. Whether employee returned to work after treatment: if not, when.

The keeping of medical records is really an index of the quality of medical service being rendered in industry. We know that all the benefits of a good medical service can not be measured in terms of dollars and cents alone. However, from a practical point of view, one of the best means to sell a medical service to business and industry is to show that it has a real value in the over-all contribution to productive capacity by reduction in sick absenteeism and the prevention of occupational diseases and industrial accidents. The proper keeping of medical records is the first step in this direction.

"Health means Wealth," is certainly an old adage that is true. In as much as the welfare of industry is built and survives on the ability to produce and market a product at a profit, it is important that those employed to do this job are healthy and happy.

In closing, I would like to remind you once again that the doctor, the nurse and all those connected with the medical program are only the "hub" around which a health program in industry revolves and without the support and integrated coordination of management, personnel, safety, research and development groups, and in fact all company employees, such a program would be relatively ineffective.

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CHECKING PERFORMANCE OF LOCAL EXHAUST SYSTEMS

Published by the National Safety Council
425 North Michigan Ave., Chicago 11, Ill.

This Data Sheet is one of a series published by the National Safety Council, reflecting experience from many sources. Not every acceptable safety procedure in the field is necessarily included. This Data Sheet should not be confused with American Standard Safety codes, federal laws, insurance requirements, state laws, rules and regulations, or municipal ordinances.

1. Changes in manufacturing procedures in the last few years have resulted in the use of more toxic materials and in the generation of more finely divided particles and greater quantities of smoke and fume. At the same time, there has been a greater effort to maintain a safe, comfortable atmosphere for the employee.

2. It has been estimated that about 80 per cent of the contaminants are controlled by ventilation, and today many operations have ventilation included in the original installation. Although a ventilation system is considered necessary for safety and comfort on new installations, responsibility for its satisfactory performance is seldom assigned to any one individual. Therefore, it frequently is not tested when put into operation and is allowed to become inoperative from lack of maintenance.

3. Excellent handbooks have been written on installation of local exhaust systems, but too little has been given on how to maintain them in top operating condition. There are two reasons for this lack of information.

4. First, a local exhaust system usually is not a piece of production equipment. Its maintenance may be slighted in favor of machines essential to the manufacturing process. Second, a local exhaust system has a dual aspect.

5. Strictly, it is an engineering or mechanical device, consisting of sheet metal, fans, motors, arresters, etc., whose performance is specified in terms of rate of air flow, static pressure, rpm, etc. This aspect is the responsibility of the engineer.

6. Yet the basic purpose of a local exhaust system is maintenance of health or comfort, and sometimes fire prevention. Its effectiveness is measured by how well it removes dust, fume, vapor, or gas that would otherwise make working conditions unsafe or unhealthful. This aspect is the concern of the industrial hygienist, who has been mainly responsible for developing exhaust and dilution ventilation for the control of atmospheric contaminants.

7. In the absence of an industrial hygiene engineer, the safety engineer is usually responsible for the exhaust system. Whenever necessary, he should consult the industrial hygiene personnel of the state health or labor department, of his company's insurance carrier, or of the home office if he is in a plant of a large corporation.

8. Management should try to develop in the plant engineer greater interest in the principles of local exhaust ventilation. Because these systems have been installed for health reasons, the plant engineer may not feel responsible for their unsatisfactory performance. The safety engineer, on the other hand, who does have an interest in the safety of work places, is generally unfamiliar with the principles of such systems.

9. Therefore, in a plant which does not have an industrial hygiene engineer, neither the plant engineer nor the safety engineer pays much attention to ventilation systems designed for the control of air contaminants. In such a plant, the safety engineer should be concerned with the satisfactory performance of ventilation systems. With the guidance of outside industrial hygiene engineers, he can become sufficiently familiar with ventilation equipment and terminology to check, to some extent, the performance of local exhaust systems.

10. The purpose of this data sheet is to suggest methods by which a local exhaust system can be checked when first put into operation, to determine if it fulfills the specifications, and by which it can be rechecked at intervals, to determine when, where, and what kind of maintenance is needed for maximum efficiency.

11. The performance of the system should be the responsibility of the plant engineering and maintenance departments. If, as in many cases, this responsibility is not now assigned and the equipment is not maintained, then it may be well for the safety engineer to try to interest management in assigning the responsibility to the proper people.

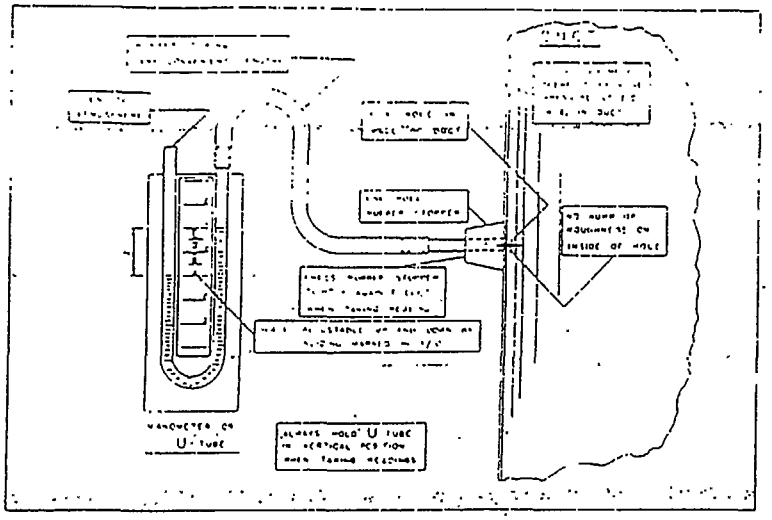


Figure 1. How to use U-tube (manometer) for measuring air pressure in ducts.

Definition of Terms

12. A local exhaust system is one that removes an air-borne contaminant, such as dust, fume, vapor, gas, odor, or hot air, as near its source as possible. A general exhaust system, or general ventilation, by contrast, removes air from the room after the contaminant has spread. The general exhaust method merely dilutes the room air by bringing in clean outside air, while the local exhaust traps the material at its source before it is dispersed throughout the room.

13. A hood is a specially designed fitting at the entrance of the duct to cause the flow of air to form a pattern that will best control the contaminant. It is a partial enclosure around the source where the contaminant is produced, connected with an exhaust duct, usually round sheet-metal pipe, to an exhaust fan.

14. A booth is a hood, usually rectangular or box-shaped, that encloses the operation on the two sides, the top and bottom, and the back, with only the front or face open.

15. A collector (arrester) is a device for removing the air-borne material from the air stream. It may be a cyclone or centrifugal collector for large-size particulate r ial like rough-grinding dust, c cloth filter for finer dust, or a water-wash, fog or spray device, electrostatic precipitator, dynamic precipitator, or other type.

16. Every exhaust fan operates by inducing a suction or negative pressure in the duct leading from the hood. This means that the air in the duct is below atmospheric pressure so that room air rushes into the duct. This negative pressure is an indication of the air flow, commonly expressed in cubic feet of air per minute (cfm), that enters the duct. The negative pressure may be directly related to air flow or, in the case of a plugged duct, inversely related.

17. The negative pressure is easily measured by gauges of various types, the basic one being a U-tube or manometer (a piece of glass tubing shaped like a U, the legs being about 8 inches long) half filled with water. A rubber tube from one leg is held at the point where negative pressure is to be measured, and the other leg is left open to the atmosphere (Figure 1).

18. The unit of pressure, which may be positive ("blowing out") or negative ("sucking in") is inches of water, abbreviated w.g. (water gauge). It is the elevation of one water column above the top of the other.

General

19. A good local exhaust system is a well-engineered project, based on precise design data—not merely a collection of piping.

20. Many states have codes that specify duct sizes and velocity of air in these ducts (hence, air flow in cfm) for different industrial processes and industries. These are minimum standards that must be met. Good engineering practice often calls for even larger air flows than those indicated in the codes. The engineer should have a copy of state regulations. Plans for new exhaust systems often have to be approved by the state before installation, and he should find out if this is the case in his state.

21. The engineer should secure a blueprint showing piping layout, if possible, together with data giving the cfm the designer intended to exhaust from each hood. For new systems, blueprints will be available. For old systems, the plant maintenance or engineering department may not have a drawing. It is still possible, however, that he can get the layout and data by writing to the sheet metal company from which his plant bought the equipment.

22. From this material he can determine whether an old system is the same today as it was when it was installed, or whether it has suffered the fate of all-too-many exhaust systems—has had extra branches added or changes made that may now render parts of it less effective.

23. Rare is the exhaust system that does not require understanding and cooperation on the part of the man who works at the process. Sometimes he has to modify his work habits to permit certain hoods to be used. The engineer should always find out just how the designer of the system intended it to be used. The engineer can often help by seeing that the men know the why of their exhaust systems and know how to use them.

Air Samples

24. If the equipment handles silica dust, asbestos fibers, or other toxic materials, such as chromic acid mist, lead fumes or dust, or solvent vapors, the system may be exhausting the "correct" volumes of air (according to the blueprint), the fan and collector may be in A-1 condition—yet a health hazard may still exist. The final and all-important measure of whether an exhaust system

is controlling a hazard is whether the air in the working region is clean enough to breathe without injury. This question can be answered only by taking air samples and analyzing them to find out if the contaminant is below the maximum allowable limit.* These tests are needed because a person cannot look at a dust cloud or smell toxic vapor and tell if the condition is unsafe.

25. Collection of air samples, both in general working areas and in ventilation ducts, is a principal activity of the industrial hygienist. It is, therefore, imperative that the safety engineer have such personnel secure this information. Not only does the collection of samples require extensive experience, but also the interpretation of the results and, equally important, the analytical procedures from which the results are obtained involve detailed and exacting methods for which experience and judgment are necessary. In the plant where an industrial hygienist is employed, the problem falls within his jurisdiction.

26. In the absence of a staff industrial hygienist, the safety engineer may obtain the services of the state bureau of industrial hygiene (in either the health or labor department), the services of the insurance carrier or of private consultants. Such services may also be found in institutes of industrial health or divisions of industrial hygiene in some of the medical schools or in schools of public health.

27. Once it has been determined through air samples that an exhaust system is keeping an exposure within safe limits, the negative pressure or "suction" in each branch duct, the pressure drop across the collector (if one is used), and the negative pressure at the fan inlet may be measured. At any future date, if rechecks show that these pressure readings are the same and if no changes have been made in the process, the hoods, or raw materials handled, it can be assumed that the hazard is still under control. (Cross drafts, as from a man-cooler, will change the control.)

28. Arranging for air samples and suction tests is the responsibility of the safety engineer rather than the maintenance engineer. (It is also frequently considered a responsibility of the designer.)

29. When the air contaminant is not toxic but causes merely a comfort problem, little is gained by air sampling.

Checking the System

30. For two reasons, it is well to make a complete check of the exhaust system. First, it can be determined whether it is meeting specifications for air volumes, resistance of ducts, horsepower, etc. Second, this information will be available for reference when the system is rechecked at later dates.

31. Some of the measures which will provide the safety engineer, in the absence of an industrial hygienist, with a program for checking the performance of a local exhaust system are discussed below.

32. **Layout.** The safety engineer should get or make a simple line drawing showing the layout of each main duct and branch, together with the location of the arrester, fan, and motor. He should measure the duct diameters and note them on the drawing. He should also secure the open face dimensions of hoods and record them. He should note on the sketch the type and size of fan, motor, drive, and arrester. This drawing need not be elaborate, or even to scale, and can be taken from the drawing of the system mentioned earlier.

33. **Test holes** should be drilled in each branch. The easiest and cheapest method is to make a 1/16-inch hole, leaving no burrs on the inside of the duct. (See Figure 1.) It is not necessary to cover or plug such a test hole when it is not in use. Sometimes a one-inch length of small copper tubing or even a small brass petcock is fastened permanently over the hole, but these refinements are not necessary. Each hole should be circled with a ring of [illegible] paint, and its

*Most state labor or health departments have now incorporated maximum allowable limits in their codes: these limits should be observed. Engineers in states which do not have such limits are referred to "Table of Chemical Hazards," Section 41, *Accident Prevention Manual for Industrial Operations*, 3rd edition (1955), published by the National Safety Council.

EXHAUST SYSTEM NO.. .. CHECKED BY..... DATE

Location. .. Material being exhausted .. .. ..

MOTOR 15 HP 1750 RPM

AMMCO TYPE AYZ 182 2320 SQ FT OF CLOTH

FAN BACKWARD CURVED WHEEL TYPE ABC-18. TO HANDLE 6400 CFM PLUS 10%, OR 7100 CFM AT 6" TP, 2650 RPM.

6463 CFM

640 CFM

1000 CFM

675 CFM

950 CFM

975 CFM

850 CFM

Test point	Condition of hood and branch (Battered? Removed? Plugged? Repair?)	Hood Suction (inches water) Originally	Checked
A		2.0	
B		2.1	
C		2.5	
D		2.0	
E		1.9	
F		2.1	
G		2.2	
H		1.0	
J		3.0	
Collector resistance (J)-(H)		3.0	

Material collected since last check .. lbs. Hours of operation .. Interval betwn. req shakings hrs

COMMENTS of men, and YOUR comments (use back, if necessary):

Figure 1. Safety engineer's inspection report

number or letter painted on the duct—the test points for the whole system being numbered serially. On the sketch, each test hole, with its number, should be marked.

34. **Balancing the system.** Before routine inspections are begun, and even before air samples are taken on a newly installed system, the system must be "balanced," that is, the proper amount of air must be flowing through each hood. Also, in the case of dust exhaust systems, the air velocity in branches and main ducts must be high enough to prevent settling of material, which leads to plugging.

35. In the original design, one of two means of balancing a system is used. The more common is to provide blast gates (dampers) in each branch which can be opened or partially closed so that each hood, regardless of whether it is near the fan or at a distance, handles its proper amount of air.

36. The other method is to size the diameter of the branches so that more or less air is introduced to serve the same purpose as blast gates. This must be done before the system is installed, since once the duct work is in, the duct diameters are fixed. Figure 2, adapted from Brandt, *Industrial Health Engineering*, shows a balanced system that does not rely on blast gates.

37. Each method has advantages. If blast gates are used, they should be bolted or welded after the system is balanced, to prevent tampering. Blast gates should not be used on a long, complicated system.

38. **A record form** (Figure 2) can be mimeographed for each exhaust system, with a suction pressure reading printed for each test hole. These readings are made immediately after the system has been balanced and dust counts (or other air samples) have been made to show that the air contaminant is under control.

39. **Periodic checks.** Each time the safety engineer makes an inspection, he fills out a report form. He compares the suction pressure readings he finds on recheck with the original readings printed on the report. He makes the following observations and records the results:

a. Look at all hoods. See if they are battered, partially removed, missing, or mangled in any way.
b. See if the manufacturing process and machines have been altered in any way. Make certain that strong cross drafts are not preventing the air contaminant from entering the hoods.
c. Whatever the provision for make-up air, make sure that replacement air has ample opportunity to enter the room.
d. Tap the duct at various points with a screwdriver or other metal object and listen to hear the pipe "ring," showing there is no appreciable settlement of material in it.

The frequency of periodic checks will vary with the type of service performed by the system. Some systems will need checkups weekly; others, monthly.

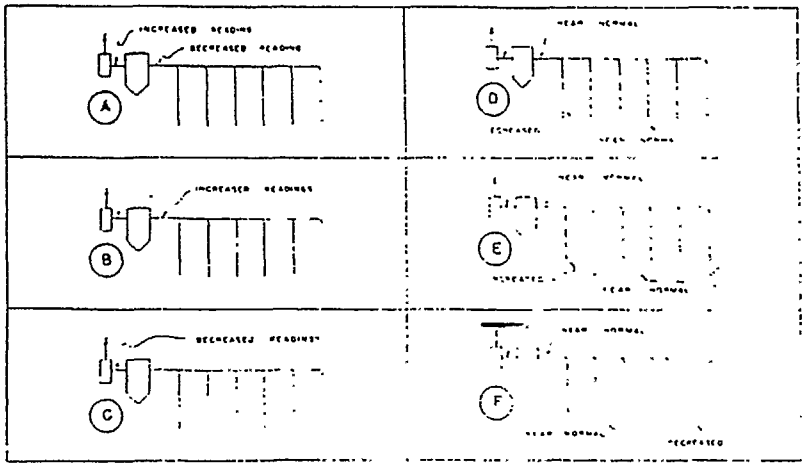
40. **Interpreting suction pressure readings.** If the suction pressure at a test hole differs by more than 10 per cent from the original readings (printed on the report form), the reason can generally be figured out without difficulty. Figure 3 shows how to interpret the U-tube values.

41. **Estimating control velocities or velocity contours.** One of the most important factors is that the control velocity at the source of the contaminant or the face of the booth (where the source is inside the booth) can be quickly measured by a sensitive direct reading instrument such as the velometer or thermo-anemometer. Where the source may cover a considerable area, the maximum and minimum should be indicated.

42. **Source, location, direction, and velocity of make-up air.** In addition to the amount and temperature of the make-up air, its source and method of distribution may be almost as important to successful control of the hazard as the design of the exhaust system itself. Since air blowing out of a duct carries 30 times as far as the same volume of air moving toward a similar exhaust duct (Figure 4), it is very important that the make-up air be diffused in such a way that no disturbing cross currents interfere with proper functioning of the exhaust hood. Frequently, such a disturbance can be anticipated if the essential facts are noted, and smoke tests may confirm its presence.

43. **Maintenance orders.** When the system needs mechanical repairs, such as replacement of worn ducts or hoods, filter cleanout, duct cleanout, fan belt adjustment, etc., the safety engineer should see that work orders are processed to the maintenance department according to the plant's customary procedure.

44. **Record filing.** The safety engineer should keep a file of his inspection reports and records of



(A) Dust arrester partially plugged causing increased resistance. Needs cleaning.

(B) Increased resistance or plugging in header pipe or in branch.

(C) Decreased fan capacity, open cleanout door or disjointed pipe.

(D) First branch pipe partially plugged somewhere between header and test hole near hood.

(E) First branch pipe partially plugged somewhere between test hole and hood face.

(F) [illegible]

Figure 3. How U-tube readings [illegible] to show where plugging has occurred. (Courtesy [illegible])

45. Periodic air samples. If toxic material is handled by the system, in addition to the initial air samples, the industrial hygienist or safety engineer should arrange for periodic samples of the air-borne contaminant in the workroom.

Inspection by Maintenance Engineer

46. The maintenance engineer should check and lubricate the fan, motor, and drive on schedule, just as he would any other piece of machinery. If the exhaust system has any special interlocking gates, motor-driven dampers, solenoids, or the like, these parts should come under this inspection and should be observed through a cycle to assure that they are operating.

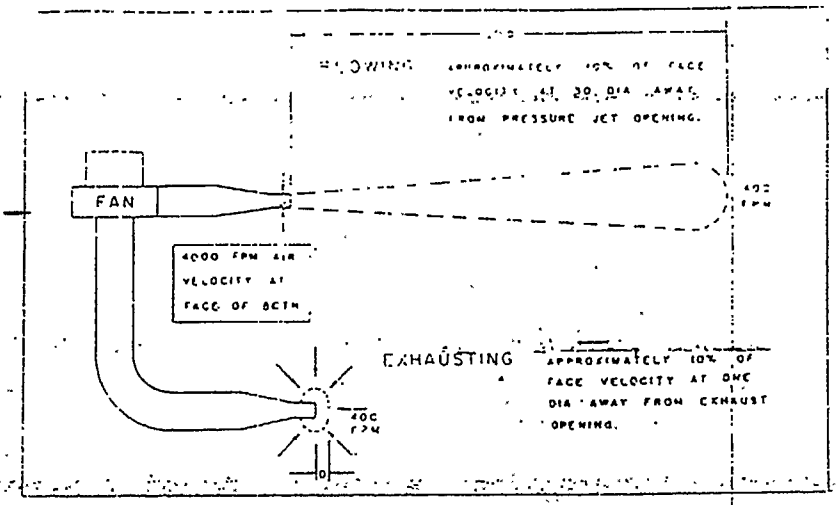


Figure 4. Effect of air blowing OUT of a pipe is felt many feet away, but an exhaust pipe has no effect beyond a few inches from pipe end. Thus it cannot "pick up" material unless pipe and hood are close to the dust source. [Courtesy "Industrial Ventilation—A Manual of Recommended Practice."]

47. He should check the inside of the collector with a flashlight each week, using an access door in the casing. The clean-air side of the collector should be examined to see that there are no accumulations of dust, which would mean that the collector was not functioning properly. He should look in the hoppers to see that they are not overfilled and should check bag collectors for torn or leaky bags.

48. Wet collectors should be checked for plugged spray nozzles, plugged drain pipes, sludge accumulation, and proper water level.

49. Fan speed should be checked monthly with a tachometer. Fan blades and scroll should be examined for wear and dirt accumulation. For this check, a hinged inspection door in the side of the fan casing or in the outlet duct near the fan discharge is necessary.

Design for Maintenance

50. Good first design will hold down maintenance problems later.

51. **Hoods and ducts.** The hood should be placed as close to the source of contamination as possible. The source should be enclosed if possible, with enough openings left for air to enter. Canopy hoods should be used sparingly. Too often the operator puts his head between the hood and the contaminant so that he may get much greater exposure than he would if there were no hood. If particles are thrown off by the machine (e.g. a grinder), the hood and the exhaust duct should be placed so that material will be thrown into them. Accessible cleanout doors should be provided in ducts, collector, and fan housing.

52. Sheet metal thick enough to minimize erosion should be used. For corrosive materials, ducts should be lined with resistive coatings or made from suitable corrosion-resistant material. If condensation may be a problem, the need for thermal insulation, "drip" elements, water traps, etc. should be considered. The possibility of a fire hazard, depending upon the material to be handled,* should also be considered.

53. Construction details are of utmost importance: gradual tapers, baffled hoods, wide-sweep elbows, 30 degree angle of entry to main, etc. Design of a "balanced" system, instead of relying on blast gates, should be considered. Total pressure loss should be calculated carefully, not guessed at. Natural drafts and cross currents of room air that may keep the contaminants from entering the hood should be noted. The hood should be arranged so that it will interfere as little as possible with the worker and still be effective.

54. **Collectors.** The collector should be selected for the substance to be handled, considering such factors as particle size, dust loading, wettability, corrosion, etc. Thought should be given to community air pollution that may result if there is no collector or if too much contaminant is exhausted to the outside.

55. If a bag-type filter is selected:

a. Consider size, storage hopper capacity, free-flowing hoppers.

b. Provide a permanent outside ladder and catwalk for easy access; with nonflammable dusts, light the inside of the filter housing for ease of inspection.

c. Provide a motor-driven shaker rather than a manually-operated one wherever possible.

d. Provide time-delay relays and interlocks so that when the fan wheel comes to rest, after the fan motor has been turned off, the shaker motor starts operating and continues for two or three minutes, after which it stops and the fan can then be restarted.

56. Fan and motor. The fan should be put on the clean-air

Standards for the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying, Pamphlet No. 91, National Fire Protection Association and National Bureau of Fire Underwriters, American Standards Association, Z33.1-1950.

Although the basic purpose of ventilating systems is to serve health and comfort, the use of these standards will result in a system which is also of value from the fire prevention standpoint since it will not transmit smoke and flame through fire walls and throughout the premises. The standards give specifications for reference with regard to the other components of the system and relate the extraneous [illegible]

side of the collector. When flammable solid materials or vapors are passed through the system, the provisions of NFPA and BFU Bulletins No. 91* should be followed.

57. Fan guards and a test hole for a tachometer to take speed readings of the fan should be provided. Service and inspection doors should be placed in the side of the fan housing, or in ducts at the inlet and outlet of the fan. Resistance of the fan discharge stack should be kept low. A weather cap should be omitted wherever possible.

Points on Testing

58. Here are some over-all considerations that should be kept in mind in the testing of local exhaust systems.

59. One of the initial steps that may be taken is to ensure that outside vendors or contractors provide a meaningful guarantee of performance for their equipment or system. Then the vender is made responsible for equipment or systems which do not perform properly.

60. Many a good exhaust system has been overloaded and made ineffective by the addition of hoods in later years. Before hoods are added, it should be ascertained that the present equipment can handle the additional air flow which will be needed without robbing the existing hoods.

61. Make-up air is sometimes a bigger problem than the exhaust system itself. Provision should be made for the air to get into the room to replace the air exhausted. In winter the make-up air may have to be tempered. A room should never be closed up tight and "air bound."

62. The man on the job must know the reason for the exhaust system and must understand how to use it. Better yet, the safety engineer should consult with him before the installation is made, to make sure that hoods, enclosures, and other parts of the system will interfere as little as possible with his work.

63. For testing exhaust systems visually, smoke tubes are commercially available (or may be made by dipping cotton into titanium tetrachloride). The smoke given off reveals the path of the air currents as they enter a hood. Smoke tubes are a boon to the safety engineer. Using them, he can show the operator how a hood works and thus often convince him how important baffles are, how necessary it is to have the hood close to the dust source, and so on.

64. Two common fallacies need clearing up. First, because people can feel air blowing out of an air line some feet away from the end of the pipe, they think dusty air can be "sucked into" an exhaust hood from several feet away. It cannot. Air can be "sucked" only 1/30 the distance it can be blown (Figure 4). In exhausting, the air velocity at a distance of one diameter from the pipe end is about 10 per cent of the velocity in the pipe; in blowing, this 10 per cent figure is reached 30 diameters from the pipe.

65. Suppose, for example, that a pipe 6 inches in diameter has air traveling through it at a velocity of 4,000 feet per minute. *Six inches* from the "sucking" end, the air velocity will be 400 feet per minute (hardly detectable by feel); at the blowing end, the 400 fpm velocity is reached some *15 feet* from the end of the pipe.

66. A second fallacy is that downdraft ventilation or hoods at floor level are required because organic solvent vapors, like benzene (benzol), trichloroethylene, carbon tetrachloride, and the like, are heavier than air. Heavy gases introduced into air tend to fall before they become mixed with the air. Thus, a vapor train of pure gasoline can form and travel along the floor many feet.

67. However, as vapors are given off from industrial processes, the atmosphere contains not pure vapor, but a mixture of vapor and air. Even air saturated with the vapor remains saturated for a very short time; it soon becomes diluted with more air because of random convection and wind current in the room.

68. A concentration of 1,000 parts per million of benzene, which is 25 times the maximum allowable health limit, is only 1.0017 times as heavy as air (although pure benzene vapor is three times as heavy as air). That is, the ratio of weight of air to weight of the benzene-air mixture is only 100 to 100.17. There could never be any sinking or stratifying of even this dense (1,000 parts per million) benzene concentration. Consequently, a side or back hood would be just as effective as a downdraft hood.

REFERENCES

Perhaps the best technical reference not only for design of exhaust systems, but also for checking of them, is: *Industrial Ventilation—A Manual of Recommended Practice*, published by the American Conference of Governmental Industrial Hygienists (3rd ed., 1954), available from the Committee on Industrial Ventilation, P. O. Box 453, Lansing, Mich.

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Flammable Liquids and Gases, Vol. I; *Combustible Solids, Dusts, Chemicals and Explosives*, Vol. II, National Fire Codes, 1955, National Fire Protection Association.

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PUBLISH CASE HISTORIES

Still another letter recommended publishing actual case histories of the misuse of toxic chemicals and their results. Since the same toxic chemicals are used in many laboratories or pilot plants, it would no doubt be worthwhile to make available information of this kind.

Setting up a toxicology chart was another idea received. This chart could contain columns giving the name of the toxic material, maximum allowable concentration, appearance, the type of operation where this material would be used, how it is absorbed by the body, the symptoms, first aid and the safe way to use the chemical.

These are all good ideas but your committee on Toxic Chemicals needs more information both on an expansion of the preceding ideas listed as well as new ones.

It is the responsibility and moral obligation of each of us to do what we can to further the cause of safe practices which will prevent suffering and the loss of human life. Please send your ideas on the use of toxic chemicals to R. V. Montello, Research Division, National Cash Register Company, Dayton 9, Ohio.▲

A BIBLIOGRAPHY OF TOXIC CHEMICALS

**Prepared by: Toxic Chemicals Committee,
Laboratory and Pilot Plant Group,
Chemical Section of the National Safety Council**

This compilation of references on toxic chemicals is made possible through the cooperation of the following committee members: John E. Fox, safety director of the Monsanto Chemical co., Texas City, Tex.; Robert A. Quisno, president, Hill Top Research Institute, Inc., Miamiville, Ohio and Ralph .V. Montello, head, materials dept., Research Div., National Cash Register Co., Dayton, Ohio. Assistance was also given by J. B. Black, department of health, education, and welfare; A. H. Christian, American Viscose Corp.; H. H. Fawcett, General Electric Co.; and J. N. Romine, Phillips Petroleum Co.

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out that liquid oxygen is commonly referred to as LOX in the Missile and Rocket Industry. The oxygen manufacturers were not aware of this practice but felt that it should be discouraged because for many years the term LOX has stood for liquid oxygen explosives in which liquid oxygen is only a part. Also, tanks, sold under such trade names as LOX and LOXETTE, may be used for the storage and handling of many liquefied gases such as oxygen, nitrogen, argon, hydrogen, etc.

At that meeting the group suggested that the secretary of the International Acetylene Assn. take steps to discourage this usage. The secretary of the IAA wrote several letters to principals of the Rocket and Missile Industry. A safety engineer in the Air Force read the minutes of last year's meeting in the Chemical Section Safety Newsletter and contacted the IAA. Through his efforts, the Air Force has taken steps to discontinue the use of the term LOX. This was reported in the October 1957 issue of Missiles and Rockets in an article entitled "Liquid Oxygen Replaces LOX Abbreviation in USAF."

The Air Force is undertaking this action to prevent dangerous and possibly disastrous results of the use of the term LOX for liquid oxygen. The term LOX will be deleted from all USAF technical orders and contracts including re-identification to the Department of Defense that it also take steps to abolish the use of the term LOX.

A member of the group reported that he had received a full tank car of helium compressed in long tubes manifolded together. In attempting to open the main outlet valve, they twisted the stem off. He wanted to know how to release the pressure. It was the group's recommendation that the gas supplier be contacted in any case where the valve is found to be inoperative, whether it be on a tank car or individual cylinder.▲

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This is sheer gain, but these laws still focus on doing something for the man who has met with an accident, rather than on driving full steam into eliminating causes for accidents. When a ship is sinking, then the whole weight of responsibility rests on manning the life boats and getting the passengers and crew off the vessel. When an auto has gone hurtling off a thruway then the weight of moral responsibility is to rush medical care.

But neither life boats nor ambulances are the full measure of moral responsibility that rests upon us today when ships still sail the high seas and cars ride the highways. Our moral sense has grown up beyond that level of moral satisfaction. In its modern concept moral responsibility stresses preventing the worst from happening on the oceans and on our roads rather than being content with picking up the pieces after the worst has happened.

Total security is a goal that is beyond our reach, but great progress can be made when men of competence and good will and devotion join together to help each other in every way possible to promote safety measures against accident hazards. The symbol of this step is, I suppose, the National Safety Congress itself. It stands for moral responsibility toward these hazards at its best, for our deepest responsibility toward the victim of accidents is to see to it that all is done to keep him from becoming a victim. And that is a worthy cause for all of us, wherever we are—in labor and in management, in education and in government.▲

LABOR'S STAKE IN SAFETY

by A. J. HAYES

international president, International Association of Machinists; vice president, AFL-CIO, Washington, D. C.

I don't intend to stay within the limits of this title because I am certain little new information could be said about "Labor's *Stake* in Safety. It is obvious that no one could have a greater stake in industrial safety than the men and women who are the direct victims of industrial accidents.

To an employer — matters of industrial safety, occupational disease, accident prevention and workmen's compensation—are all tied up with economic considerations. They are important insofar as they affect—and can be made to reduce—insurance costs, training costs, and material costs. But these are all money costs—cash costs—costs that are measured in dollars and cents.

To a worker, on the other hand, an industrial accident is a matter of something that is even more tangible than money. It is a matter of a man's blood, bones and sinew—of tragedy, suffering and sorrow. And sometimes, in fact, more than 50 times a day—on every working day—it is a matter of life itself to someone, somewhere, in this coun

That is why I say that labor's stake in safety is pretty obvious. Therefore I will touch upon aspects of the subject that are not often discussed—aspects that are somewhat controversial. Perhaps they are not discussed because they are controversial.

ETHICS IN SAFETY

Since my views and public statements on the "corruption in unions" issue have been as frank and honest as I can make them, I see no reason to be any less candid in stating my views about matters of industrial safety. I assure you, however, that I am not injecting controversy for its own sake, but because these are matters that concern the men and women who run the daily risk of being injured, diseased or killed on their jobs.

Safety—and accident prevention—have their ethical as well as an economic side. I think none of us—whether we represent labor or management — would disagree with certain basic ethical principles in the field of industrial safety. We would all agree, for example, that the objective of industrial safety should be the preservation of human life and the protection of human health. We would further agree that an employer has a moral responsibility to protect his workers against disease, accidents, mental stress and infections from the conditions of employment.

We all profess to agree that human life is not cheap; that man is not something to be sacrificed to a machine. And yet, these ethical principles are not always applied in day to day life nor are they self-enforcing. In practical application they come into conflict with individual economic interests, and thus must be enforced either through group action, or by society as a whole through political action.

As a rule, society does not move as fast as the need would indicate. We all know, for example, that the first industrial revolution had run its course for more than 100 years before society got around to adopting and enforcing rules and regulations of industrial safety.. For more than 100 years industrial workers were given no legal protection against the risks and hazards of industrial employment.

Here and there, a lone individual employer might attempt to provide decent and healthful working conditions for his workers. But on the whole, the story of factory employment in the 19th century—and through the early 20th century—was a pretty ghastly one.

I don't need to go into the details that are indicative of the cold indifference with which human life was held in American mines and factories. Suffice to say, it did not seem to matter how many men, women and children were killed or crippled in the course of a day. There were always more waiting at the gates the next morning—driven by raw poverty to plead for a chance to jeopardize their lives and limbs.

SOCIETY BROUGHT CHANGES

The point I am getting at, of course, is that change—when it came—was not the result of any regeneration of moral and ethical conviction on the part of employers. It came rather because society as a whole was thoroughly revolted. It came because the American people were finally shocked enough to correct a condition that had prevailed—and grown worse—for 100 years.

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So we finally got factory laws—and workmen's compensation—and an organized effort to make mines, factories and mills safer places to work. But of all the legislation aimed at this objective, workmen's compensation was the key. For until employers were made directly and financially responsible for the results of workers' accidents, they had no economic reason to prevent accidents. The whole pattern and fabric of our industrial safety program throughout the nation rests entirely on how good and how effective our workmen's compensation and our occupational disease laws are.

ECONOMIC REASONS

Oh, of course, you can point to many other good economic rationalizations for industrial safety. You can say industrial accidents add all kinds of direct and indirect costs to production. You can point to the cost of hiring and training a new employee, of equipment damaged in a work accident, of the time lost by other employees when an accident occurs.

But I will throw them all right back to you and say that these considerations were present long before we had industrial accident programs—and that it wasn't until accident prevention was reinforced with workmen's compensation and occupational disease legislation that employers really became safety conscious.

So it seems that the thing that counts here is how good our workmen's compensation and occupational disease legislation really, are.

And that's a good question! I've spent my whole adult life in the labor movement. As a matter of fact, I was projected into it by the very thing we are talking about here today—an industrial accident. I went to work at 17 years of age because my father was totally disabled by a work injury—an injury that eventually killed him.

In the course of many years of studying and dealing with the problems of my union —which are, of course, the problems of the members of my union, I realized that our present system of workmen's compensation and occupational disease legislation is completely and wholly inadequate to meet the needs of our complex industrial society.

I am not alone in that conclusion. There are, in fact, many men in the labor movement today who feel even more angly

than I do—men who are firmly convinced that workmen's compensation has been a gigantic swindle on the American worker.

This nation has tried to deal with a national problem by having 48 seperate, conflicting — and in a sense — competing state statutes. And there is no doubt but that workmen's compensation is one kind of labor legislation that states use to compete with one another to attract industry.

In fact, whenever we go into the state legislatures to get improvement or expansion of existing laws, we invariably meet employer counter-arguments to the effect that any further improvement in coverage or benefit structure will shove industry into the waiting and sympathetic arms of states which are more concerned with payrolls—than with the people on those payrolls.

SAFETY INTEREST LACKING

Certainly the health and safety of the nation's work force should not be a pawn in any state's bid for new industry. But that is just what it is under a system that allows Mississippi or Arkansas or Georgia to compete for industry by offering low workmen's compensation benefits and a minimum of safety regulation at the plant level. Why should an employer pay $40 a week for a temporary total disability in Illinois—when he can go to Arkansas and pay $25 a week for the same injury?

The situation in workmen's compensation legislation is so bad, in fact, that the Secretary of Labor, Mr. Mitchell, although speaking for an administration that normally follows a hands-off policy in state legislation, has been constrained to speak out and to plead with the states to bring their laws into line with modern conditions.

But because employers can play off one state against another in this matter, the results have been somewhat negligible. There is no indication that the remedy will ever catch up with the need, until there is broader recognition that industrial accidents are a national problem—one that is truly solvable only on the national level.

The lack of a strong and equitable workmen's compensation system leads to a corresponding lack of interest in enforcement of safety codes and regulations. In many states the Bureau of Factory Inspection—by whatever name it goes under—is little more than a sop to the conscience of the state legislature. In fact, the inspection service in such states is not only understaffed, but the staff is underpaid, untrained and technically unqualified to do a competent job in a field that needs a high degree of competency.

But as bad as the situation in workmen's compensation and factory inspection may be, the situation in occupational disease coverage verges on the criminal. And this is a matter of more than just poor legislation. It is incredible to think that in the second half of the 20th century 20 states still either have no coverage or limited coverage of occupational disease.

But the greater problem is that there is too little understanding of the nature and complexity of occupational disease. The range and source of occupational disease in modern industry is practically limitless. None of the ways by which man makes a living is completely free of some hazard to physical or mental health. The risk of occupational disease grows greater every day as industrial processes become more and more dependent upon and saturated with toxic dusts, fumes, vapors, gases, acids and alkalies.

Every day thousands of workers are exposed to everything from arsenic to mercury poisoning, from benzine compounds to magnesium poisoning, from sulphuric acid to chromium poisoning. Thousands have no physical or legal protection whatsoever against the chemicals and poisons that are slowly killing them.

UNAWARE OF RISKS

In fact, many are not even aware of the risk. They will find out when it is too late. In many states they will also find out that they have no right to compensation under the occupational disease law. I wonder how you tell a man who has contracted carbon tetrachloride poisoning, for example, that he isn't entitled to benefits under the occupational disease law because the legislature of his state hasn't seen fit to recognize that carbon tetrachloride poisoning is an occupational disease?

I recently read a statement to the effect that "the scope of occupational disease is vast almost beyond calculation" and "it comes, in fact, unpleasantly close to being the major public health problem of our time."

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If that is so—and I for one am inclined to believe it—it is tragic commentary on our time—on the ethics of a business community that has done so little about it. It is even more tragic in view of the fact that we are now entering a new phase in our industrial development—a phase of such sweeping change that some commentators have referred to it as a new industrial revolution. Think of that—we are entering a new industrial revolution without ever having fully solved the problems that attended the old one.

I wonder if it will again take us 100 years to make even a decent start on the health and safety problems that will arise out of automation and atomic energy. These problems are not a part of a distant tomorrow but are already a part of the world today. Now more than 1,500 industrial plants are using atomic materials in one form or another—in 1,500 establishments American workers are already exposed to the hazards of atomic radiation.

Can we say the state laws in existence today—indeed can we say that any system of state inspection and compensation — are adequate to care for the workers who will get leukemia or bone cancer because of exposure to atomic radiation?

DON'T KNOW PROTECTIONS

Personally, I feel somewhat discouraged about the prospects. How can the states protect and care for victims of industrial radiation when they haven't yet learned to protect and care for victims of occupational diseases that have been prevalent for generations? We need only look at silicosis and pneumoconiosis to see the failure. And failure to provide adequate treatment and compensation for these dreadful dust diseases is paralleled by the failure of industry to finance programs of research that would lead to their prevention at the source of exposure.

Related to the problems of occupational disease and radiation is another matter that has received almost no attention in industry, or in government. That is the matter of mental disease. We already know enough about automation to know that it will throw workers into a lonely and eerie world inhabited by monster mechanical devices.

We also know that our mental hospitals are already crowded with people who have broken down under the stress of life in a complicated, impersonal and highly industrialized society. But we don't know how much more stress people can take, or what effect automation will have on a worker's nervous system. At what point does the human mind crack up from sheer loneliness, lack of contact with fellow workers, from uninterrupted repetition and brainwashing boredom?

I am not just tossing questions out at random here. All of the things I am talking about—from workmen's compensation and occupational disease to radiation and mental distress—have a valid relation to industrial health and safety—and are proper subjects of labor interest.

LOOK FOR DANGERS

For safety is a broad term. It is defined as: (1) the state or condition of being safe; (2) freedom from danger or risk; and (3) freedom from injury.

Safety means freedom from any kind of danger, risk or injury. When we apply that definition to industrial problems we must think in terms of hidden dangers. We must change our attitude toward occupational diseases—go out looking for them instead of trying to pretend they don't exist, or implying if they do exist, that they have no relation to industrial causes.

I am not exaggerating when I say that industry has taken a "head-in-the-sand" attitude up to now. It has tried to cover up occupational diseases rather than to isolate, prevent and care for them.

There has been little research—either governmental or private—in the field. The Public Health Service spends less than one cent for each worker each year on the prevention of occupational diseases. The National Institute of Health, which has made hundreds of research grants during the past three or four years, has made less than half a dozen in the field of occupational health. There is an iron curtain of secrecy around this whole subject.

Not only does industry fail to support and subsidize research in occupational diseases, itself, but men who have tried to do independent research find that it is virtually impossible to get facts, information, or cooperation from the people in industry who are in a position to help. Worse still, if a

research project does tend to show a correlation between employment and disease, the authors find it is almost impossible to get their work published or distributed.

The result is a deplorable lack of information about occupational disease. We are years behind other countries in this respect. One expert in this field said that research in pneumoconiosis in this country is 25 years behind that of Great Britain.

SECRETS PREVAIL IN INDUSTRY

Industry actively opposes objective research and free interchange of information on occupational diseases because it is more afraid of the possibility of paying compensation benefits than it is that workers will die from lack of proper information and adequate precaution.

Here are specific examples that will illustrate this point. There is some medical evidence that the chemicals used in the dye industry and in the manufacture of synthetic rubber cause or contribute to cancer of the bladder. In fact, one of these—amine—is so dangerous that it has been outlawed for all industrial uses in Britain since 1951. But efforts to prove, publicize and restrict the dangers of this deadly acid have hit *stubborn resistance in this country.* The large chemical companies have refused to find out if amine does contribute to cancer of the bladder and have strongly resisted independent research into this problem.

Much the same situation holds true in the asbestos industry. There appears to be decided after-effects on workers who produce asbestos in that there is a marked correlation between asbestos employment and lung cancer. Here again, the industry has been traditionally reluctant to cooperate in a full scale scientific study of this curious correlation. This reluctance to do research in health hazards recurs in industry after industry.

DOCTORS OFTEN BIASED

But even worse when workers do succumb to cancer of the bladder or the lung, or to some other equally horrible diseases, we are treated to the spectacle of company doctors who testify that the disease couldn't possibly have been caused by their employment. Doctors are supposed to be above reproach in our society. But as a labor official I have known of too many cases in which company doctors have testified against workers and for management in occupational disease cases even though they knew their testimony was biased.

It should not surprise us that doctors can be unobjective in these cases where their testimony is bought and paid for. We have only to look at the wide-spread difference of opinion among doctors as to the effect of cigarette smoking to see that their testimony can sometimes be something less than truthful. Most doctors who are not in the pay of cigarette companies are convinced by all the scientific evidence on record that cigarettes undoubtedly contribute to lung cancer. But the doctors on the payrolls of the tobacco companies either deny that cigarettes contribute to lung cancer, or at best maintain that there is not yet enough proof.

As we contemplate these conflicting views among professional men—and as we thoughtfully study the reluctance of industry to be honest about this matter of occupational disease—we cannot help but wonder whether the lust for profits has made many men forget the real purpose of life. What is the real purpose of life? Is it production and profit—or the well-being of the individual? If there is conflict between the two, do we sacrifice production and profit or the well-being of the individual?

The ethical answer is obvious. But the practical methods of reaching the logical ethical conclusion are more difficult.

FEDERAL ACTS NEEDED

We could make a start by enacting comprehensive federal workmen's compensation and occupational disease legislation to take the place of the chaos that results from having 48 different state systems. But I have no hopes for such a constructive approach in the foreseeable future. I am afraid the insurance lobby, and the employer groups that profit from weak administration are too strong for us at this time. So we'll just have to make that one of our long range objectives.

But there are some things we can do right now. We can try to have programs set up in the National Institute of Health and in the Public Health Service which would recognize the importance of occupational disease—and which would put the research effort in this nation on a par with that of other civilized industrial nations.

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If we cannot get decent factory inspection from the state goverment, then we in the labor movement must resort to self-help. Many unions are thinking in terms of collective bargaining clauses which would require the employer to adopt the safety standards set by the American Standards Association as the minimum acceptable in the shop.

LABOR FIGHTS FOR SELF

We are also prepared to bargain *for* more supplemental injury benefits when the compensation provided by state laws is not adequate to sustain a worker and his family. Although our efforts will directly benefit only the 17 million organized workers, perhaps they will release new pressures that will eventually result in improved legislation benefiting all workers.

The American labor movement has but one purpose—one reason for existence in American life—to serve and protect American workers. There are times when we make ourselves pretty unpopular because we keep looking for the things that are wrong with American industry and American society.

I may have offended industry men with this indictment of the ethics and morals of our business community. But I would be derelict in my duty and false to my trust as an elected officer of one of America's greatest unions if I did not say frankly and candidly that we in the labor movement are not satisfied with present legislation relating to industrial health and safety, workmen's compensation and occupational diseases.

In a sense this is a great challenge to the National Safety Council—a challenge that can be met only if all facts are squarely faced. If we in the labor movement could count on your assistance in the fight for better legislation and more research on both the state and federal levels we might, together, make this a far happier, healthier and safer nation in which to live and work.

GOOD COMMUNICATIONS HELP SAFETY

by GEORGE SCRIVEN

public relations director, United Rubber, Cork, Linoleum & Plastic Workers of America, AFL-CIO, Akron, Ohio

Our organization has been safety minded for many years. The record on that score speaks for itself in a loud and clear manner. The results of our efforts, in cooperation with enlightened managements, tell the story of how we have seen the number of accidents reduced in the plants in which our members work. I shall not go into specific figures on frequency rates and such.

I don't suppose any of you would dispute the flat statement that good communications help safety. But I'd like to try and give you some of the techniques, the how and the why of that statement.

First, let's do a little word analyzing. I certainly don't want to sound like the pontifical professor lecturing his class on semantics. But when we say *good* in our topic, "Good Communications Help Safety," we immediately infer that there is another kind besides good. And there certainly is. I think there is a lot of bad and fuzzy communications going on in all fields.

Within the subject matter at hand, I would say the word *good* means that type which gets some concrete reaction and results. In the United Rubber Workers, we think our communications have been *good* because we have the results to show for it.

MUST HAVE RECEIVER

Now for the word *communications* in the phrase. You can't have communications—the *good* type that is—unless someone is sending the message and someone is receiving it. I was in the Air Force in World War II, and I served as a radio operator in the Pacific aboard a B-29 Superfortress. When I sent a message and no one received it, I didn't have communications. I was

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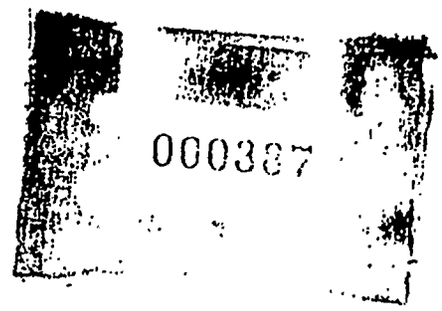
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Volume 1



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Transactions of the

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(October 21-25, 1957, Chicago, Ill.)

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LEARNING TO LIVE . . .

Learning to live—safely—was the drawing card which brought more than 13,000 men and women from the United States and 27 other countries to Chicago for the 45th National Safety Congress. These people gathered to exchange the latest ideas in safe attitudes, safe methods and safe equipment. Through speeches, panel discussions and symposiums, they acquired new ideas for helping others—and themselves—to live, work, and play safely.

This was the reason the National Safety Council was organized less than half a century ago, a time when man's thoughts barely kept pace with the industrial revolution. Since then, man has introduced an atomic age which is bringing the continents closer and has made the earth a smaller world. And now man anticipates inter-space travel!

Through science and technology, man is progressing to increasing speeds in travel and production, and increasing dangers—new dangers never before encountered. These, in addition to the everyday hazards of life, occupied the thoughts of the safety people at the Congress.

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THE CHEMICAL SECTION

This volume is a record of the sessions held at the 1957 National Safety Congress by the Chemical Section. The conduct of these Congress sessions each year is only one of the many cooperative activities which the Chemical Section carries on in behalf of its members, and for the benefit of accident prevention work in the chemical industry generally. The section gives guidance in the preparation of a great variety of technical and educational material useful in the day-to-day safety programs of chemical companies.

The activities of the section are under the direction of its executive committee, the members of which are listed at the close of this volume.

SAFETY IN HIGH PRESSURE CHEMICAL REACTIONS

by M. R. KINTER
assistant director, high pressure laboratory, The Dow Chemical co., Midland, Mich.

Before we can intelligently discuss the subject of high pressure, we must first define it. Any definition we propose will be arbitrary since it depends on your frame of reference. To a pipefitter, a 400 p.s.i. steam line may well be "high pressure." To the mechanic in an ammonia plant, the term may mean 5,000–10,000 p.s.i. The gunsmith will think of "high pressure" in terms of the breech pressures in a 30-06 rifle with a heavy powder load, which go to 50,000-55,000 p.s.i. For many purposes we might say that anything above 500 p.s.i. should be considered as high pressure.

However, when discussing this topic from the viewpoint of safety, we must remember that any amount of pressure may be hazardous. A few years ago an auto mechanic in our city suffered serious permanent injury when a new auto tire, which apparently was defective, ruptured while he was inflating it. A pressure of less than 30 p.s.i. was involved. The hazard attendant on working with liquids or gases under pressure is not strictly a function of the pressure alone, but is more properly considered in terms of the amount of stored energy involved.

A consequence of my last statement leads to another point we must always keep in mind. There may be hundreds, or even thousands of times more energy in a gas at a given pressure than in a liquid under the same conditions. We do not commonly think of hydraulic pressures of a few thousand p.s.i. as being particularly dangerous. However, a gas under the same conditions presents an entirely different situation.

I shall try to discuss the philosophy, principles, and pitfalls of working safely with high pressures. In doing this, I hope that we may come up with some ideas which may be of value to anyone working with high pressure, be it in a large elaborate, industrial high pressure laboratory, or in the limited facilities found in many schools or small companies.

Let us first briefly mention the principal hazards we find in high pressure work:

Projectiles—In event of an uncontrolled reaction or explosion, parts of ruptured vessels, gauges, or fittings may be propelled at high velocity from the equipment. Such missiles can easily kill a man.

"Secondary" Explosion—The sudden release of flammable gases into the cubicle or work area followed by ignition may result in a violent explosion. The shock wave from such detonation can result in serious damage to the cubicle and injury to personnel.

Toxic Materials—Failure of high pressure equipment may release substantial quantities of toxic gases—e.g., when working with carbon monoxide.

Fire—The failure of high pressure equipment or a burst frangible safety when working with flammable materials frequently results in fire. Although usually of short duration, these "blow-torch" type fires are often very intense.

The safety measures taken in high pressure work do not basically differ from good laboratory safety practices. However, the potential severity of the consequences of a given incident—e.g., rupture of a vessel at 50,000 p.s.i. compared to a crack in a glass flask—demand considerable extension and amplification of safety measures.

BASIC PRINCIPLES

Our first basic premise must be that all reactions under pressure are hazardous. Not that the types of experiments we may carry out are fundamentally any more unpredictable than most laboratory reactions, but we must consider the amount of energy stored. This emphasizes the importance of conducting unknown or exploratory experiments on a small scale.

In addition, a basic characteristic of high pressure vessels must be kept in mind. It is very easy to have a large safety factor in strength built into a small—say 500 ml. or less—pressure vessel. This however, becomes more and more difficult as size in-

creases, due to size and weight considerations.

Conduct all pressure experiments behind barricades, and base practices and procedures on the assumption that the experiments will get out of control. The barricade or cubicle may vary depending on the scale of operation. It is essential that the men never, except under extremely unusual circumstances, enter the cubicle while the system is under pressure.

Strict adherence to safety rules is essential and presents the usual problem of "familiarity breeds contempt." We have found no magical *solution* to this problem. I know of no other approach than repeated and repeated instruction and education of all people who have any contact with this type of work. Also, one must never assume that, because an experiment has been carried out many times without incident, it may then be regarded as *harmless*.

This calls to mind an accident resulting from just such a situation. The experiment, conducted at 500–1,000 p.s.i., had been run countless times in an open laboratory without barricades. One morning a technician unthinkingly changed the order of the application of heat and the addition of catalyst. The resulting explosion did extensive damage to the laboratory and, but for extremely good fortune, could have resulted in very serious injuries.

CUBICLE LAYOUT, BARRICADES

The purpose of a high pressure cubicle or cell is to protect operating personnel from injury as a result of a *mishap* with the experiment. This is best accomplished by directing flying fragments and the force of an explosion away from the workers rather than trying to confine them. There are many possible arrangements which may be used to accomplish this, but they all have one thing in common—at least one wall acts as a "blow-out wall."

Care should be taken in the installation of doors to be certain that they cannot blow out. When considering the labyrinth type entrance, the possibility of shock wave rebound should be kept in mind. Many instances of serious injury by a reflected shock wave are known.

The materials used for the construction of cubicles may vary, but steel plate or concrete are most common. A number of "sandwich" types may be used, e.g., a double steel plate wall filled with sand. This latter type presents some annoying problems if any new openings through the wall are to be made. We use steel walls for small-scale work and heavily reinforced concrete for large-scale experiments. Welded construction is much preferred with steel plate, because of the possibility of bolts being sheared by an explosion.

I know of a case in recent years in which extensive damage was done by flying half-inch bolts which were sheared by an explosion of a vessel in a bolted steel cubicle. They were propelled with sufficient force to penetrate a concrete block wall and would have easily killed a man. Metal cubicles may be lined with wood which will absorb much of the force of a high-velocity fragment and reduce the possibility of penetration of the metal plate.

ONE UNIT CUBICLE

One type of cubicle we use for small scale work is arranged so that the platform on which the equipment is mounted and the front wall of the cell are one integral unit. When the equipment is in place the cubicle cannot be entered, since the area behind it is restricted. This system is useful where frequent equipment changes are necessary. Transparent plastic sheet is used as a "blow-out wall" in these cubicles. It has the advantage of low cost and it admits additional light, thus making the area safer.

A concrete cubicle is used for larger-scale work. The walls and roof are 15-inch, heavily reinforced concrete. The observation windows are of two-inch laminated glass which is capable of withstanding a .38 caliber magnum shell at point-blank range. All lines and valve handles enter the cubicle through steel strips or sleeves mounted in the concrete.

The area behind our high pressure cubicles consists of a river and a large waste pond. We have no wall behind the area. Placing a large wall behind a high pressure area presents the problem of reflection of a shock wave, particularly from a secondary explosion of flammable material in the cubicle. Of course, it is not always possible to locate near a large, vacant area. The next best thing is a hill or slope of some sort. This will absorb any fragments and tend to dissipate the force of an explosion.

Good ventilation is important in a high pressure area. We recommend 10 to 20 complete air changes an hour. This is sufficient to remove any flammable or toxic materials which may be released through leaks, which are an everlasting problem in high pressure work. Rapid air flow through the cubicle may also prevent the detonation of a quantity of flammable material released by rupture of the equipment.

Such ventilation should be arranged to prevent the accumulation of heavier-than-air vapors on the floor of the cubicle. An added safety feature may be the use of automatic detecting and alarm devices for such materials as hydrogen cyanide, carbon monoxide, or hydrocarbons.

The use of systems to flood the cubicles with carbon dioxide are useful. Such installations vary from a simple manual arrangement to empty the contents of a large carbon dioxide cylinder into the cubicle quickly to an automatic system triggered by temperature sensitive elements. An installation of the latter type recently prevented extensive damage to pilot-scale equipment in our laboratory when several pounds of a pyrophoric material were suddenly released into the cubicle. The ensuing fire was so quickly and effectively snuffed out that the paint inside the cubicle was not even scorched. The hazards involved in working with purely hydraulic systems are much less than with gaseous systems. It is not uncommon to work at extremely high hydraulic pressures without any protection. I know of an instance in which this practice resulted in an unusual type of injury. The failure of a fitting in a high pressure system resulted in the release of an extremely high velocity jet of hydraulic fluid. The spray hit a worker in the face, penetrating the unbroken skin. The resulting injury was quite painful and was several months in healing. Therefore, some sort of shielding, even if quite light, should be used even with strictly liquid systems.

A high pressure system should never be operated without some sort of pressure relief mechanism. This usually is in the form of one or more frangible safety discs, depending on the number and location of pressure vessels. However, it is not sufficient to place frangibles in the system—there have been innumerable cases of vessel rupture in systems in which there were frangibles. Except for cases of an extremely violent detonation in a vessel, such failures can usually be laid to one of two causes.

In the case of a sudden pressure rise, the frangible safety cannot do its job if the vessel fails before the pressure surge reaches it. It is therefore essential to place the frangible as close as possible to the vessel, and to use as large a diameter frangible and connection to it as possible. We frequently conduct experiments with solids or liquids which can freeze, either of which can solidly plug a line.

EQUIPMENT

Thus, it is essential under such circumstances to arrange the equipment to minimize the possibility of such materials entering the safety assembly. Careful inspection of the safety assembly after each experiment is also necessary to be certain that it is clear.

A frangible safety assembly should be pointed in the direction of the "blow-out" panel and must be securely anchored. If it is deemed necessary to vent a frangible to the outside, this must be done through a large line with no bends. One should not attempt to use a frangible disc at an operating pressure which is close to its rated burst pressure, because of deviations of actual rupture pressure from rated pressure. Corrosion and fatigue of frangibles must also be kept in mind to prevent unexpected failure.

CONSTRUCTION MATERIALS

A few general comments concerning materials of construction may be in order at this point. First, I should like to consider the question of hardness or ductility of the metals used in the construction of such equipment. This is important when we call to mind the relatively smooth, tangential "tear" type ductile failure as opposed to the unpredictable, random shattering effect of the brittle failure. Ductile failures rarely yield any fragments, whereas a brittle failure may result in almost anything.

For this reason, hardening is a poor way to achieve strength in high pressure equipment. The most frequent occurrence of a

highly hardened component in high pressure equipment is the cap of the common, flat-gasket type high pressure reactor or "bomb." This is required for practical, structural reasons, but we attempt to avoid it by using other types of closures in all but small, medium-pressure vessels.

With this one exception, a minimum of 10 per cent elongation should be specified for materials used in the construction of high pressure equipment. When purchasing metal stock for this use it is wise to specify metal that is free of flaws or inclusions, and is warranted by x-ray or other suitable tests.

Before a vessel is placed in service it must be pressure tested, preferably to one and one-half times its maximum working pressure. A log sheet should thereafter be kept for each vessel so that a history of its service is available. Frequent inspection of each vessel and regular periodic pressure tests are required to avoid failure resulting from corrosion, small stress cracks, embrittlement, etc.

CONED CONNECTION

The common coned high pressure connection has frequently been a source of difficulty, most of which is easily avoidable with a little care and attention. The sealing surface is on the tapered end of the tubing, and the force is applied from the threaded gland via the collar on the tubing. First, the seating surfaces and threads should always be smooth, clean, and in good order. If not, they should be remachined or replaced as may be the case.

A common error in assembly of one of these connections is in not placing the collar the proper distance back on the tubing. If it is too far back a good seal can be made but all of the force is taken by only a portion of the threads of the gland, resulting in failure under pressure.

High pressure gauges present some problems, but a little thought when locating them will easily remedy this. Always use the solid front or "blow-out" back type of high pressure gauge and remove the glass face cover. A piece of plastic film may be placed over the front of the gauge to keep out dirt. Gauges should never be placed in such a position as to be directly in line with operating personnel, but are best located behind a barricade and observed with mirrors. They should not be used to more than 70 per cent of rating, and will last a lot longer and maintain accuracy better if used at only 50 per cent of rated pressure.

Gas storage or supply cylinders are rather "thin-skinned" and should not be located in an operating cubicle. In event of trouble, their presence can only add to the problem. The use of check valves in lines between vessels, reactors, supply cylinders, etc. adds greatly to the safety of the operation. These one-way valves prevent the possible backing up of a reactant or catalyst, which can have disastrous consequences.

However, a word of caution concerning the use of check valves! They are usually a spring-loaded ball valve and are easily fouled and rendered inoperative by small amounts of foreign material or dirt. Frequent inspection and testing of these devices is imperative, otherwise one may be led into a false sense of security.

In essence, the human side of safety reduces itself to one point—education. The problem becomes one of teaching men to understand their equipment and to think carefully before they act. For instance, one must somehow get across the idea that high pressure equipment, just because it looks rugged, does not require a strong arm and a long-handled wrench for assembly. Care, cleanliness, and a sawed-off open-end wrench will usually do a much more effective job on research scale equipment.

OPERATING PRACTICES

Points such as this must be emphasized, demonstrated, and then continually re-emphasized. We had a technician with whom we had to go so far as absolutely to forbid him to operate a high pressure valve with any more force than he could exert by holding the valve handle between his little finger and thumb. This may have been an extreme measure, but the man finally understood.

We use job description sheets, our accident prevention Key Point Cards and other means of discussion to review important points and hazards with the men. One must cultivate the idea that the safety practices are ground rules which are just not to be broken. In a large plant such as ours the men who come into the area from the shops and services department present a difficult problem. These people may be in the area only occasionally and for short periods of time.

They may have little knowledge of the equipment or work, and must be carefully instructed regarding safety practices which may be peculiar to high pressure work. This type of situation will vary with the particular installation and circumstances, but we should always keep in mind the uninformed "stranger" who has occasion to be in the area.

Clear thinking and attention to detail are essential in this type of work. Always be on guard for signs of trouble. For instance, when releasing the pressure from a system it is possible to detect an obstruction in the entry to a pressure vessel by observing such things as the rate of fall of pressure in the lines. Abnormal behavior in this respect is a sign of danger.

Observation of such signs may avert the disastrous consequences of opening a supposedly vented vessel while it is still under full pressure. Men must learn to detect plugged lines, leaks, etc. by these subtle signs and to deal with them safely.

The same philosophy applies to disassembly and maintenance work on such equipment. Each line and vessel must be treated as though it is a loaded gun until you are absolutely certain about it.

High pressure work may be done safely if we use clear, critical thinking and careful planning. We cannot afford to be hasty, to disregard safety practices "just this one time" or to let our guard down in any other way. This applies to all types of high pressure work, be it large or small, simple or elaborate.

Even if the installation is small and funds are limited, it is still possible to keep this basic philosophy and conduct the work in a safe manner. In that respect, safety is like happiness—it is the man that counts and money just cannot buy it.

CONTROLLING HEALTH HAZARDS IN A CHEMICAL PLANT

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Hazards that are likely to be present in a chemical plant are:

1. Ordinary mechanical hazards
—accidental injuries (falls, dislocations, sprains, fractures, contusions, lacerations, thermal and chemical burns, foreign bodies in eye or skin)
—in association with mechanical equipment, noise, vibration, fires, explosion, flying particles or missiles, slippery floors, rigging, stairs, ladders, elevators, vehicles

2. Modern physical hazards
—ultraviolet and infra red radiation; ultrasonics, high frequency waves; X-ray, radium, other alpha, beta or gamma radiation

3. Chemical hazards
—old and well known (but not fully controlled) chemicals
—new products of research and development (often unexplored)
—exposure in course of research on new products
—pilot plant development of new products or processes
—new manufacturing processes involving new ways of handling well-known chemicals or new chemicals.
(1) locus of hazards—aspect of portal of entry—local effects, such as contact with skin, dermatitis—sensitization, gross injury to skin, skin cancer, or inhalation of gases, vapors,

mists, fumes, dusts. Also asphyxiation, irritation of lungs—acute (edema, pneumonitis), irritation of lungs—chronic, pneumoconiosis, fibrosis, emphysema, and granuloma (Be). In addition cancer of lung, deposition—radition within lung and hilar lymph nodes; specific carcinogenic agents are hazards. Ingestion of chemicals, following upper-respiratory trapping of dusts, following contamination of hands and handling things that go into mouth and following contamination of food stored in work rooms—eaten in dirty lunch rooms are potential dangers.

(2) nature of hazard—aspect of absorption—systemic effects such as: acute intoxication, percutaneous, respiratory, alimentary absorption (often two or all three combined); chronic intoxication—remote enzymatic or metabolic effects and organic damage; or remote radiation effects following absorption and distribution of radioactive materials in body—example—bone and marrow, following absorption, distribution and metabolism of specific carcinogins—example—bladder tumor.

RECOGNITION AND IDENTIFICATION OF HAZARDS

1. Toxicologic investigation (in laboratory) (stepwise with progress of research and development in industry)
   (a) screening—preliminary choice or elimination of materials under consideration—
   —immediate toxicity—indicative of type of control measures based on portal of entry (type and point of application of preventive procedure) (degree of precision required in protection, i. e. extent of apparent danger) (medical criteria—type of anticipated injury or disease)
   (b) Comprehensive—(adapted to the problems to be met)
   —manufacturing hazards
   —hazards of transportation and use as raw materials by others
   —hazards of consumer of final product
   —cumulative effects if any
   —metabolic fate in body—remote effects—long-term—chronic—injurious effects
   —diagnostic and prognostic procedures based on results of investigation
2. Toxicologic investigation—(in plant) clinical investigation of personnel
   —basis of all specifications for safe environment
   —sometimes the only basis for recognition of hazard, e. g. beryllium, occupational cancer

CONTROL OF HAZARDS

1. Medical measures of control—environmental—(operations, plant conditions and (how men work)
   —clinical examination—all types.
   —policing the plant—(clinical findings and tests on personnel)
   —identification and quantitation of responses to observed exposure—within physiological (tolerable) limits—beyond physiological limits
   —warning of need for further protection
   —disposition of personnel with respect to exposure restriction of time (duration) of exposure—removal from exposure—temporary or permanent
   —personal protective equipment (choice and supervision, physiological criteria) adequacy of equipment employed—adequacy of its maintenance—adequacy of its use
   —education, group meetings, written instructions, hygienic manual, combined with operating manual
   —reports to engineering personnel (in both operations and industrial hygiene) and to management
2. Engineering measures of control
   —designing and applying measures of control—physical devices for protection against chemicals—plant design—operations design—ventilating design
   —policing the plant (environmental monitoring) inspection—critique of maintenance operations—analysis of materials—air analyses.
   —personal protective equipment (choice and supervision—engineering criteria)
   —reports to medical personnel, and management (directly or through physician)

3. Administrative measures of control
   —appropriate organization of hygienic facility in relation to operations
   —appropriate budgetary provision for hygienic effort

Adequate control depends upon the complete understanding of the hazard through physiologic and toxicologic research.

In addition, satisfactory team work includes:

1. Physician (including nurse and technicians) measures applied to personnel measures to be applied to environment (hygienic specifications)
2. Engineer (including chemist, physicist and technicians) measures to be applied to environment (hygienic technologic applications)
3. Management
   proper organization
   proper financial implementation▲

LIVING IN THE AIR WE BREATHE

by H. H. FAWCETT

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Living in the air we breathe has been a problem since God created man from dust and then breathed into him the breath of life! But even today, the vital role of breathing in our daily life has not been completely appreciated. This paper reviews briefly (1) air contaminants, and (2) commercially available respiratory protective devices, with emphasis on their limitations, and on the training and maintenance necessary for safe and effective use.

Each of us is a creature of habits, but none of our habits is more vital to life than is breathing. So automatic and effortless is this habit that we give almost no thought to our respiration, although most of us cannot live without air for more than five minutes. From the second of our birth when we descend from in utero (where the oxygen partial pressure corresponds to 33,000 feet altitude) into a world with a mixture of gases called air, we must breathe several quarts of air each minute so our body cells can exist, grow, and perform their functions.

For an average lifetime of 70 years, we may breathe in excess of a half billion times. By contrast, we consume "three square meals" and "six glasses of water" daily. Our air requirements which we obtain virtually without effort are of greater significance by any standards than water, food, clothing, and shelter, which demand much "day-by-day" thought and deliberate action to obtain.

We live at the bottom of an ocean of air called the atmosphere, a name given to a mixture of several gases which consist mainly of four-fifths nitrogen and one-fifth oxygen. Virtually limitless in volume and mass as we view it from the ground, it thins out into space. Half of its density is under 18,000 feet. In a multitude of ways the air assists all living things to exist.

FUNCTIONS OF AIR

Besides providing oxygen for breathing-oxygen which lungs transfer to the blood—air conveys both sound and light, absorbs heat, enables fires to burn, propels boats, turns windmills, makes possible air brakes, vacuum cleaners, and other useful machines. Air in motion forms winds which modify climate, equalize heat and cold, and distribute rainfall. Rivers high in the air, such as the jet stream, greatly influence weather and are an increasingly important factor as airplanes travel at higher altitudes. The ancient Greeks ranked air with earth, fire and water as one of the four fundamental elements.

Since each of us has been breathing several times each minute from our birth, respiratory protection and devices to aid or supplement breathing might seem unnecessary. If pure air were truly ubiquitous, and no harmful gases, vapors or dusts existed,

breathing problems would be confined to underwater or to travel in high altitudes. Unfortunately, pure air is a relatively rare commodity, and is much harder to obtain pure than many chemical elements and compounds.

Some variations of the air are caused by natural forces (such as moisture from rain or dust from winds on dry earth), while some are due to man (such as combustion products, unburned or incompletely burned fuels, solvents, vapors, dusts, fumes, inert and toxic gases). When these variations are small, we say that the air is "pure," but when the variations, either alone or in combination, exceed our ability to adapt to them, or our ability to tolerate them, we say the air is "bad."

AIR POLLUTION

No simple yardstick has yet been devised to tell us when air ceases to be "pure," although numerous air pollution studies are underway, and *threshold limit values* (maximum allowable concentrations for industrial exposures) are available as a guide. We have just begun to realize that air pollution control may be even more important than stream pollution control. When extreme conditions exist, as in London, Meuse, Donora or Los Angeles, we know that human life is more difficult than other times when smog is not present.

On a minor scale, every year a serious problem exists from dust or pollen (such as rose fever, hay fever, or ragweed fever) for allergic persons, and we have found that respirators are frequently considered a a welcome supplement to medication for the relief of such conditions.

Most breathing air supply problems can be controlled with adequate ventilation. If air could be *properly* treated to remove particulate matter, noxious vapors, and toxic gases, heated or cooled, and then distributed as required, breathing can be reduced to a minor problem insofar as purity of air is concerned. Unfortunately, adequate ventilation and air treatment is sometimes impossible or impractical where emergency action must be taken to preserve life and property.

Therefore, we must provide man with respiratory protection if we expect him to survive. A glance at the case histories of incidents collected at *random* from many sources and appended to this paper shows that respiratory problems have occurred in many diverse activities. Specialized knowledge and action in advance is essential if such injuries are to be prevented.

It is sometimes glamorous or unusual incidents which produce serious results; failure of a pressure system in an airplane at high altitudes will cause blackouts in seconds; above 43,000 feet, even breathing pure oxygen is not adequate— a pressure suit or a pressurized cabin is essential. On the other hand, no less serious are the problems when commonplace materials, such as a few sausages overheating and burning on a frying pan on a kitchen range produced sufficient smoke and toxic gases to overcome the occupants: firemen required respiratory protective apparatus to effect a rescue of the unconscious victims.

Gases and smokes resulting from fires have been studied for years, and excellent reports are available, but it is impossible to predict what gases may be encountered or in what concentrations in a given fire. A large number of different flammable chemical compositions or chemical combinations that change with heat, such as plastics, fabrics, insulation, refrigerants, solvents, paints, insecticides and building materials, play important roles in our daily lives.

VARIETY OF GASES IN FIRES

In addition to carbon monoxide, carbon dioxide, and water (present in nearly all fires), one may expect ammonia from burning wool, cyanogen from burning silk, acrolein from burning fats, sulfur-containing gases from burning rubber and leather, and chlorine-containing gases from burning or smouldering chlorinated plastics. From piled newspapers smouldering in limited oxygen, 41 per cent of the total gases given off was found to be carbon monoxide, and 43 per cent was carbon dioxide.

A pile of newspapers in a large open hallway would give an entirely different concentration of carbon monoxide and carbon dioxide within the breathing zone than the same pile burning in a small enclosed basement. Determinations ranging from two per cent to four per cent carbon monoxide have been made using recognized CO detectors in the smoke of building fires in the same room in which firemen were engaged in extinguishment, by a medical doctor wearing self-contained breathing apparatus. A vigorous movement is now underway to encourage fire and other rescue services to use adequate respiratory protection more effectively.

AIR CONTAMINANTS

The conventional classification of air contaminants follows:

A. Aerosols (dispersoids) (particulate contaminants)—dusts, fumes and mists.

A better classification of aerosols is based on physiological effects:

A. Nuisance and Inert: produce no known injuries: calcium carbonate, magnesium carbonate, gypsum

B. Inert pulmonary reactions: produce *non-specific pulmonary reactions*: silicates, carbon, aluminum

C. Minimal pulmonary fibrosis-producing barium compounds, tin, iron oxides

D. Extensive pulmonary fibrous-producing silica, asbestos

E. Chemical Irritants: produce inflammation or ulceration alkaline reactions: acids, fluorides, chromates

F. Toxic systemic poisons: produce pathological reactions: lead, manganese, antimony, arsenic (not more toxic than Pb), arsenates, organic-phosphates, cadmium, radioactive, beryllium (more toxic than lead)

G. Allergic manifestations: produce allergic reactions: pollens.

H. Fever-producing reaction: action unknown or allergen: metal fumes, certain textile dust, (hemp, cotton, jute, bagasse)

A. *AEROSOLS*

Formerly called dispersoids or particulate contaminants, these are substances present in the air as minute particles (such as dusts), as fumes (such as metal fumes), or as mists (such as chromic-acid mists). In grouping these together, it is recognized that they may be physically filtered, screened, or adsorbed from the air with properly designed filters. Aerosols may range in size from 150 microns to a thousandth of a micron in size (1 micron equals 39.37 millionths of an inch or 1 x 10-4 centimeter). Many dusts are also fire and explosion hazards.

Pneumonokonioses (Greek for lung dust) or pneumoconioses are a group of lung conditions which result from the inhalation of dust. Silicosis is one of the most common types of pneumoconiosis, and is caused by the inhalation of "free" or "uncombined" silica, such as quartz, opal flint and cristobalite. Many other dusts may produce lung involvement such as asbestos, talc, the silicates, carbon, iron and barium.

Other dusts cause chemical irritation, such as the acids, alkali substances, fluorides and chromates. Allergic reactions may be caused by common dusts such as pollens, synthetic resins, plastics, felt, fur, gums, spices, tobacco, paper, rubber, wood, starch, flour, and wool. The Bureau of Mines groups all the above dusts as "Pneumoconiosis-Producing and Nuisance Dusts."

TOXIC DUSTS

Another classification of dusts refers to "Toxic Dusts." Some have a lower threshold limit or maximum allowable concentration than does lead, although the Bureau of Mines classification uses lead as a reference. Among aerosols more toxic than lead are: cadmium oxide fume, chromic acid and chromates, mercury, mercury (organic), yellow phosphorus, picric acid, selenium, tellurium, calcium arsenate.

Respirators approved for all the above dusts (both toxic and pneumoconiosis-producing and nuisance dusts) are called "*dust*" respirators. A few substances, such as beryllium and radioactive substances, are not currently covered by Bureau of Mines schedules.

"Fumes" include aerosols formed by the condensation of vapors from heated metals. Melting, cutting, and welding of zinc, lead, cadmium and other metals produce such fumes.

"Mists" and "Sprays" include liquid droplets formed when liquids are carried into the air or are formed by a reaction with the moisture in the air. An interesting example is 0.3 parts per million sulfur dioxide, with sunlight, forms 20,000 particles per c.c. of sulfuric acid mist.

The availability of filters with pore sizes from 10 millimicrons (approximately the size of the polio virus) to five microns (the size of common contaminants in liquids) has greatly improved and speeded up analyses

of aerosols such as acid mists, metal fumes, smokes, and radioactivity.

In recent years, study and measurements of even smaller particles in air than previously observed, known as condensation nuclei, have contributed greatly to our understanding of the nature and number of particles in air. The particles in the air on which water will condense are called condensation nuclei; under natural conditions only the larger particles are so effective. When the air is sufficiently super-saturated apparently any particle will serve as a condensation center.

Particles from such diverse substances as platinum, silver, stearic acid, glycerin and lubricating oil will all form droplets at a sufficiently high supersaturation of water vapor. Practical methods are now available to measure the number of particles in an aerosol in free air. A wider use of the technique already available for size and numbers of an aerosol would not only throw light on some of the problems of air pollution but would certainly lead to further improvements in our knowledge of aerosols.

Respirators for insecticides are tested and listed by the U. S. Department of Agriculture.

B. *GASES AND VAPORS*

In this major group may be included most of the air contaminants which are not classified as aerosols.

1. *Irritant gases* are those which produce inflammation of tissue, such as the skin, the eyes, and the respiratory tract membranes. They are divided into two general groups:

a. action is limited to irration (such as hydrogen choride)

b. action extends to systemic effect (such as oxides of nitrogen)

Some of these gases and vapors have pronounced odors, but the nose cannot be depended upon as a reliable method of estimating concentrations.

2. *Asphyxiants* are substances which deprive the body tissues of oxygen, causing hypoxia (oxygen starvation). Two general methods of action are known: *simple* asphyxiants (such as nitrogen, hydrogen, helium, and methane), which dilute or replace the oxygen partial pressure in air; and chemical asphyxiants (such as carbon monoxide, hydrogen cyanide, hydrogen sulfide, acetonitrile, aromatic nitro and amino compounds like aniline, nitrobenzene and derivatives), which combine with the hemoglobin of the blood to prevent oxygen-carbon dioxide exchange.

The insidious nature of the action of the simple asphyxiants, and the speed with which they can act, is still not widely appreciated; whereas most people have a healthy respect for the chemical asphyxiants. Under proper medical supervision, pure nitrogen may be breathed for several seconds and this technique has been used clinically by Himwich and others. However, nitrogen and the other simple asphyxiants give almost no warning between the time breathing air is replaced with the asphyxiant and unconsciousness overtakes the subject.

PHYSICAL REACTIONS

A loss of mental facilities begins within a few seconds, and unconsciousness may occur shortly after with no warning. The brain is the first organ of the body to be affected seriously by oxygen want, and the subject "blacks out" quickly. Mention is made of this little-appreciated phenomenon not only because asphyxiants can be released in a room or tank with inadequate warning from the action of a fixed carbon dioxide fire extinguishing system, from a large spill of liquid nitrogen, from a leaking gas system, from an inert-gas producer, or from a leaking cylinder, but also because airline-supplied respirators, hoods and suits are frequently attached to a plant air supply with little appreciation of the hazard.

For example, at the Acids and Heavy Chemicals sub-section meeting, Chemical section, National Safety Council, October 25, 1956, no company present reported use of a special air system for respiratory equipment. If a cross-connection should occur anywhere in the air system which would permit an asphyxiant, toxic, or flammable gas to enter the air used for breathing, the results can easily and rapidly be fatal.

Oxygen, used indiscriminately, may also be a hazard, since serious fires have been reported where oxygen, either from a cylinder or an airline, or a leaking hose or pipe, was used for breathing purposes in an airline respirator or hood where welding or other flames were involved. Only a completely separate air supply, supplied by a compressor which cannot evolve carbon monoxide, carbon dioxide, oil mist or other unwanted impurities or from cylinders of tested known purity should be used for airline respirators, hoods or suits. In any event, regardless of supply, the system should include pressure relief valves, filters and absorbents as recommended.

2. *Anaesthetics* are gases and vapors whose action is primarily by inducing the symptoms of anaesthesia when inhaled in sufficient quantities. These include the substances which come to mind when the word "anaesthetics" is mentioned, such as the ethers, chloroform, methyl chloroform (1,1,1-trichloroethane), trichloroethylene, ethylene oxide and nitrous oxide (laughing gas), as well as hydrocarbons, aldehydes, ketones, other halogenated hydrocarbons, the aromatic hydrocarbons, alcohols, esters, and carbon disulfide.

DECOMPOSITION OCCURS

In addition to the physiological action of these materials alone and in combination, decomposition products are produced in a fire or when they are otherwise subjected to heat. Even relatively harmless substances such as the Freons and the Genetrons, (widely used as non-flammable refrigerants of low toxicity, as replacements for ammonia, sulfur and ethane), will evolve toxic decomposition products if they are heated above their decomposition temperatures. This has occurred where Freons and Genetrons were used as cleaning solvents.

Metal parts, after cleaning, were heated above the safe limits in order to dry and flash off the remaining solvent. Several persons were hospitalized with pulmonary congestion. Trichloroethylene degreasers, properly installed, maintained and operated, are safe, yet the failure or misuse of these vapor degreasers has created serious hazards including both fires and toxicity.

Mass hysteria and unconsciousness due to the little-appreciated anaesthetic action of the trichloroethylene has occurred in seconds; in one incident 72 persons were overcome, and in another, 26. Fortunately, all recovered after removal to fresh air and oxygen inhalation. The hazards of carbon tetrachloride mixtures in fire fighting and in other applications are well documented.

4. *Substances producing other effects*—This classification includes several substances whose action differ from previously-mentioned substances. Included in this group are mercury, white phosphorus, tetraethyl-lead, nickel carbonyl, arsine, the boron hydrides, phosphine, hydrogen sulfide, and the widely-publicized military "nerve gases." The initial action of these gases and vapors is primarily on the nervous system, with respiratory arrest following.

CONTAMINANTS COMBINE

If the above classifications appear complicated, it must be remembered that these air contaminants seldom occur alone, and that even less is known about the combined action of two or more substances, especially if they are in different groups, than of the individual substances. Even if particles in the air are non-toxic in themselves, they are known to act as carriers of condensable toxic vapors—formaldehyde can have its toxicity increased five times by the presence of an aerosol.

It is little wonder, then, that respiratory protection can become a highly complicated subject, and that the practical application of respirators, gas masks, and self-contained breathing apparatus (all with their limitations), even by persons thoroughly trained in their use, is not cut-and-dried or foolproof.

Relatively untrained persons in an emergency situation, are in especially vulnerable positions. Many of the case histories attached to this paper clearly point to the need for more widespread appreciation of the nature of the hazard, as well as of the limits of the various respiratory protective equipment used.

RESPIRATORY PROTECTIVE DEVICES

A. *AIR-PURIFYING RESPIRATORS*

The fundamental limitations of any air purifying device are that the air must be within the limits for which the respirator was designed (for example, the oxygen content must be more than 16 per cent); the particular unit will only protect against the specific substance or combinations for which it was designed, (for example, aerosol [dispersoid] [filter type] respirators will give no protection against gases and vapors); and the canister or filter must be

maintained in proper working condition (on a properly maintained facepiece that fits snugly enough to exclude leakage).

Aerosol (filter type) respirators require frequent changes in filters when breathing resistance becomes uncomfortable when used where excessive dust or fumes are involved. Chemical cartridge respirators will safely protect only against the specific vapors and gases in non-emergency situations where no more than 0.1 per cent is encountered.

Extremely toxic materials, such as acrolein, acrylonitrile, aniline, dimethylaniline, arsine, bromine, carbon disulfide, carbon monoxide, dimethylsulfate, hydrogen cyanide, hydrogen fluoride, hydrogen selenide, hydrogen sulfide, iodine, methyl bromide, methyl chloride, nickel and iron carbonyl, nitrobenzene, nitroglycerine, nitromethane, oxides of nitrogen, ozone, phosgene, phosphine, phosphorus, trichloride, stibine, sulfur chloride, the boron hydrides and others are too toxic even in low concentrations for reliance to be placed on simple cartridge type respirators.

NOT FOR ODORLESS GASES

Chemical cartridge respirators should not be used against gases which are odorless or whose odor threshold is high, since the only warning of failure of the respirator or of concentrations which are above the ability of the respirator is odor. Methyl chloride is an example of such a gas whose warning properties are too slight for practical purposes. Substances which are highly irritating to the eyes, such as sulfur dioxide, require eye protection (such as a gastight goggle, an air-supplied hood, or a full-facepiece).

Several lacrimatory (tear-producing) substances, such as benzyl chloride, are in the same classification, and a respirator alone is clearly inadequate. Some substances, such as carbon monoxide, cannot be stopped by a chemical cartridge (except by the Hopcalite in the Type N universal gas mask and in the miner's pocket self-rescuer). Ammonia cartridge respirators will protect against ammonia up to 1,000 p.p.m., while eye irritation from ammonia begins at about 700 p.p.m.

Mercury cartridge respirators are effective against concentrations of mercury vapor normally encountered at ambient temperatures, but service life is proportionately reduced where higher concentrations of mercury from elevated temperatures and pressures are present. (There is no Bureau of Mines approval schedule for mercury respirators). Combination cartridges have the limitation of a shorter service life when used with one particular type of hazard than the equivalent specific single-purpose canister would have for the same hazard.

FACEPIECE TYPES

Normally, respirators use a "half-mask" facepiece, covering the nose and mouth, while gas masks use both full-masks and full facepieces. (Only full facepieces on gas masks are approved by the Bureau of Mines). Recently, the "self-rescue" or "pocket" respirator, normally used with a cartridge containing Hopcalite with a dryer and designed for escape from mines, has been extended into other cartridges.

The mouthpiece of this style respirator is held tightly by the front teeth of the wearer, and the breathing is accomplished through the mouth. A nose clamp blocks off the openings of the nostrils, and prevents irritation of the membranes of the nose. A neckband permits the respirator to be worn ready for instant use. Twelve different filter cartridges will fit the basic holder and mouthpiece.

Industrial canister-type gas masks, with canisters designed for specific substances or combinations, have the same limitations in general as chemical cartridge respirators, except they are effective in concentrations of any specific gas or members of the same group of gases for which they are designed of not more than two per cent in air or a two per cent total for a mixture of gases for which the canister is designed.

The ammonia canister is approved for three per cent ammonia. For shorter periods of time, industrial canister-type gas masks can be used in higher concentrations, but the time of service life will be reduced. Depending on the size of the canister, and the service for which it was designed, the service time varies.

Protection for a combination of various gases, such as acid gases, organic vapors, and ammonia can all be obtained in one canister, but the service life of such a combination is shorter in the combined canister when used with one specific substance, than is the life of an equivalent canister designed for specific substance alone. The only warning that a canister or cartridge is "exhausted" is the detection of odor of vapor or gas passing through the canister or cartridge.

Persons who need corrective lenses in order to work properly when wearing the respiratory protection, especially full facepieces, may find of interest two methods of incorporating lenses inside a facepiece. One method consists of wire frames which fit around the circumference of the sight lenses, and hold a 50-mm round prescription lens.

PRESCRIPTIONS IN FACEPIECES

A second method consists of a center post built inside the mask, onto which can be attached 40mm rimless glasses. Such arrangements seldom allow perfect alignment of the prescription lenses to the viewer's eyes, but, with adjustment, a sufficiently accurate fitting can be achieved for most purposes for reasonably long periods of time.

The type N universal gas mask canister is constructed of several layers including activated carbon (to remove organic vapors), soda lime (to remove acid gases and carbon dioxide), copper sulfate (to protect against ammonia gas), silica gel and other dryers (to remove moisture both before and after the Hopcalite), and Hopcalite itself (a mixture of metallic oxides which catalyzes the conversion of carbon monoxide to carbon dioxide), plus a filter for smokes.

This canister can be used as protection against smoke and gases which do not exceed two per cent by volume total, where adequate amounts of oxygen are present. Sixteen per cent oxygen is cited as the practical minimum, but life is not actually in danger until about 14 per cent or less oxygen is present. A timer is used to count the number of inhalations, and indicates about two hours total use.

DISPOSE OF CANISTERS

A canister should be discarded at least as soon as the timer indicates the pointer has completed one revolution, if not sooner. One authority recommends that universal canisters be weighed immediately on receipt from the manufacturer, and that they be discarded as soon as they have gained 45 grams. This 45 grams limit was imposed since it represents the limit of the dryers to keep the Hopcalite dry, and also to prevent excessive breathing resistance from developing as the dryer becomes moist.

The shelf-life of the universal canister, once the canister has been attached to the facepiece is one year, if stored with the bottom seal in place, even though the mask has not been used. If stored with both top and bottom seals unopened, as received from the manufacturer, the shelf-life is considered by some to be four, and by others, five years.

With an respirator or gas mask, the problem of proper fitting of the facepiece is critical. In addition to the time honored technique of holding the hand over the opening in the bottom of the canister while inhaling gently to see that the facepiece will collapse on the face, another technique recently suggested by the A.E.C. is to use isoamyl acetate.

Since isoamyl acetate (which smells similar to bananas) can be detected in a concentration of as low as one part per million, a small leak will be detected if the acetate is placed on cotton and the cotton passed slowly around the edges of the mask without touching either the wearer's face or the mask. If the wearer can detect the odor, a leak is indicated and the mask should be further adjusted until the odor can no longer be detected.

CIVIL DEFENSE MASKS

As part of its chemical warfare defense program, the Federal Civil Defense Administration is stockpiling a mask designated as CD V-800 organizational mask for use by civil defense personnel. The canister on this chin-style mask is the same as used in the U. S. Army Assault Mask. This mask is reported to give "excellent protection against CW (Chemical Warfare) and BW (Biological Warfare) agents, as well as against the inhalation of radiological particles, or CBR (chemical, biological and radiological)".

Designed to be used in conjunction with a detection kit, CD V-810, which will detect and distinguish between the nerve gases and the mustard gases, the V-800 mask is a specific mask for war gases (including nerve gases) and will not protect against carbon monoxide, ammonia and other gases. The Army Chemical Corps recently an-

nounced a new E-13 mask for troops. It is designed to give the soldier complete protection against the inhalation of war gases, germ warfare agents and airborne radioactive fallout particles, but does not protect against direct radiation.

The new mask does not have the protruding canister used in current masks. This was made possible through development by the Chemical Corps of a new light-weight, pliable gas-aerosol filter material. Pads of this material are enclosed within cavities molded into the rubber facepiece of the mask. Lower breathing resistance, superior vision, better speech transmission, and greater comfort are claimed.

It should be noted that the CD V-800, the existing and the new Army gas masks should be used for purposes for which they were designed only. After both World War I and II, several instances were reported where "surplus" Army masks were used for protection against gases for which they were not designed, with serious consequences. It is important that gas masks are not misused.

B. *AIR-SUPPLIED RESPIRATORS*

Since the simplest solution to all respiratory problems is to supply pure air to the breather, the use of an air supply from some remote source where the air is not contaminated is both simple and logical. For many applications, air-supplied equipment has real advantages, but this equipment is subject to definite limitations. The simplest type is the Bureau of Mines Type B hose mask, which is a facepiece to which is attached a hose without a blower which must extend to a respirable source of air. This mask depends on the breathing action of the wearer to move the air. For this reason, a maximum hose length of 75 feet has been established for the hose mask without blower.

Low pressure blowers, operated either by hand or by power (power blowers do not carry Bureau of Mines approval) are used to supply Bureau of Mines Type A hose masks up to 150 feet. All hoses should originate at the blower.

A respirable source of air must be assured, and a safety man must be present at the blower at all times. Fouling of the hose may cut off the air supply, and the exit route must be the same as the entrance route. These hose masks can be used safely only if the above precautions are observed.

Airline-supplied Bureau of Mines Type C respirators are divided into two classes: (a) the continuous flow type and (b) the demand or intermittant demand flow type; (a) is usually used with a powered compressor or blower, while (b) is usually used with breathing air supplied from cylinders. The use of such equipment in atmospheres immediately hazardous to life is not recommended since failure of the air supply or fouling of the hose would be serious, and further, it is absolutely necessary to have respirable air of unquestioned quality.

We have previously noted the hazard of using a plant air supply for air-supplied breathing equipment. It is recommended that a separate air system be used exclusively for breathing air. Depending on the pressure available and the diameter of the hose, there is a limit to the length of hose which is practical.

Wherever possible, such systems should be piped as close to the outlet as possible, so possibility of fouling of the hose and cutting off the air supply will be minimized. Exit from areas where air-line respirators are used must, of course, be the same as the route in. If a compressor or tank supply is used, sufficient pressure relief control must be available to protect the wearer against pressure in excess of that prescribed for the equipment.

AIR-INFLATED SUITS

Air helmets, air hoods, and air-supplied suits have the same general limitations as for air-line respirators. An interesting development in this field is the use of air-inflated suits for protection of the whole body against hazardous materials.

In one form, the large impervious plastic tunnel or pipe allows a man to work in one room while using air from another—the slight air pressure supplied giving both breathing air and inflation (or body) to the suit. The front of the suit is tailored into a facepiece, and arms with gloves are attached. Mobility is reported good within the obvious limits imposed by the length of the tunnel attached.

In another form, a complete suit with built-in arms and legs is supplied with air for inflation and a hood, also air supplied, is used for head, face and respiratory protection. Depending on the particular fabric, plastic, or composition used in its construction, this suit allows work inside tanks, reaction vessels and other confined space which still contain a hazardous atmosphere.

Properly used, together with safeguards to insure that the wearer's air supply and lifeline are always in proper position and working order, this suit has increased safety and decreased operating costs in maintenance work inside tanks containing materials which are corrosive or are easily absorbed through the skin such as aromatic amino and nitro compounds. The same limitations noted above for air-line respirators should be noted.

Regardless of the type "respirator" used, a definite program of control is necessary to insure the device is used properly, is properly maintained, and that it is doing what is expected of it. After the Canadian Chalk River atomic reactor incident, respirators were used to prevent inhalation of radioactive contaminants. This program was successful only after a respirator official was appointed to control the use and maintenance of respirators, regular urine-samples were analyzed to show definitely the degree of absorption, and an improved respirator was made available.

C. *SELF-CONTAINED BREATHING APPARATUS*

Self-contained breathing apparatus supply complete respiratory protection in any concentration of toxic gases and under any oxygen deficient atmosphere. However, certain gases and vapor will cause systemic poisoning by skin absorption. Although a small group, these exceptions are highly important, including hydrogen cyanide, nitro and amino aromatic compounds, ethylene imine, phenols and a few others. These gases and vapors require complete skin protection of an impervious type in addition to respiratory protection.

EARLY REBREATHING APPARATUS

The early self-contained rebreathing apparatus, which was imported from Europe, had serious deficiencies. Loss of life was reported by users in this country; 19 accidents are reported involving 26 facilities between 1911 and 1940, due partly to equipment failure and partly to improper use. Where life-lines and standby rescue squads were employed, the apparatus was generally satisfactory in the hands of well-trained users.

The first self-contained breathing apparatus to be approved by the U. S. Bureau of Mines was of the two-hour rebreathing type.

The oxygen rebreathing type apparatus is relatively heavy (39# for the two-hour type) and is bulky. Most self-contained (closed circuit) oxygen breathing apparatus in use today require mouth breathing with a nose clip, but a full facepiece has recently been approved. Careful training is required in use and in maintenance of this apparatus. A minimum of 20 hours initial training is recommended by the Bureau of Mines.

RESTRICTS MOVEMENT

Demand-type air and demand-type oxygen breathing apparatus is available in half-hour, quarter-hour and 7½ minute ratings. Only the half-hour demand apparatus is Bureau of Mines approved; the Bureau has no approval schedule at present for any self-contained apparatus of less than a half-hour. Although the schedule of work on which the Bureau's half-hour rating is exhausting, large men under extreme stress have exhausted a half-hour (40 cu. ft.) cylinder in significantly less than a half-hour.

Differing only in whether it is supplied with compressed oxygen or compressed air, the apparatus weighs nearly 30 pounds for the half-hour type, with the large cylinder (40 cubic feet) on the back. It is relatively awkward to put on and it restricts action in confined spaces. With practice, it may be put on and into operation from a mounted backboard in less than 20 seconds.

The back position of the cylinder makes it difficult to crawl under equipment. Climbing in and out of small openings, such as manholes, requires care when wearing this type apparatus. Operation of a motor vehicle is awkward when wearing a cylinder on the back. (15-minute and 7½-minute demand apparatus use smaller cylinders slung on the side of the wearer, which overcomes this objection to some extent.)

The purity of the air or oxygen with which the cylinder has been charged should always be questioned since other gases such

as nitrogen, acetylene and carbon dioxide and gas mixtures other than air have actually been found in "breathing air" cylinders. Errors in compressed air used for breathing may be rapidly fatal, and every newly-filled cylinder should be checked to insure it actually contains "breathing air," regardless of the source of supply.

Unless the user has his own compressor producing air of an unquestioned purity, no cylinder should be put on a demand breathing apparatus or air-supplied respirator, hood or suit until the contents have been checked for purity. The Orsat gas analyzer or the Beckman paramagnetic oxygen analyzer are often used in analyzing oxygen percentage while carbon monoxide may be checked with the National Bureau of Standards colormetric tester available from two manufacturers.

High pressure cylinders may leak, and frequent inspection is necessary to insure that the air or oxygen is actually available for use in an emergency. High pressure valve, gauge, and demand regulator must be maintained in top operating condition by inspection and a regular preventative maintenance schedule as recommended by the manufacturer.

ATMOSPHERE CUTS SERVICE

If demand-type apparatus is worn in environments where pressure above one atmosphere is present (as in caissons or tunnels under higher than atmospheric pressure), the service time is reduced as the pressure increases. This is also true of underwater use of the regular demand-type apparatus; a special adaption is available for underwater swimming. Other peculiar effects have been reported when demand and closed circuit oxygen breathing apparatus was worn under pressure.

The use of oxygen in atmospheres above two atmospheres absolute pressure should be avoided since oxygen produces a toxic effect under such conditions. For periods up to 12 hours at normal atmosphere pressures, however, oxygen may be used without apparent ill effects by healthy persons—persons in questionable physical condition should *not* wear *any* emergency breathing equipment, but should remain away from contaminated air and underwater.

When the supply of air or oxygen has been depleted, the supply in the demand type apparatus cuts off abruptly, and the facepiece must be removed immediately or asphyxia can occur. One British half-hour breathing apparatus has available as optional equipment an automatic warning whistle (Pat. No. 644105) which will start to blow when the cylinder pressure falls to 300 pound/square inch, to aid in warning the wearer to return to fresh air at once.

The seal around the facepiece must be absolutely gas-tight in a toxic atmosphere since in the demand-type apparatus the facepiece is under slight negative pressure momentarily during the beginning of the inspiration phase of the cycle. A recent revision by one manufacturer eliminates this negative pressure part of the cycle. Another novel feature of another demand mask (54 cubic feet of air or oxygen divided between two 26 cubic foot cylinders for balance) is a plug-in attachment carried with the mask for administering resuscitation to an overcome person on-the-spot while still in a toxic atmosphere.

In the above discussions, no mention has been made of the fire and explosion hazard of air which is richer than 21 per cent in oxygen, or of pure oxygen itself. Certainly air should not be replaced with oxygen, either in a breathing apparatus, in a ventilation technique, or for any other purpose, without full consideration of the increased potential hazards from fire, as the oxygen concentration increases above the 21 per cent oxygen content of air. A flammable vapor-oxygen mixture requires only about one thousandth the energy to ignite it as does a corresponding flammable vapor-air mixture.

The resulting fire or explosion is many times more violent. Failure to appreciate these facts (which have been published and well documented for years) has cost many lives. For this reason, it is as important to analyze a suspected atmosphere for oxygen concentration as for flammable vapors and gases, and for toxic gases. By using either the time-honored mine safety lamp as an oxygen indicator, or the more recently available Beckman paramagnetic oxygen analyzer, it is possible to obtain fast and sufficiently accurate oxygen analyses for practical purposes.

Combine such oxygen analysis (which will reflect inert gases or oxygen deficient atmospheres as well as excessively high oxygen concentrations) with a check for flammable vapors and gases (using one of the many instruments commercially available), and a check for whatever toxic gas is suspected (for CO, for example, the National Bureau of Standards glass tubes containing palladium chloride which changes color with CO). To ignore any one of these fundamentals is to run risk of trouble.

SAFE 45 MINUTES

The self-contained oxygen-generating breathing apparatus is approved by the Bureau of Mines, and is rated for 45 minutes. Some of the models produced for the military are not Bureau of Mines approved, however. The weight of 14#, carried on the chest and stomach, gives it a decided advantage both in weight and convenience over the demand-type apparatus, although the chest position creates limitations in use under some conditions.

The highly exothermic reaction which generates oxygen from the potassium superoxide (K_2O_4) evolves significant heat, which might serve as an auto-ignition source to carbon-disulfide or nickel carbonyl vapors under extreme conditions. This temperature of the canister surface may reach 250°F, and is equivalent to the hazard presented by unshielded incandescent lamps, hot plates and steam pipes in such an atmosphere.

When worn in hot areas, or while working hard in the heat, the oxygen generated may occupy a volume which requires "dumping" of surplus oxygen to maintain comfort. The apparatus requires care in starting, especially in sub-freezing temperatures—for this reason it is considered good practice that both the apparatus and the canisters be stored inside or in a heated truck cab or automobile, and that the apparatus be thoroughly started above freezing temperatures, if possible.

Unless the sub-freezing starting is thorough, the wearer may be aware of insufficient oxygen during the first few minutes, by a feeling of "light headedness" and difficulty in coordination. If such a condition is noted, he should return to fresh air, deflate the bags and re-start the apparatus, until the breathing rate and the generating rate balance before re-entry.

In inserting the canister in the canister holder (canister is stored separately), care must be exercised to avoid cuts from the torn top seal when removing it, and the canister brought securely into place after it has been punctured by the sharp point designed into the apparatus for that purpose. The facepiece should not be donned until the canister is completely seated. A fresh canister should always be used in any emergency.

Once opened, a canister will continue to evolve oxygen even when removed from the apparatus and re-capped. To enter a hazardous atmosphere with a used canister is a highly dangerous practice—a fresh canister must be employed to insure safety. In view of the relatively high cost of these canisters, the temptation to re-use canisters is great, but should be avoided, and canisters promptly disposed of to insure the safety of the next user.

DON'T RE-USE CANISTERS

The disposal of the self-contained oxygen-generating canisters must be performed according to the instructions. Oil, grease, gasoline, or other flammable or combustible liquids must be kept from the canister mouth, or an explosion will occur. Only clean water in large quantities should be used to destroy a canister. The canisters should be promptly disposed of, and not be left sitting around where they could contact combustibles.

For reasons noted under discussion of demand-type breathing apparatus, the self-contained oxygen-generating apparatus should not be worn under pressures greater than two atmospheres absolute.

Smaller Self-Contained Breathing and Oxygen Inhalation Devices

U. S. Bureau of Mines approval for self-contained breathing apparatus currently makes no provision for apparatus rated for less than 30 minutes. In emergencies where a smaller, less cumbersome device with a shorter life would give adequate protection, the only available devices until recently were regular demand masks with smaller cylinders for 20, 15, and 7½ minutes service, using the same facepiece, reducers and regulators as on the larger approved devices.

Recognizing that many (perhaps most) breathing emergencies can be brought under control in 10 minutes, and that the first 130cc of expired air contains relatively lit-

tle CO_2, there is now available a lightweight device in which oxygen from small cylinders, supplemented by the first 100cc of the previous exhaled breath, is used for breathing at a rate of seven liters per minute. The device is still too new for extensive field experience, but represents a novel and new approach to the weight, bulk and cost of presently approved equipment.

Another recent development is a small portable anaesthesia and oxygen breathing device which is designed for use by medical personnel primarily, but which has obvious application as a "self-rescuer" for escaping toxic atmospheres. The device consists of a face piece with pressure limiting valve, an aluminum central body, a soda lime canister in volumes of 100cc to 500cc, two aluminum cylinders, each containing three liters of oxygen, and a six liter rubber rebreathing bag.

Using the device for escape, it is claimed a young male adult walking three mph can travel safely for 1100 yards using a 200cc soda lime canister, and 1800 yards using a 500cc canister. Since the complete unit weighs less than two pounds, and the oxygen cylinders are pocket-size, the device may rightly be called pocket-size, and, in the hands of trained personnel, should be useful for self-rescue oxygen inhalation or resuscitation.

Maintenance, Training and Medical Precautions

In discussing respiratory protection, we have shown the importance of breathing "good" air, briefly reviewed the major air contaminants, and discussed briefly apparatus available. We have stressed the limitations of each type, rather than the advantages, since we believe that limitations were not as widely appreciated as advantages. The ideal breathing apparatus has yet to be developed. We have tried to create the impression that a thorough knowledge of the particular apparatus used is essential for its safe use under various conditions.

Maintenance of the apparatus in first-class condition so it is immediately ready for use at any time is likewise important. Metal parts of apparatus will wear, tarnish or corrode; rubber parts will slowly "age." Facepieces will take a "set" and must be discarded. Cylinders, regulators and valves on demand-type apparatus must be checked frequently for leaks; canisters on industrial or universal service masks or chemical cartridge respirators must be replaced.

Washing the facepiece with an antiseptic solution or soap, rinsing in clear water, and drying will assure that sanitation and cleanliness is not neglected. This also prolongs the useful life of the facepieces. Proper storage conditions and frequent checking for deterioration are as important with respiratory protective equipment as with fire extinguishers, parachutes and life-lines.

TRAINING DEFICIENT

Training is the third, and perhaps most important leg of the triangle of respiratory safety. There is serious deficiency in this phase of the respiratory program. Putting on a device for a few minutes once a year is not adequate training. The U. S. Bureau of Mines Health and Safety Activities, through its district and sub-district offices, conducts training courses in first-aid, and also in the use of various emergency breathing apparatus.

The course can be modified to meet special needs on request. Addresses of offices which offer these courses may be obtained by contacting the Health and Safety Division of the Bureau of Mines, 4800 Forbes St., Pittsburgh 13, Pa. This service of the Bureau is available to the mineral and allied industries, as well as to governmental agencies. The Bureau has at each of its Health and Safety field offices throughout the country mine-rescue equipment, and will make it available to trained personnel in any emergency.

During training, breathing apparatus should be worn for relatively long periods, in dark and confined spaces, climbing hills or stairs, duplicating all manual labor expected, and in smoke-filled atmospheres by hand-carried lights while performing work. Smoke generators are available, which will quickly fill a room, a basement, a tunnel or a small building with a smoke that is realistic, but which is relatively harmless and can be ventilated out without any damage.

The "buddy" system and team drill should be practiced, as in a real emergency. The use of life lines should be a part of this training, and should be a standard part of any underground, tank or smoky operation.

Signals as used by mine rescue teams based on OATH (O=OK=1 pull; A=advance=2 pulls; T-take-up=3 pulls; H=help=4 pulls) should be employed and stand-by men, ready to enter the area for rescue, should always be on hand.

Hand-carried short-wave two-way radios may also prove useful for communication between base and field party. When used in atmospheres which may contain flammable vapors or gases, any electrical devices should have a "permissible" rating by the Bureau of Mines for the gases or vapors involved.

PHYSICAL EXAMS LACKING

The need for proper physical examinations for persons wearing emergency equipment has not always been appreciated in the past. A regular program of physical checkups with particular attention to the respiratory and circulatory system as well as general physical condition probably would have prevented some cases where inhalation of a smoke combined with physical exertion with or without respiratory protection, has produced serious illness.

Pulse rates before, during and after exercise, general physical condition, moderate weight, good eyesight and proper teeth alinement (where mouthpiece breathing is involved) are considered vital to pre-training by the Bureau of Mines instructors. A practice of not permitting persons to return unprotected to smoke or fumes after they have been overcome and revived, would help prevent more serious inhalation effects.

Such restraining action may require physical force to implement it in practice, since a patient who is partially recovered from fume or smoke inhalation may display highly irregular behavior. One recommendation is that persons sufficiently exposed to smoke and carbon monoxide to require treatment should not return to active duty in less than four to six hours, while those who have been rendered semiconscious or unconscious should rest 24 to 48 hours.

Properly maintained breathing apparatus, used with full appreciation of its limitations, by healthy persons, properly and adequately trained, will eliminate most "fume" disabilities in the future. However, the ideal breathing apparatus for all applications has not been developed, and may not be developed until there is sufficient demand for it.

CASE HISTORIES

AMMONIA

The incident in question took place in Singapore, Malaya, during the early days of the war 1942, just prior to the fall of the city to the Japanese.

Our ship was tied alongside the docks, having just completed a mission. The city was under air attack continually, so that we maintained a full scale Battle Watch, ready for any emergency. It was after one of these raids that a strong odor of ammonia was observed on our ship; our blower ventilating system was picking it up. Investigation by our shore patrol informed us that a large cold storage plant had been hit and that the local fire department was attempting to rescue several members who were trapped inside the buildings.

Our fire and rescue section was dispatched to the scene at once; we were equipped for such work with demand-type breathing apparatus, with proper protective equipment and safety lines. Upon arrival we were briefed as to the plant layout and the possible location of 10 men inside the building with a British type canister mask for protection. We entered the area working in pairs, and during the next 20 minutes removed 10 firemen, who had been well trained by the best of British methods, but unfortunately ill equipped for such violent conditions.

When found, all men were unconscious and upon removal from the building were rushed to the hospital, oxygen being administered enroute by a fine Australian medical team. Of the 10 men rescued, six died from the effects of ammonia inhalation, four men recovered completely.

During the entire operation none of our team experienced any breathing difficulty; the teaching of damage control, fire and rescue work by Naval standards are very good. Their careful selection of reliable equipment has been the result of careful research and experience.

NITROGEN IN AIR-LINE RESPIRATOR

Employees in an area were required to use air-line respirators as a precaution against inhalation of radioactive particles. The air line was also used to provide instrument air.

FILMS

1. *Mechanisms of Breathing* (EBF) 612.2-1, Pennsylvania State University, Audio-Visual Aids Library, State College, Pa. or Encye. Brit. Films, Inc. 1150 Wilmette Ave., Wilmette, Ill., (16mm sound, 11 min).
2. *Oxygen*, 16mm sound, 10 min., B&W and color, Coronet Films, Coronet Bldg. Chicago 1, Ill.
3. *The Air We Breathe*, 16mm sound, 26 min., B&W; Mine Safety Appliance Co., 5-45 49th Ave., Long Island City, N. Y. or local sales office.
4. *The City That Disappears* (Los Angeles), 16mm sound, color, 30 min., (Stanford Research Institute, Menlo Park, Calif.
5. *A Report on Smog*, 16mm sound, color, 20 min. (same source as 4).
6. *You Bet Your Life*, 25 min., 16mm sound B&W, available same source as 3.
7. *Use of Oxygen in Aviation*, TF1-4595, 22 min., 16mm sound, color, same source as 8.
8. *Oxygen, In-Flight Requirements*, TF-1-5038A, 25 min., 16mm sound, color, Air Force Training Films, Eastern Film Exchange, 1356 Film Library Flight (APCS) (MATS), Marietta Air Force Station, Marietta, Pa.
9. *Oxygen-In-Flight Equipment*, TF 1-5038B, 30 min., 16mm sound color, same source as 8.
10. *The Physiology of Anoxia*, 30 min., 16mm sound, B&W, same source as 11.
11. *The Breath of Life*, 10 min., 16mm sound color, H. J. Polk, Oxygen Therapy Dept., Linde Air Prod. Div., U.C.&C., 30 E. 42nd St. New York 17, N. Y.
12. *Safe and Efficient Oxygen Therapy*, 20 min., 16mm sound color, avail. same source as 11.
13. *Nitrogen Inhalation Therapy*, 10 min., 16mm silent color, Dr. H. E. Himwich, Galesburg State Research Hospital, Galesburg, Ill.
14. *Solvey Chlorine Emergency Devices*, 16mm silent color, 40 min., Research Dept., Solvey Process Div., Allied Chem. & Dye Corp., Solvey, N. Y. or local Solvey sales branch off.
15. *Use of the Air-Chem Suit*, 16mm sound, 30 min. color, Cost Reduction Section, Chamber Works, Organic Chemicals Dept., E. I. DuPont deNemours & Co., Inc. (Penns Grove, N. J.) avail. both with magnetic sound tract & regular optical sound tract.
16. *Breathing Apparatus*, Fire Dept. Training Film, 16mm sound B&W, 30 min., Public Relations sect, Los Angeles Fire Dept., Los Angeles, Calif., also avail. as Navy Train. Film
17. *Breath of Life*, 16mm sound, color, 10 min., Scott Avia. Corp., Lancaster, N. Y.
18. *No. 2 Training Film*, 16 sound B&W, 20 min., Scott distributors.
19. *Damage Control, Oxygen Breathing Apparatus*, MN-6931A, 16mm sound, B&W, 22 min., Navy Train. Film, U. S. Naval Train. Aids Center, E. Coast, 207 W. 24th St., N. Y. 11, N. Y.
20. *Rescue Companies*, 16mm sound 30 min., by Warwick & Tompkin, Public Relations section, Los Angeles Fire Dept., Los Angeles, Calif.
21. *Nerve Gas Casualties & Their Treatment*, 16mm sound color, 30 min., State CD Offices, or thru the Federal CD Admin., Battle Creek, Mich. on Fed. contributions prog. or thru W. B. Jacques, E. R. Squibb & Co., 745-5th Ave., New York, N. Y.
22. *Gas Obstacle Course*, TF-14440, 16mm sound, B&W, 19 min., 1943 (Air Force) same source as 8.
23. *The Effects of Weather on the Travel of Smoke & Gas Clouds*, TF-1-4666, 16mm sound, B&W, 21 min., 1949, avail. same as 8.

A regular compressor and a standby compressor were provided on the air line. Over a week-end, both compressors were out of service, so bottled nitrogen was manifolded into the line by a temporary jumper connection to maintain instrument air pressure. An employee, aware of the circumstances, was told to wear a filter-type mask. By habit, however, he entered the area and was found dead several minutes later due to *nitrogen* inhalation in the air-line respirator he had worn instead of the filter-type mask.

Breathing air systems, using an approved compressor or tank system, should be closely supervised and used only for breathing. Employees whose work takes them out of contact (visual or audiable) with others should be closely supervised. Human error caused this fatality.

CARBON TETRACHLORIDE AGAIN

Bunker C oil leaks had sprayed oil over the walls and ceiling of a small boiler room. Fearing the fire hazard which might result from using kerosene on the electrical equipment, the plant engineer had four men use a bucket of carbon tetrachloride with a *long*-handled brush.

Respirators of the proper type were provided and worn, but due to a missing part and poor fitting on one mask, one of the men became ill and was hospitalized three weeks with typical carbon tetrachloride poisoning symptoms.

A properly adjusted respirator, a less toxic solvent (such as 1,1,1-trichloroethane), and ventilation—any combination of these measures would have prevented this injury. It was also noted that the injured man occasionally consumed alcoholic beverages—a contra-indicated action in solvent areas.

PHOSGENE

A chemist suffered a major injury when phosgene gas containing dissolved HCl escaped from a cylinder too fast for the capacity of the hood. The chemist was wearing a Type N universal canister mask, but he noticed that his eyes were irritated when he took the mask off moments later in the fresh air.

Two men who worked alongside him were wearing air-line respirators and did not smell phosgene nor notice any eye or throat irritation. The chemist was hospitalized for 10 days from a toxic exposure to phosgene fumes, and was absent from work for about one month. The two other men suffered no ill effects whatsoever.

NO RESPIRATORY PROTECTION

A chemist was decomposing a reaction mixture containing phosphorous oxychloride in a hood by pouring it over ice onto a four-liter beaker. While his back was turned, the reaction became violent and the mixture overflowed onto the hood floor. A small amount also spilled onto the laboratory floor, since he did not have a catchpan under the beaker.

He directed his laboratory assistant to *leave the room promptly*, but stayed behind to throw some ice on the spill on the floor and open windows. He re-entered the laboratory after 10 minutes, when the fumes had subsided considerably, and cleaned the spilled material off the floor. This required 10 minutes, during which period he inhaled some of the fumes, chiefly HCl. He did not use any respiratory protection, although it was available.

He did not notice any ill effects that day, other than eye and throat irritation, but he was hospitalized on the following day for bronchial and pulmonary congestion. He was in the hospital for four days.

* * *

A vertical catalyst bed was being rodded out to remove solids. Dust and fumes from the solids being discharged at the bottom of the reactor were sufficient to cause coughing and discomfort to the operator, although spot ventilation was being used at the top of the column.

The operator continued to work out his shift, but that night he had an attack of nausea and vomiting, accompanied by persistent coughing. Following a recurrence of the original attack, he was admitted to a hospital for four days.

An air line respirator was readily available, although the magnitude of the dust hazard was not fully appreciated at the time.

* * *

During the operation of a small scale reactor housed in a barricade, it was necessary to enter the barricaded area and withdraw condensate every half-hour. This removal consisted of opening a valve at the

bottom of a condenser to check for and remove any unconverted by-products. In performing this operation it was necessary to discharge some vapors to insure complete withdrawal of the condensate.

The injured had been doing this during his shift without using the air-line respirator which was prescribed protection equipment for this operation. In addition to this exposure, he had entered the barricade during the early part of the shift to make minor repairs to a leaky blower.

The injured worked for several days with no apparent ill effects. While at home he developed a fever and shortness of breath which was subsequently diagnosed as acute bronchial asthma. He was home for three days.

In this case, the injured failed to obey written and verbal instructions to wear an air-line respirator, and the injured's shift leader failed to enforce this rule. Since then, all operators in this group have been reinstructed in the necessity for observing regulations regarding barricade entry, and have been informed that repeated violation of safety regulations may constitute grounds for dismissal.

WRONG TYPE MASK

An employee washing out a chlorine tank car passed out due to insufficient oxygen. A fellow employee put on a Type N universal canister gas mask and entered the car for rescue purposes. He, too, passed out and it was necessary to use self-contained breathing apparatus to rescue both. Fortunately, both men recovered.

• • •

Fire was located in a drying-storage room of steel construction, measuring 8 feet x 50 feet x 30 feet closed by an absestos curtain at one end. There was no possibility of ventilating. The room was located on the sixth floor of a factory and contained a large quantity of "wood flour" (pulverized saw dust), used in casting ornaments, contained in 100# bags. Fire was started by an electric motor in the rear-most portion of the room.

The fire had smoldered for some time and this room was heavily loaded with smoke, and obviously a high CO and CO_2 content. Alarm was sounded when the heat finally built up enough to activate a sprinkler head, which transmitted an A. D. T. alarm. Since very little smoke was visible external to the drying room (which was held at approx. 150°F) the first firemen went in without any protection. They were quickly overcome.

Members of the rescue company followed closely behind using Type N universal canister masks. These functioned well on the sixth floor outside the drying room, but inside, one of these five men was overcome. The other four heeded the warning sign of "overbreathing" and retreated to fresh air before being overcome. These same men returned to the room after donning self-contained breathing apparatus. In all, 30 men were overcome in this multiple alarm fire—multiple only because all men from the first companies were overcome. All the firemen recovered.

NO RESPIRATORY PROTECTION

A chemist was preparing to use hydrogen sulfide for a determination and when the valve was opened, a leak developed because a washer did not seat properly.

Before the employee could close the valve, the hydrogen sulfide was ignited by the flame from a bunsen burner located in the same hood. In an attempt to close valve, the employee re-entered the room, without wearing protective equipment, was overcome and struck his head on the edge of a bench as he fell to the floor. He was rescued by another employee who was wearing a demand self-contained breathing apparatus. He was hospitalized for three months and as a result of this incident lost his sense of smell.

ANOTHER SOLVENT INCIDENT

Two electricians, journeyman and apprentice, were working in a concrete pit—four by six foot top opening and standing on the bottom, the ground level was in the proximity of their eyes, nose and mouth. Repair of the small motor involved using a solvent an inhibited grade of 1,1,1-trichloroethane. Approximately 10 minutes after entering the pit, the one electrician appeared to be swaying, somewhat in a stupor, and somewhat incoherent. A combination of lifting and pushing forced the man out of the pit. The other electrician used the ladder in leaving the pit.

A few minutes exposure to fresh air and the "overcome" electrician stood up and walked to the dispensary. Examination revealed him to be coherent and no signs of narcosis. He rested for about half an hour and returned to his job—by this time the job in the pit was completed.

A few pertinent facts are in order: solvent was not spilled on the floor of the pit, the "overcome" electrician had returned to work that morning after being off for several days due to a bronchial inflammation, and the other electrician never demonstrated or mentioned any ill effects.

INERT GAS IN TANK CAR

A tank cleaner entered a tank car (which had previously contained caustic soda) and started to wash it down with a hose with the bottom outlet open. After failing to reappear in a normal time, investigation revealed the man lying in the bottom of the car. Upon removal and attempts at resuscitation, it was determined that he had died as a result of weak alkali solution having been taken into the respiratory tract.

This is strong evidence that the inert gas used to unload the car was a byproduct of chemical operations, low in oxygen and could have contained carbon dioxide, carbon monoxide, nitrogen and other constituents. Upon checking the air oxygen and 2000 ppm of reducing gases which would commonly be reported as carbon monoxide.

Inasmuch as the official coroner's report stated that the man fell to the bottom of the car apparently due to heat exhaustion, there was no significant publicity concerning this incident. Corrective measures have been taken to avoid any recurrence.

TANK JOB CLAIMS LIFE

A maintenance mechanic lost his life, and his assistant narrowly escaped in tank incident.

Repair work had been scheduled inside the tank to begin after lunch, and two men assigned to the job. The mechanic decided to look over the job about 11:30 a.m. and went into the tank after sending his helper for certain supplies. The inert gas (which contained essentially nitrogen with small percentages of CO and CO_2) supply to the tank had not been shut off, since the mechanic had not informed anyone of his entry. The mechanic was quickly overcome.

His helper returned a few minutes later, shouted for help, then went into the tank to aid the first man who was unconscious. Before help arrived, the helper was also overcome, but both men were promptly removed to fresh air. The helper was successfully revived, but the mechanic could not be brought back to life.

Failure to follow established tank-entry procedures was the reason given for this fatality.

INERT GAS

Two men entered a kettle to repair an agitator, which is normally a two day job. On the first day nothing unusual happened. On the second day the men went into the kettle, worked for an hour, and came up for a coffee break. When they re-entered kettle, they began to feel weak. They were actually too weak to climb out of the manhole after 15 minutes, but finally crawled out. They came to as they stepped out into the air.

After investigation, it was discovered that one of the men had opened an inert gas line instead of an air line. Close to the top of the kettle was a section for a hose line to be piped to outside the building. The hose was only half-way down into the kettle. The inert gas was heavier than air, when they bent over to pick up tools, they would get inert gas until they eventually were made ill.

• • •

An engineer went down to inspect a kettle. He began to feel sick and came out. Upon investigation later they found the kettle had been "blown-out" with inert gas and did not follow through by removing the gas with proper air ventilation. (The engineer recovered immediately upon leaving the kettle)

• • •

A man went into a non-enameled kettle. The complete kettle was blanked off with exception of entrance. The kettle had been "blown-out" with inert gas. He was overcome. It was necessary to resuscitate the man quite a while before he recovered.

ILLUMINATING GAS IN TRENCH

Two men were working in a series of three by seven by seven foot trenches dug along a 75-foot length of a street. While tapping a high pressure illuminating gas main to install a jumper line into a low

pressure main, a drill slipped and opened a valve in the tapping machine. Gas was released into the trench.

One man immediately left the trench, but the other was overcome. A laborer standing on the bank observed this, and immediately descended into the trench. He tied a rope around the waist of the unconscious man before he, too, was overcome. Meanwhile the foreman of the job put on an air-line respirator and went into the trench to close the valve. By the time the two unconscious men were brought to the surface by the foreman, one was sufficiently ill that inhalators could not revive the laborer even after a half-hour of resuscitation. The other unconscious man was revived.

The final score: three men treated at hospital for gas inhalation while one man was dead on arrival.

MASK IMPROPERLY ADJUSTED

A near fatality occurred when an operator went to tighten a chlorine line in the Waste Treatment Plant and the line disintegrated, thus exposing him to a full blast of chlorine. He had his face mask on, but due to maladjustment, he was hospitalized for twenty-four hours.

NARROW ESCAPE

A plant protection officer entered manhole to inspect water valves, collapsed after about three minutes, was unconscious for three and one-half hours, revived by artificial respiration. If there had not been another officer watching and a truck with a rope on it nearby, this would likely have been a fatality. A six inch artificial gas main 30 feet away had broken and the gas had seeped into the hold. No respirator was worn.

METHYL CHLORIDE

A leak developed in the methyl chloride compressor which was being used to transfer methyl chloride from the drier through a tank to storage. The leak was first discovered by a foreman who had heard the compressor pounding and who entered the area to investigate.

Two men inhaled excessive quantities of methyl chloride. An operator entered the area with a filter type respirator, but left when he detected methyl chloride through his respirator. Shortly afterward he was observed staggering and shouting outside. He was wearing a dust respirator. Both men were given oxygen and sent to the dispensary. Each of the men had a pale white complexion with a bright red overtone.

An examination of the compressor after the incident showed a crack along the base of the compressor housing. This was caused by liquid methyl chloride in the compressor.

The tank had been full for three days and had been frosted over, indicating the presence of liquid.

The incident was caused by attempting to transfer through the full tank.

OXYGEN WASN'T THERE!

During degreasing operations involving the use of Freon-113 (Trifluorotrichloroethane), it appears that one operator fell into the tank while attempting to disengage the basket. The other operator, without calling for help, immediately entered the tank to go to his assistance. Both men lost their lives due to suffocation in the oxygen-deficient atmosphere.

In fire safety, we have long hammered at the point of calling assistance before tackling any fire alone. The same point should be reiterated again and again in training personnel where the hazards of suffocation or entrapment exist. In many large chemical plants, personnel are often widely spaced and telephones are not always readily available at all locations. In practically all plants, however, a fire alarm box is located quite conveniently to all operating stations. Pulling the fire alarm box summons trained assistance and supervision in a matter of seconds. Where feasible, employees should be trained to use the fire alarm box instinctively to summon assistance before attempting on their own.

In any case where hazard evaluation discloses the possibility of suffocation or entrapment, personnel should be thoroughly trained to overcome the instinctive reaction to go immediately to the victim's assistance and to summon help first by the fastest available means.

HYDROGEN SULFIDE!

One man suffocated and two escaped death when exposed to H_2S.

This accident was caused when a precipitation tank overflowed and spilled acid-

bearing liquor on the floor. The liquor drained into a sump near the leach station and was then pumped into a reserve holding tank. Later, pipes from a reserve sulfide holding tank were disconnected, allowing the contents to drain on the floor.

The sulfide, during clean-up was washed into the sump and then pumped into the same reserved holding tank. An immediate reaction generated large quantities of H_2S, filling the area surrounding the tank. Unaware of this, three employees entered the area.

The first employee collapsed just as he passed the tank. The remaining two men walked a few feet further; one collapsed and the other reached a window and called for help. Other members arrived and gave artificial respiration while the ambulance was summoned. On arrival at the hospital, the first employee was pronounced dead.

Processing plants and laboratories in the program contain the elements to produce not only gases like H_2S but disastrous fires and explosions as well. These can occur from an uncontrolled chemical process reaction or, as in this case, from improper mixture of two chemicals. Infrequently, storage of incompatible chemicals can be separated physically for safety, which was done here afterward. More reliably, however, the employees should be instructed fully in the adverse effects of chemical combinations possible in the operation.

ALIPHATIC HYDROCARBONS

A pipe-fitter, aged 26, was gassed by aliphatic hydrocarbon fumes in a pit 20 feet by 10 feet by 6 feet deep in an oil refinery while he and another man were inserting a blank in a pipeline which had been shut off. Both men were wearing breathing apparatus supplies with air from a hand-pump, a Y piece being used to supply the two sets of apparatus from a single pump.

While working in the pit, the pipe fitter, who was apprehensive and difficult to reassure, was seen to remove his mask. The safety attendant, who, with the foreman, was watching from ground level, replaced the mask and assured him that it was working properly. When the joint was opened, some liquid escaped owing to residual pressure, and the pipefitter endeavored to come away, but was persuaded to return.

Later, when he again attempted to leave the pit, his airline caught on the bottom of the handrail and impeded his exit. This caused him to panic and he took off his mask. The foreman and the safety attendant running to his assistance, pulled him to safety as he collapsed. His workmate continued to work in the pit without any trouble.

After being given artificial respiration and an injection of corammine, the pipe-fitter was removed to hospital where he recovered. The apparatus which he had been wearing was subsequently found to be in good order, but it was unwise to compel him to work under circumstances of which he was obviously afraid.

AMMONIA

One afternoon, while the engine-room foreman of an ice-cream factory was standing near an oil separating unit, there was a report and ammonia liquid and gas issued from the sump. It was later found that the rubber seal between the sighting glass housing and the sump had "blown." The engine room was immediately evacuated, the foreman taking with him a canister respirator from a rack.

The fire brigade was called and warning given to all employees in the factory. As the concentration of gas was too high for the canister respirator, the foreman was unable to re-enter the engine room to reach the ammonia isolating valve. The gas spread rapidly through the factory area and many of the 100 employees, most of them women, were affected.

There was some degree of panic and some women were rescued from the canteen by firemen. Sixteen women employees and two firemen were admitted to hospital but only three persons were detained overnight. Seven of the women were sufficiently affected to require notification. Occupants of houses within a radius of 50 yards of the factory were also affected. The firm had already been advised to provide self-contained breathing apparatus and they were again advised to keep apparatus of this kind outside the engine room as well as the canister respirators.

TWO FATAL ACCIDENTS WITH BENZENE VAPOR

In one accident a laborer, aged 23, was fatally gassed and an ambulance room attendant and a fireman were also gassed while

attempting to rescue him. The foreman had given instructions for four of a series of 16 benzol tanks to be cleaned after they had been steamed out, tested and declared free from gas. While the laborer with his workmate was preparing to start work on a tank which had been steamed out, he enquired about another tank which had not been steamed and was told they were not instructed to clean that tank.

When the workmate returned after fetching a respirator and a lifeline he saw that a ladder and hose pipe had been lowered into the unsteamed tank and that the laborer had unaccountably entered without a lifeline or respirator. After shouting for help he attempted to enter the tank, at the bottom of which there was about 12 inches of liquid, but was forced to come out because of the fumes.

During the rescue operations a fireman, who in his hurry entered the tank without a mask, was gassed, as was the ambulance room attendant who had donned a fresh-air mask and a lifeline but dislodged his face mask while in the tanks and lost consciousness. The laborer was given artificial respiration and oxygen but failed to recover.

The other fatal case was a benzol house attendant aged 47, who was found lying prone and unconscious on the floor, which was saturated with benzol. He was immediately dragged into the open air and artificial respiration was started at once, this being continued with the aid of a rocking stretcher, oxygen also being given. Despite this treatment, he was found to be dead on arrival in hospital.

When the distillation temperature had been reached it was the attendant's duty to reduce the steam sufficiently to allow distillation to proceed in the normal manner. If this was not done, the crude motor spirit would boil rapidly and would eventually overflow on to the floor. After the accident, the plant was found to be in order, and it was assumed that the accident was due to the use of too much steam.

CARBON DISULPHIDE

Following the discovery of a leak at a rotary valve on an electric arc furnace used for the preparation of carbon bisulphide, the manager decided that breathing apparatus was necessary while repairs were being effected and he issued a permit-to-work certificate accordingly. Without being instructed to do so, a laborer climbed up a ladder to the top of the furnace.

He was not wearing breathing apparatus and, being overcome by escaping gas, he fell to the ground about 10 feet below. After recovering consciousness he was able to walk to the ambulance room.

FOUR CASES OF CHLORINE POISONING

In four cases in which only slight exposure to chorine gas occurred, the effects were stated to have been aggravated by the existence of a previous chest condition. One of these cases was a plant operator who inhaled a whiff of chlorine when adding hydrochloric acid to a reaction vessel under negative pressure, after having put in a slurry of sodium chlorite. The doctor who treated him in hospital considered that the inhalation of a small amount of chlorine had "triggered off" an acute attack in a man subject to asthma.

A process operator, aged 32, whose exposure to chlorine from a leak in a plant for the chlorination of dimethylacetal was slight, suffered from cough, breathlessness and pain in the chest. The chest physicist, who found a lesion in the left upper zone and kept him under observation at rest at home to assess the activity of the tuberculous lesion, thought the infection was a factor greater than chlorine exposure in this case. A night watchman, aged 58, said to have had a previous chest condition, suffered from a sensation of choking, cough and respiratory tightness following a slight leak of chlorine from a control valve.

The fourth case in this group was a fitter, aged 57, who, with other men was cleaning an air-cooler plant from which some water containing four p.p.m. of chlorine was leaking. The other men were unaffected by the small amount of chlorine, but the fitter, who was stated to be a heavy smoker, which caused him to cough continuously, became unconscious and suffered from lachrymation and cough.

IMPROPER VENTILATION

A laboratory technician was cleaning a vessel with a mixture of hydrochloric and nitric acids. The work was being done at a sink in front of an open window. However, there was not sufficient ventilation to prevent the worker from inhaling fumes to make him sick to his stomach. The proper type Canister Respirator was available on the lower floor but the person was not familiar with its use.

NO RESPIRATORY PROTECTION

Several specific instances are known where personnel should have worn protective equipment and did not although it was available and the specific personnel were familiar with use. For the most part these instances involved professional grade personnel of the "difficult personality" category engaged in Research and Development. Injuries were in all of these cases from volatile vesicants, and though injuries were serious enough to have resulted in lost time, there was, in fact, no lost time.

In one instance the employee was convinced to use recommended safety procedures by a combination of greatly increased supervisory pressure and alarmist industrial hygiene propaganda. In another instance such stresses produced no apparent effect.

RESPIRATORY PROBLEMS

We have had people injured while they were wearing respiratory equipment and also we have them injured by not wearing them even though they were available. Some of the latter are the "Smoke Eater" type who think they can get along without the stand-by equipment.

A basic problem with any respiratory protective equipment is knowing the limitations of a particular device. Actually, the popularity of the self-contained breathing apparatus can be attributed to the fact that its limitations are far less than any of those that depend on chemicals for air purification. In addition, the operator does not have to be concerned in knowing whether there is sufficient oxygen in the air.

In one particular process we were confronted with a number of stages in which reactants were more or less open to the atmosphere. In spite of a number of spot ventilators there was a prevalence of noxious odors, most free chlorine.

Chlorine is considered here for its nuisance and noxious characteristics rather than for its toxicity. Even small amounts have a definite odor and they usually cause an operator to get out of the contaminated area. This latter incidently provided cause for an additional problem and usually ended in a lost time injury. Many times the individual would go outside for fresh air where it was too cold for his condition. He would catch cold and would come near to developing into pneumonia.

During the time this particular process was being developed, operators got used to the chlorine type odor. At this same time the self-contained breathing apparatus was not the popular item it is today. A chemical cartridge respirator was what they generally carried draped about their neck. Probably many times the trouble was located and the mask removed after the contaminated area was under control without the operators' having an exposure.

A number of times though, the capacity of the cartridge was unknowingly depleted by prior uses. Then again, the general contamination would instill in the operator the idea that his mask was O.K. when it really wasn't. The operator would then prolong his trip beyond limits and have an exposure. To sum up then an operator:

a. would not know the conditions of his mask because he was generally conditioned to the contaminant.

b. would not know the remaining capacity of the mask.

c. would realize that the mask was not working but would remain in the area thinking he could get by or hold his breath a moment longer in order to complete the job.

The second part of the problem refers to the people that do not use the equipment that is available. These are the "Smoke Eaters" or the ones that think they can chance it. Even today with the self-contained breathing apparatus available, this practice continues. I witnessed an entry to a contaminated area (FH fog).

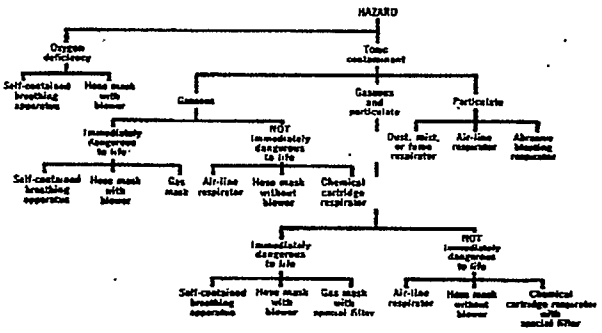
This particular entry was made for no good reason at all. Two men were putting their self-contained breathing apparatus on and this fellow decided to go in with a handkerchief over his nose. It turned out that the men wearing self-contained breathing apparatus made the necessary emergency shutdown, ventilators soon decontaminated the area, and normal entry could be made.

SOAP DUST

Our operation is essentially a soap manufacturing plant and the air in our factory is frequently contaminated with soap dust from detergents and dust arising from fine woodflour and cornmeal. We issue our employees a dust mask (not Bureau of Mines approved). The filter element consists of a honeycomb construction of whipped foam latex.

This device does a modest job of filtering, however, we have never been completely satisfied. Despite the fact that we have issued masks to all personnel about half of our personnel prefer to use an ordinary handkerchief wrapped about their face which appears to do a satisfactory job without the unpleasantness of the dust mask.

OUTLINE FOR SELECTING RESPIRATORY PROTECTIVE DEVICES



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copy pp. . charts, illustrations, etc in v. of. Ch322

LABORATORY AND PILOT PLANT SAFETY

(A Symposium)

LABORATORY BARRICADING OF HIGH PRESSURE AND EXTRA HAZARDOUS REACTIONS

by **GODFREY J. MOLL**

chemical engineer, CIBA Pharmaceutical Products, Inc., Summit, N. J.

Safety engineers are often called on to formulate or approve plans for laboratories in which high pressure or extra hazardous reactions will be safely operated. In these designs the protective shield or barricade is the only fixed piece of safety equipment which will remain operable 100 per cent of the time. Equipment, instrumentation, and safety devices are all apt to fail at any time regardless of maintenance and inspection. The judgement of the best-trained operating personnel need only be wrong once. The barricade may be considered as the primary safety device.

High pressure and extra hazardous research projects are being carried out in unbarricaded laboratories in many universities and at some industrial research centers in the United States. Workers at these installations will point with pride at their perfect safety record, but tomorrow might yield their first and last accident. The management of CIBA Pharmaceutical Products Inc. of Summit, N. J., has recognized the risk involved in not barricading high pressure reactions.

Our high pressure laboratory was constructed in a built-up area presenting the problem of not only protecting the operating personnel but also the personnel of adjacent buildings from the effects of missiles and shock waves. A suitable barricade was constructed of 16-inch reinforced concrete with a reflector wall of similar construction eight feet from the frangible wall. Further protection was provided by hanging one-half inch wire rope blast mats between the building and the reflector wall, which would operate on the ballistic pendulum theory in stopping missiles and dissipating shock waves. This is but one approach to the problem of barricading.

The question often arises as to what should be considered hazardous enough to warrant the expense of barricading. Some authors feel that when equipment is installed to handle inflammable materials at pressures greater than 500 psi the use of some form of barricade should be considered. When research at high gas pressures or work on known explosives is conducted the protection of personnel and other facilities with an adequate barricade must be considered.

In small-scale flow experiments where the amount of material in process is small, it is common to use pressures as high as several thousand pounds without special barricades. Once it has been decided to build a barricade there are still many questions to be answered. The two most important as far as the barricade is concerned are the materials of construction and their thickness.

MUST KNOW MISSILE

If we knew the velocity, weight and shape of the missile and the maximum force expected from an explosion, we could design a barricade using a minimum wall thickness. Barricades must be designed to prevent penetration by large missiles at low velocity, such as reactor heads, and also small missiles at high velocity, such as tubing, nuts or other small fittings. Penetration is dependent upon the velocity of the missile at impact, the physical properties of the missile, and the characteristic of the material used to construct the barrier.

The speed of sound has been suggested as a velocity, as most objects when propelled through air decrease in velocity to the speed of sound. If missiles of higher velocity are expected, the modified Petry equation for penetration can still be used to calculate a

satisfactory wall thickness. Ballistic tests have shown that if the velocity of missile is twice that of sound, the depth of penetration is almost quadrupled. High pressure autoclave heads have sheared eight-inch "I" beams without being stopped and have penetrated as much as 40 feet into dirt embankments before being stopped.

A barricade which will prevent penetration if designed properly can withstand the blast effects of explosive gases and the shock waves of a detonation within the equipment. The thrust of an explosion should be absorbed by the main framing of the building behind the barrier and the floor of the cubicle should be of sufficient thickness and weight to resist the turning moment created by the pressure on the barricade. It is assumed that some form of frangible wall or relief area will be included in the design with a recommended minimum of five square feet of relief area for every 100 cubic feet of volume.

Many formulas have been proposed to find the resistance to penetration of various materials. Although most of them have a theoretical basis, practically all involve constants for different types of materials. The formulas which seem to be the most logical are the sectional pressure formulas. The formula proposed by Petry in 1910 with additional constants arrived at by Bazant in 1937 for more recent building materials were the standard used in British bomb shelter construction. Knowing the weight and area of contact of the largest probable missile it is possible to calculate the minimum thickness of any desirable building material to be used as a barricade.

CONSTRUCTION METHODS

There are seven basic methods of constructing effective barricades in use today:

1. Earth embankment or underground cell
2. Sand bag barrier
3. Rope or steel matting
4. Steel boiler or armour plate
5. Various sandwich-type constructions
6. Reinforced concrete
7. Protection based on the ballistic pendulum theory

Of these reinforced concrete and steel in various forms are the most widely used.

For extremely hazardous reactions the use of earthen or underground barricades provides a maximum in protection at a minimum in cost. For every eight feet of sandy soil placed between an operator and a reactor the equivalent of one foot of reinforced concrete is realized. The added cost of complete remote control operation in some instances might offset the savings afforded by the use of the natural barrier earth. The advantage of soil over the other types of materials can be realized in the construction of embankments as safety or reflector barriers to protect the surrounding area. Army and Navy Ordnance have long made use of this type of barricade.

As a temporary protective shield a three-foot thick wall of sand bags filled with dry sand cannot be beat in cost and availability. When a hazard is recognized and a shut down would cause delay of a research project, a sand bag wall would solve the problem until a more permanent installation could be constructed.

ROPE, STEEL MATS USED

The use of rope mats as protection against missiles has been practiced many years. Steel blast mats have found their maximum use as missile-proof ceilings in installations where the roof is part of the relief area. Mats are also hung a few feet away from frangible walls to deflect missiles. As an additional or auxiliary protective barrier the steel mats cannot be excelled.

Modern tanks require a minimum of five inches of steel armour plate to stop high-velocity armour piercing shells. Fortunately the missiles encountered in a normal laboratory explosion do not have a propellant to maintain their velocity and will decrease in velocity to the speed of sound in air. Steel plates may therefore vary in thickness from a quarter inch to one inch according to the severity of the hazard. Accidents involving barricades of the riveted or bolted type construction have shown that the weakness of the rivet or bolt can produce additional missiles on the operating side of the barricade.

It has been found that a continuous weld on both the inside and outside of the steel plate will provide five times the resistance to shock wave damage as a single weld on the outside. Steel panels should be fastened to angle irons or structural members that are an integral part of the building and not bolted to the concrete floor with expansion bolts which would not prevent the entire barrier from being overturned by a major explosion. Care must be exercised to prevent corrosion of the steel which would rapidly lower its effectiveness as a barricade.

Field tests performed by the Ordnance Department of the U.S. Army have shown that two steel plates with an air space in between are 20 to 30 per cent more resistant to penetration than a single plate whose thickness is equal to the two plates. This essentially is a sandwich-type construction and eliminates the necessity of bracing to decrease the steel plates' resistance to shock waves. The steel plates are often welded to two-inch pipes imbedded in the concrete of the structure or to four-inch "I" beams which are part of the structural steel.

REDUCE SHOCK WAVES

By introducing dry sand into this steel sandwich it is possible to reduce the shock wave transmitted to the outer member. Other fillers which will not pour through holes drilled for control purposes have been successfully used, such as cotton batting, rope, wood, and more recently fiber glass insulation which will also contribute to the warmth of the building.

Another method of reducing the shock from flying missiles is to place a wooden barrier on the inside with the steel on the outside. This may also be filled with a desirable filler. Where space is extremely limited the entire sandwich wall can be mounted on floor casters and overhead trolleys so that it can be rolled out of the way when not required. Steel has one distinct advantage over concrete as a material of construction in that it is able to absorb about 1,600 times as much energy per unit volume; hence, enormous masses of concrete are required to provide energy capacities equivalent to steel.

During the war it was shown that massive walls of concrete do not afford unlimited protection. A test missile with a velocity of 2,000 feet per second was able to penetrate 23 feet of reinforced concrete and emerge with a residual velocity estimated at 300 feet per second. Missiles of this velocity are not likely in laboratory work, and walls of this thickness are out of the question. Many factors determine the effectiveness of reinforced concrete as protection against penetration by missiles. Concrete with a crushing strength of less than 4,000 psi should not be considered for barricade construction. To obtain resistance to penetration, one-half to three-quarter inch reinforcing rods should be placed in both faces of the wall with a maximum spacing of six inches in both a horizontal and vertical direction.

Lateral reinforcement with three-eighths to one-half inch rods on a maximum of 12 inch centers would decrease scabbing on the outside of the wall. One laboratory uses an "anti-scabbing" plate of steel on the operating side to guard against spalling. Welding at all intersections would provide additional protection against penetration. Data from the Bureau of Yards and Docks on the use of reinforced concrete is included in the Appendix.

There is a wide spread of opinion as to what is an adequate barricade, which is evidenced in the manner in which the various laboratories have constructed their barricades. The type of research conducted determines the best type of barricade to use. One research laboratory has an extremely flexible system using one-half inch steel plate as the barrier. The high pressure equipment is mounted on a one-half inch steel plate welded to two pieces of six inch channel iron to which a front one-half inch steel plate is welded and braced. This assembly is placed into a cubicle which has a frangible wall and relief type ceiling.

The necessary facilities are connected from the outside through steel overhead hatches. The front panel is fastened rigidly only at the top which in case of an explosion will allow the unit to take advantage of the ballistic pendulum theory developed by Robins in 1740. This flexibility allows the shock wave time to burst the frangible wall without creating undue stresses in the barricade wall.

Having established a satisfactory method of barricading a reactor, care must be taken not to reduce the effectiveness when introducing the remote control systems necessary for operation. Openings for tubing, control rods, visual inspection, and other

necessary breaches of the barrier must be engineered so as not to weaken the wall. If the method of entry to the hazardous area is to be through the barricade wall, the closure used, whether it be a sliding or swinging door, should be designed to withstand the same conditions as the barricade itself. Baffled entries leading into an operating area have not proven satisfactory for stopping or dissipating blast waves which are not affected by turning corners. It takes only about one pound per square inch to hurl a person about and at seven pounds per square inch the ear drums are fractured.

LOOSE ITEMS DANGEROUS

The hanging of control instruments and other accessory equipment on the outside of a barricade wall has proven to be a dangerous condition. Shock waves passing through the wall are transmitted to these relatively loose items casting them about the operating area. If at all possible the barrier wall should serve only one function and that is to protect the operating personnel. It should not be weakened by drilling and tapping to support items which could be easily supported in other ways.

The physical location of the high pressure or extra hazardous laboratory will determine the type of construction and the need for a safety or reflector wall. Regardless of the amount of open space behind the frangible wall the hanging of a steel blast mat curtain or the forming of an embankment should be considered to protect personnel who might accidentally wander into this area. When a laboratory is located in a built-up area the reflector wall should be at least as heavy as the barricade itself.

Barricades are too often based on the make-it-big and make-it-thick principle. If the operators of high pressure and extra hazardous laboratories would pool their accident histories, it would be possible to evaluate the various barricade designs and check the validity of the application of ballistic information on missile penetration.

APPENDIX

Sand Bag Walls—Filled sand bags are 20 inches by 10 inches by five inches and contain one-half cubic foot of sand. These walls require about 40 to 50 bags per foot of length.

Proportions, Strength Requirements for Portland Cement Concrete

Nominal Mix	Minimum resistance to crushing (cube strength) in lb/in² within 28 days after mixing	
	Preliminary	*Works*
1:1:2	5250	4500
1:1-1/2:3	4375	3750
1:2:4	3500	3000

Empirical Expression for Penetration

Petry Formula

$$D = KA_s \log_e \left(1 + \frac{V^2}{215{,}000}\right)$$

D = depth of penetration, ft.
K = experimentally determined coefficient of penetration ft³/lb
A_s = sectional pressure, weight of missile divided by its maximum cross-sectional area, lb/ft²
V = impact velocity, ft/sec

Values of Penetration Coefficient (K) for Various Materials

Material	*K, ft³/lb*
Soft soil	0.0732
Soil with vegetation	0.0482
Pine wood	0.0410
Sandy soil	0.0367
Oak	0.0328
Gravel	0.0205
Brickwork	0.0205
Stone masonry	0.0117
Concrete (1)	0.00799
Limestone	0.00536
Reinforced concrete (2)	0.00476
Specially-reinforced concrete (3)	0.00282

1. Mass concrete with a crushing strength of 2,200 psi
2. Normal reinforced concrete with a crushing strength of 3,200 psi and a 1.4 per cent of reinforcement
3. Specially-reinforced concrete with a crushing strength of 5,700 psi and 1.4 per cent of reinforcement.

When calculating the depth of penetration, D, the effect of relative thickness must be considered. If the barricade thickness is only 2D, the wall will be penetrated. The thickness must be not less than 3D to prevent penetration.

Various Barricades Used by Industrial Research Laboratories

Steel

1. 3/8-inch all welded steel plate with 2 x 2 x 1/4-inch angle iron stiffeners welded with 3-inch welds every 6 inches.
2. 1/2-inch steel plate fastened at the top and weighted-down by the weight of the reactor attached to a steel platform welded to the front plate and braced by angle irons.

Steel and Wood

3. 1/2-inch steel plate with 3/4-inch plywood fastened to inside wall.

Double Steel

4. 1/4-inch steel plates welded to 4-inch "I" beams, no filler.

Double Steel, Sand-filled

5. 3/8-inch steel plate inside and 1/4-inch steel outside welded to 4-inch "I" beams with space in between filled with dry sand.

Steel, Wood, and Sand

6. 1/2-inch steel plate with 2-inches of wood on the inside and 4 inches of sand in between.

Reinforced Concrete

7. 8-inch reinforced concrete.
8. 12-inch reinforced concrete, two companies.
9. 12-inch concrete with 3/4-inch steel reinforcing rods on 6-inch centers, both horizontally and vertically in both faces of wall.
10. Same, except with 1/2-inch steel rods.
11. 16-inch concrete with 1/2-inch steel reinforcing rods on 6-inch centers, both horizontally and vertically in both faces of wall. 3 companies.
12. Same, except with 3/4-inch rods on 4-inch centers, and lateral reinforcement with 3/8-inch rods on 12-inch centers.
13. 18-inch reinforced concrete.

Reinforced Concrete and Steel

14. 18-inch reinforced steel with a steel plate on the operating side to prevent injury from scabbing. ▲

FLAMMABLE MATERIALS—SYSTEM FOR RATING

by WILLIAM S. WOOD

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The purposes of this committee as set up last spring were as follows:

1. To review published information on flammable materials.
2. To collect ideas from the members of the laboratory subsection by means of a questionnaire.
3. To present information on flammable materials as applied to laboratory and pilot plants.
4. To study the definition of flammable hazard in the hope of improving standards of use in laboratories.

This last objective could permit the most realistic recognition of flammable hazards in laboratories and lead to better control of amounts, improved procedures for safe use and the optimum in protective measures.

Perhaps the most promising approach is that taken by the National Fire Protection Assoc. Committee on Classification of Materials under the chairmanship of J. Sharp Queener. The three part proposed classification system is briefly outlined at the bottom of the page.

A questionnaire was made up by the committee to find out how laboratory safety men evaluate the flammable hazard of materials frequently found in their areas of work. About 150 questionnaires were mailed out and 30 were returned answered. A few declined to answer because of insufficient experience. Others were unwilling to answer the questions as presented and expressed their reasons.

A number of notes and comments on the questions and their answers are listed following the question. These remarks were perhaps the most important gain from this effort.

NEW NFPA COMM. ON CLASSIFICATION OF MATERIALS

Flash Point & Vapor Pressure	*Stability*	*Health Hazard*
1. Flash above 140°F	1. Normally stable	1. Low hazard. No injury if no treatment is given.
2. Flash 100-140°F	2. Reactive with strong contaminant or catalyst.	2. Light hazard. Minor injury if no treatment is given.
3. Flash 73-100°F	3. Reactive with contaminants including water. Self reactive at elevated temperature or pressure.	3. Major injury if no treatment is given.
4. Flash below 73°F a. BP over 100°F or RVP below 14.7. b. BP under 100°F or RVP above 14.7.	4. Detonate with shock.	4. Major injury in spite of prompt treatment.

QUESTIONNAIRE ON FLAMMABLE MATERIALS

1. Please indicate below in order of importance the factors you consider in evaluating the flammability hazard of a material.

	Gas			*Liquid*			*Solid*		
	1st	*2nd*	*3rd*	*1st*	*2nd*	*3rd*	*1st*	*2nd*	*3rd*
Flash Point	3	2	2	16	4	1		4	
Fire Point		1			4	2	4		1
Vapor Pressure	1			2	9	2	1		2
Lower Flammable (Explosive) Limit	13	5	2	2	4	6	1	1	1
Upper Flammable (Explosive) Limit		6	2			2			
Spread of Flammable Limit	3	3	2		4				
Autoignition Temperature	3	3	5	3	1	3	5	2	2
Vapor Density		2	3		1	1			
Boiling Point					1				
Melting Point								1	1
Water Solubility						1			
Particle Size								5	3
Special Properties									
Impact Sensitivity	1			2			4	2	2
Spontaneous Heating					2		2	2	2
Friction Ignition		1	3					2	
Ignition by Moisture Absorption						1	1	1	2
Spontaneous Ignition in Air	1		3				4	2	3
Ignition by Moderate Heating		2				3		1	3
Other (Specify)									
Compatability with other chemicals									
Decomposition during storage									
Means of fire fighting									
Rate of flame spread									
Toxicity									

Comments: The order of importance varies with material and also with environmental circumstances. The relative importance of a characteristic depends on its test value. NFPA Committee on Classification of Materials had 35 hazard characteristics.

2. In your laboratory, do you limit quantities of flammable materials on the basis of items marked in (1)? Yes 25 No 2

	Single factor	*Combination*
a. In laboratory areas	10	15
b. In process in glass	5	9
c. In process in pilot plants	1	7

If combination, give an example showing relationship.

Comments:

—Limit solvents in glass to 1 quart.

—Generally keep less than 1 liter of volatile materials.

—Limit solvents in safety cans to five gallons.

—Five gallon limit—avoid five gallons in glass where possible.

—Limitation based on amount of damage possible if all of the material were to catch fire.

—Should be limited, usually on a combination of factors but occasionally on one outstanding.

—NFPA classification (which?)

—Would allow methanol in dry ice traps in areas not explosion proof since the methanol temperature would be below the flash point.

—Due to nature of work we must disregard lower explosive limit and provide more than adequate ventilation.

—Sodium, metal hydrides, aluminum alkyls, sodium amide and extremely toxic materials are segregated.

—Raney nickel in glycol is not hazardous, in acetone it is a great hazard.

3. Do you specify safety cans or other containers for use in laboratories based on the properties indicated in (1)? Yes 23 No 3

Single factor 13
Combination 10

Comments:

—No Class I or II liquid in glass larger than one quart.

—Original suppliers metal containers not larger than five gallon.

—All solvents must be stored in safety cans.

—Safety cans specified for more volatile flammable liquids, acetone, ethyl acetate, etc.

—Should require safety cans for larger quantities. Small amounts in glass or plastic may be justified to avoid contamination.

—Specified in some cases for large quantities.

—Containers specified primarily for insurance and toxicity reasons—based on volume of use.

4. Do you provide special or additional fire equipment based on the properties indicated in (1)? Yes 20 NO 5

Single factor 5
Combination 15

Comments:

—Provide automatic dry chemical units in hoods where 5-12 liters of flammables are used.

—Combination of extinguishers for various materials.

—Provided on basis of flammability and reactivity of the chemical with the extinguishing agent.

CO_2 extinguishers used throughout. May be supplemented by dry chemical or powdered sand for metals.

5. On what basis do you specify Class I Group D electrical equipment in areas where flammable materials are used?

Do not specify 3
Do specify 22

Comments:

—National Electrical Code, Article 500.

—Local state laws.

—Plant standards.

—For all test cells from floor level to about four feet.

—Where Class I flammables are used or stored.

—Where Class I or II flammables are used or stored.

—Where extremely flammable materials are to be used.

Where high vapor pressure, low explosive limit gases or solvents are used.

—where highly flammable liquids or gases are customarily used.

—Where flammable vapors may be present in the atmosphere.

—Where large quantities of volatile flammables are used.

—Where oxidizing or flammable metal powders are used.

—Quantity of gases and liquids and degree of hazard in (1).

—Where spills will occur.

Each area analyzed separately and classification made on basis of all factors considered in (1).

—All centrifuges and vacuum pumps are equipped with explosion proof motors so they can be used anywhere.

6. How would you rate the following with regard to flammable hazard? Check in proper column.

Gases	*Extreme Hazard*	*High Hazard*	*Moderate Hazard*
Acetylene	21	7	2
Ammonia	—	3	27
Butadiene	11	11	7
Carbon Monoxide	5	14	10
Coal Gas	4	17	4
Ethylene	7	18	3
Hydrogen	24	6	1
Hydrogen Sulfide	9	5	15
Methane	2	17	6
Oxygen	5	8	9
Propane	5	15	5

General Comments: (apply to gases, liquids and solids)

—NFPA Committee on Classification of Materials has four categories.

—Hazard depends on circumstances of use.

—An explosives laboratory considered that none represents more than moderate hazard assuming (1) Control of quantity, (2) Skilled and trained personnel and (3) Proper laboratory equipment.

7. How would you rate the following with regard to flammable hazard?

Liquids	*Extreme Hazard*	*High Hazard*	*Moderate Hazard*
Acetic Acid (Glacial)	—	4	25
Acetone	8	15	8
Benzene	7	18	6
Carbon Disulfide	22	7	1
Cellosolve	—	8	21
Cyclohexane	7	14	7
Diethyl Ether	21	6	3
Ethyl Alcohol	1	13	17
Gasoline	10	14	7
Isopropyl Alcohol	1	11	17
Kerosine	—	2	29
Methyl Alcohol	3	14	14
Methyl-ethyl-ketone	3	19	8
n-Hexane	6	18	6
Oleic Acid	—	—	25
Stoddard Solvent	—	6	22
Turpentine	—	4	22

Comments:

—Low hazard category designated by one respondent for 10 liquids including MEK.

—Very moderate hazard designated by another for cellosolve, cyclohexane, kerosine, oleic acid.

—Alcohols, methyl, ethyl and isopropyl were considered extremely hazardous because of flammable limits.

8. How would you rate the following with regard to flammable hazard?

Solids	*Extreme Hazard*	*High Hazard*	*Moderate Hazard*
Benzoyl Peroxide	18	6	4
Cellulose Nitrate	15	9	3
Excelsior	1	7	18
Li Al Hydride	12	9	3
Lithium	8	12	4
Magnesium Chips	4	16	7
Paraffin Wax	—	2	23
Phosphorus Yellow	14	4	5
Potassium	16	10	2
Raney Nickel	8	13	2
Sodium	14	11	2
Sulfur	—	6	21

Comments:

Cellulose Nitrate Dry—extreme hazard
Wet—moderate hazard

General comments on the entire questionnaire.

Cannot be rated without knowing conditions of use. The questionnaire showed how little we knew about properties of hazardous materials. Most standards are based on NFPA recommendations. One NFPA subcommittee is covering "dangerous reactions."

Demonstration of flammable hazard of alcohols suggested. (Put alcohol on rag, place in can, shake, ignite.)

Conclusions from results of the questionnaire.

Although flash point and flammable (explosive) limits are the most widely accepted criteria of flammability, most people take other properties into consideration as well.

Sometimes one particular property other than flash point will carry great weight as for example, shock sensitivity, reaction with water, spontaneous ignition or low ignition temperature.

Notations as the questionnaires returned showed that knowledge of the environmental conditions and of the properties of the individual material are essential to the proper evaluation of flammable hazard.

Some answers indicated a lack of information about the properties of materials and also an insufficient grasp of the significance of the properties listed in literature. Laboratory safety men need the best in educational background, adequate information sources and then constant study to prepare them to do an adequate job.

Recommendations:

I suggest that this committee be continued and that it work closely with others such as the NFPA Committee on Classification of Materials contributing such ideas as may stem from laboratory experience.

To this end a complete bibliography and library of information on classification systems should be maintained as a service to the subsection. Information on new compounds and materials should be sent to the committee for general reference or distribution.

Another suggested activity is the collection from many people in the laboratory subsection of accounts of fires they have had involving flammable materials. Large or small they would help instruct all of us in proper measures for fire prevention and extinguishment.

TOXIC CHEMICALS

by R. V. MONTELLO

Research division, National Cash Register co., Dayton, Ohio

We do not have to let them die!

Many millions of man-hours with no lost time due to serious injuries to employees are being worked in one of the most hazardous occupations of all times, the field of atomic energy. This is possible only because the hazards are recognized and the proper precautions to preserve human life are faithfully observed.

Great strides have been made in overcoming many occupational diseases which a few years ago due to a lack of safety knowledge meant a serious loss of health and even death.

This improvement has come about not without much personal effort on the part of many individuals either singly or through committee action.

The laboratory sub-section of the Chemical Section of the National Safety Council has appointed a new committee to study the problem of Toxic Chemicals. The members of this committee are John E. Fox, Monsanto Chemical company, Texas City, Texas; Robert A. Quisno, Hill Top Research Institute, Inc., Miamiville, Ohio; and Ralph V. Montello, National Cash Register company, Dayton, Ohio.

INFORMATION DECENTRALIZED

Today there is much good and useful information on the toxicology of dangerous chemical materials. The unfortunate part is that this information is not available in any one place. Talk to any two people on the subject of toxicology and you soon realize that each will have some different source of information about dangerous chemicals. A study of the availability of information regarding the hazards of chemicals used in the chemical laboratory or pilot areas shows a rather varied list of sources for this type of information.

Virtually every technical magazine features articles from time to time on some hazardous chemical or process which yields hazardous chemical by-products. A check on the number of scientific magazines estimated by one librarian revealed 50,000 current world-wide publications. When we consider the field of insecticides, pesticides and herbicides, we find important safety articles in magazines that are distributed in the suburban and farm home.

If we move over to the field of paints and organic coatings and finishes, we find in addition to the technical magazines, interesting articles in such magazines as the *Ladies Home Journal*. Countless articles covering a wide number of hazardous chemicals are published by various governmental agencies It is indeed fortunate that manufacturers of new chemical products both raw and finished materials go to great lengths to thoroughly analyze their products to obtain toxicological data.

COLLEAGUES EXCHANGE NOTES

This information is available through the manufacturer and may not appear in published form anywhere else. The practice of writing to a colleague with particular experience in the field of the new chemical is believed to be widespread. Supplementing all this information on dangerous chemicals with books on specific fields like the solvents, with the many excellent safety articles in safety magazines, and with the wealth of unpublished information in private, university, and industrial laboratories, we are impressed with the formidable task required to be well informed on toxic chemicals.

The tremendous growth of chemical research in recent years has created an expanding field of industrial toxicology. One author estimated that more money was spent on chemical research in the past eight years than was spent in all of the rest of this century.

This committee aims to cooperate with all persons promoting safety in the use of toxic chemicals so that the hazards of these materials to human health can be recognized and proper protection used to meet these hazards in the most efficient manner.

Deciding which chemicals are toxic and those that are not depends upon the definition one chooses. *Webster's* dictionary, for instance, defines the word, toxic, as "1. of, pertaining to, or caused by poison or a toxin 2. Affected by a toxin 3. Poisonous."

Handbook of Dangerous Materials by Sax lists "toxicity as the sum total of all harmful effects upon a warm-blooded animal." It goes on further to explain that "toxicology is the study of the manner in which these toxic materials produce their poisonous effects on the body."

VARIED DEFINITIONS

In the new, completely revised and enlarged edition of the *Handbook of Dangerous Materials* by Sax which is entitled "Dangerous Properties of Industrial Materials" toxicity is defined as "The ability of a chemical molecule or compound to produce injury once it reaches a susceptible site in or on the body."

It goes on to state that "Toxicity hazard is the probability that injury may be caused by the manner in which the substance is used." The new definition of toxicology is: "In simple terms, toxicology may be defined as the study of the action of poisons on the living organism. Industrial toxicology is concerned with the human organism and consequently lies within the broad field of medicine. Since medicine cannot be considered an exact science in the same sense as chemistry, physics or mathematics, toxicologic phenomena cannot always be predicted with accuracy or explained on the basis of physical or chemical laws. It is this unpredictability which frequently reduces conclusions and decisions to opinion rather than fact."

The Manufacturing Chemists' Association states in their Manual L-1, under Warning Labels, "POISON—A chemical or mixture of chemicals which falls within any of the following categories:

a. Produces death within 48 hours in half of a group of 10 or more laboratory white rats weighing 200-300 grams at a single dose of 50 milligrams or less per kilogram of body weight, when administered orally; or

b. Produces death within 48 hours in half or more than half of a group of 10 or more laboratory white rats weighing 200-300 grams, when inhaled continuously for a period of one hour or less at an atmospheric concentration of two milligrams or less per liter of gas, vapor, mist, or dust, provided such concentration is likely to be encountered by man when the chemical product is used in any reasonably foreseeable manner; or

c. Produces death within 48 hours in half or more than half of a group of 10 or more rabbits tested in a dosage of 200 milligrams or less per kilogram body weight, when administered by continuous contact with the bare skin for 24 hours or less."

The writer has associated toxic chemicals as those materials which enter the body by the nose, mouth, or skin and produce an adverse effect on the blood composition. This change in blood composition is such that the vital organs (liver, heart, kidneys, etc.) are restricted in performing their life-giving functions and death can result.

TOXIC CHEMICALS ABSORBED

If the above can occur to the operator through absorption into the body by any chemical handled in a routine fashion which is normal for that class of chemical materials generally considered non-toxic, then the material is a toxic chemical.

The committee has received many valuable suggestions on areas of interest to our subject.

One letter suggested that a large compilation of references on toxic chemicals available to all interested persons would serve immeasurably to further the cause of safety in the chemical field. There is so much new information being printed that the books that we have become accustomed to using are soon out of date. Work has already started on this idea. A list of references has been compiled and is available. While the list is extensive, it is not believed to be complete.

Another letter suggested an index of toxic chemicals. Such an index may be a refinement of just a straight-forward compilation as suggested in the first letter above. The references could be catalogued according to the chemical name, the common name, or perhaps by the type of industry in which the laboratory or pilot plant is associated.

PUBLISH CASE HISTORIES

Still another letter recommended publishing actual case histories of the misuse of toxic chemicals and their results. Since the same toxic chemicals are used in many laboratories or pilot plants, it would no doubt be worthwhile to make available information of this kind.

Setting up a toxicology chart was another idea received. This chart could contain columns giving the name of the toxic material, maximum allowable concentration, appearance, the type of operation where this material would be used, how it is absorbed by the body, the symptoms, first aid and the safe way to use the chemical.

These are all good ideas but your committee on Toxic Chemicals needs more information both on an expansion of the preceding ideas listed as well as new ones.

It is the responsibility and moral obligation of each of us to do what we can to further the cause of safe practices which will prevent suffering and the loss of human life. Please send your ideas on the use of toxic chemicals to R. V. Montello, Research Division, National Cash Register Company, Dayton 9, Ohio.

A BIBLIOGRAPHY OF TOXIC CHEMICALS

Prepared by: Toxic Chemicals Committee,
Laboratory and Pilot Plant Group,
Chemical Section of the National Safety Council

This compilation of references on toxic chemicals is made possible through the cooperation of the following committee members: John E. Fox, safety director of the Monsanto Chemical co., Texas City, Tex.; Robert A. Quisno, president, Hill Top Research Institute, Inc., Miamiville, Ohio and Ralph V. Montello, head, materials dept., Research Div., National Cash Register Co., Dayton, Ohio. Assistance was also given by J. B. Black, department of health, education, and welfare; A. H. Christian, American Viscose Corp.; H. H. Fawcett, General Electric Co.; and J. N. Romine, Phillips Petroleum Co.

The scope of this work is aimed at presenting a list of references on the toxic chemicals useful to members of the chemical industry. It covers books and periodicals.

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WASTE DISPOSAL

by **EARL R. WALLACE**
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Editor's Note: The information presented in the following "summary of waste disposal questionnaire" should not be construed as recommended procedures. Many of the methods reported are not in keeping with safe standards. The summary was presented primarily as a beginning of committee activity to develop a good, recommended safe disposal data sheet or recommended procedures which could be used by all industries.

In order to report to you on the subject of waste disposal, a questionnaire was sent out asking for information dealing with waste disposal methods throughout the mailing list of the Laboratory Subsection. Approximately 50 corporations are represented in our mailing list and of this group 36 companies answered the inquiry.

Many of the companies who answered the questionnaire indicated the definite need for assistance, and it is my hope that this group can, through the ensuing discussion, come up with information which can be presented to industry at large as a published report through the National Safety Council's Chemical Section.

Dealing with, first, flammable liquid disposal, we find that more companies are using the incinerator method of disposal than ever before. This method may vary in its actual application, but, in general, the system operates by using an oil burner nozzle in the combustion chamber through which the flammable liquids are vaporized and burned.

Many flammable liquids can be redistilled for recovery at a fairly nominal cost thereby providing a continuing source of material for reuse or sale.

Open field burning of flammable liquids is used by many, although it is felt by some that this system presents hazards which might best be removed. The hazards of premature ignition, of odd winds and of smoke, are among those to be considered.

Today, with the high rate of community growth, indications are that available space for open field burning will be lessened considerably in the near future.

Certain groups bury flammable liquids and here, I think, we might make a note for general discussion later in the program to determine if possible the hazards of burial of flammable liquids.

Plant sewer disposal of flammable liquids is used by many, but most of those have indicated that only water miscible materials are so disposed and always with copious quantities of water.

Radioactive wastes are presenting problems to many today who, a short time ago, had no idea such a problem would exist. In this case, the best source of adequate information on disposal, we believe, is the Atomic Energy Commission.

Rivers are not used for frequent disposal of any industrial waste by nearly all plants reporting. Most plant waste water systems are operated today on the basis of well engineered and controlled systems where harmful materials (to fish, wild life, and humans) are removed. Treatment plants for industry are proving themselves valuable additions to the company's holdings.

Many hundreds of organic and other materials were forwarded with the questionnaire together with other valuable information which we hope will prove to be of some later value to our groups and others.

BURY

Rubber Dope
Vinyl Dope
Aluminum Chloride
Fluorides
Radioactive Wastes
Sulfur
Tetraethyl Lead
Radioisotopes
Parathon
Cans, Drums
Acid Cleaning Solution
Used Oil
Acetone
Mixed Solvents
Sulphuric Acid
Chromic Acid
Concentrated Sulfur Cake
Caustics

Phosphorous Oxychloride
Metallic Sodium
Aluminum Hydrides
Potassium Cyanide
Lead Acetate
Benzene
Alcohol
Styrene Syrup
Solid Noncombustibles
Fine Organic Chemicals
Tar Acids
Research Chemicals
Spent Zinc
Carbon
Radioactive Wastes
Thionyl Chloride in Chloroform
Unreclaimable Mixtures

INCINERATE

Laboratory Animals
Paper, Rags, Boxes
Paper Waste
Non-miscible Wastes
Explosive Wastes (20 gms).
Highly Toxic Wastes
Ether
Ethanol
Benzene
Radioisotopes
Solid Propellants
Radioactive Oil
Garbage
Alkyl Aluminum
Chromic Acid
Fluorides
Zirconium
Vinyl Cyanide
Phenol in water solution
Metallic Sodium
Solid Combustibles
Paint, Varnish and Lacquer Thinners
Research Chemicals
Solvents

BURN OPEN FIELD

Chlorosilanes
Resins
Varnishes
Lithium Hydride
Flammable Solvents
Cyanide Waste
Alkali Metals
Acetone
Potassium Dispersions
Metallic Sodium
Powdered Metals
Acrolein
Magnesium Dust
Titanium
Zirconium
Organic Solvents
Fuels
Lacquer Sludge
Resins
Tars and Oils

REDISTILLATION

Butanol
Acetone
Methanol
3A Alcohol
Styrene
Petroleum Solvents
Chlorinated Solvents
Mineral Spirits
Solvents

CONTROLLED VENTING

Ether
Benzene
Alcohol
Acetone
Petroleum Ether
Ethyl Acetate
Barium Trifluoride
Carbon Bisulfide
Piperazine
Vinyl Chloride

SETTLING BASIN

Trichloroethylene
Viscose Dope

SLUDGE PIT

Acids, Unknowns, and Reactive Chemicals

SEWERS

Waste filtrates from organics
Water miscible solvents—acetone, methanol, etc.,—small quantities
Acetone
Benzene
Acid or Caustic Laboratory Wastes
Highly Toxic Wastes
Detergent, Synthetic
Acids
Nonflammable Solvents
Alkalis
Inorganic Salts
Acids

RADIOACTIVE WASTES
- Corrosive Liquids
- Perchlorates
- Solvents, Oils, etc.
- Glycol Wastes
- Potassium Bromate
- Propionic Acid
- Caustics and Salts

CITY DUMP
- Charcoal
- Alumina
- Filter Cake

RIVER
- Metallic Sodium
- Chlorine Gas

SEA BURIAL
- Radioactive Wastes

SUBMERGE AND SHOOT
- Chlorosulfonic Acid

CONTRACT DISPOSAL SERVICE
- Radioactive Wastes
- Mixed Chemicals
- Phenols
- Formaldehydes
- Creosote
- Acetone
- Chloroform and Glycols

ATMOSPHERE
- Phosgene

SOLD
- Methanol
- Methylethyl Ketone

ACIDS AND HEAVY CHEMICALS

Discussion Report

R. L. ALLINSON—Discussion Leader
director of safety, Texas div., The Dow Chemical co., Freeport, Tex.

The first subject was presented by a gentleman who had asked in last year's meeting if the group felt it was reasonably safe to transfer strong acids from carboys by using air pressure. The reaction of the group at that time was negative and the gentleman on this occasion described a new system he had since set up that still utilized compressed air.

This system has a gauge in the line, then a valve, next a pressure regulator set at 2.5 pounds, then a 3/8 in. T in the line with one opening venting air to the atmosphere. The line then goes through the stopper into the canvas covered carboy but also has a leg going into a mercury seal that is an additional safety and will blow at 5 lbs. This rig is operated by the simple method of "thumbing" the small open T while visually watching the flow of acid from a dip pipe.

Another man attending suggested the use of Thompson hand pumps for this service.

The next question was on fire fighting techniques on fires around or involving storage of chlorosulphonic acid. There was no one present familiar with this problem and it was suggested that the DuPont company might be able to help.

USE OF LARGE HOSES

A discussion on the use of large hoses brought out the following points:

1. This is a specialized field because of the variety of services but in general, we have learned to use the best available for the specific purpose.
2. In attaching hoses to flanged nozzles it is wise to secure clamps to flange by steel straps.
3. The use of hose made with the rubber flanges vulcanized in place was recommended.
4. High pressure testing of hoses is practiced. There was no sure answer to the question, does this weaken the hose?

The next question dealt with the affect of ammonium nitrate on steel cables. This man has guy lines on large towers that are being deteriorated by ammonium nitrate fumes. No one present knew of anything easy to apply that would protect the steel. Coverings of rubber or plastic were suggested.

The next discussion subject was snap-on or quick couplings for small hoses. This apparently is not a problem in most plants represented. Those who did use a good many quick couplings said it is best to confine specific makes and types of couplings to specific uses to eliminate the danger of using hazardous materials in equipment and tools operated by water or air.

In answer to a question on new loading racks, one man stated that they had installed a Nichols rack and were well-pleased with it.

The next series of questioning dealt with phenol:

Question—any experience of fires where substantial quantities of phenol are involved?

Answer—no experience.

Question—are two people desirable in unloading phenol?

Answer—yes.

Question—is ethyl alcohol being used for first aid?

Answer—no—water is best first aid for this.

The next question resulted from the above and was, "Do any medical people recommend the neutralization method in field first aid on chemical burns?" No one present knew of any medical doctor that recommended anything other than water.

The subject of heating water for eyebaths and safety showers was discussed briefly. Tracing with steam and resistance heaters was suggested as well as holding tanks with regulated heat.

The techniques of fighting fires in bulk ammonium nitrate was discussed. There was little experience evidenced on this but simple water extinguishment was suggested.

Radiation was introduced but the group as a whole had little experience as yet in the use of radiation sources. One man explained the use of an elementary educational plan for employees that is available from A.E.C. The point was also made that the technical people who actually use the sources are the ones most apt to become injured due to familiarity.

One simple little test of use to people not too familiar with solvents was mentioned. This was the old trick of putting some solvent in water to determine if it is chlorinated. If it does not float, it is chlorinated.

The next question was on the use of electronic guards for machinery. There were several affirmative answers and the feeling was that most applications had worked out very well at a reasonable cost.

The next question was on the use of capacitance probe. These are used a good deal and no hazards were reported in their use.

Returning momentarily to radiation, one man stated that they had discovered that through a periodic (four times a year) dental X-ray of some employees, these people were receiving more than the recommended amount of radiation.

Floor grating was the next subject. Very few thought that common checker plate was much good. The new plate with embedded abrasives seems to work well; others recommend plates with beads welded on them for stair treads. Some of the adhering abrasives are good but need replacing periodically.

A new method is to punch plates with small holes and then invert the plate. It was also mentioned that twisted rod was superior to round stock for ladder rungs. Someone stated that they used reinforcing steel for rungs. Welding characteristics might be a problem here.

Life jackets for use around water were discussed next. Evidently not much exposure represented except some barge loading. In most cases jackets were available here and sometimes their wearing was compulsory.

The next question was on the availability of *"break-away aprons."* By this was meant a chemical resistant apron that could be ripped off easily. No one knew of any commercially available.

INDUSTRIAL GASES DISCUSSION GROUP

H. F. REINHARD, Discussion Leader
manager, Safety Codes dept., Union Carbide & Carbon corp., New York city

The meeting opened with a brief resume of the notes from last year's meeting. Some of the important safe practices mentioned in these notes were re-emphasized.

The compressed gas industry has been interested from the beginning in the safety of people who handle and use its products. The Compressed Gas Assn. and several other associations such as the National Safety Council, Manufacturing Chemists Assn., National Fire Protection Assn., National Board of Fire Underwriters, International Acetylene Assn. and The Chlorine Institute publish pamphlets on the safe handling of compressed gases. A list of 35 commonly used pamphlets published by these associations was circulated among the group. During the past year, the National Safety Council revised and reissued its Safe Practice Pamphlet 95 entitled "Compressed Gases."

Compressed gas cylinders are safe containers provided they are handled with reasonable care. Valve protection caps, if provided, should be on the cylinders hand-tight except when the cylinder is in use. Also, cylinders should not be dropped with great force on hard surfaces. Several pictures of special pallets, troughs and other devices used for the safe handling of cylinders in plants were circulated. Some of these pictures appeared in the article "Safe Practices for Handling Compressed Gases" by Messrs. H. F. Reinhard and F. R. Fetherston, published in the October issue of Industrial and Engineering Chemistry.

SULPHUR DIOXIDE FACTS

A participant asked if there is any new data on the toxicity or physiological effects of sulphur dioxide. The MAC for SO_2 which is the maximum concentration that can be safely endured for eight-hour periods is about 10 parts per million. Although he was unable to obtain a reading of one part per million in his plant, the employees complained of headaches, nausea, sore throat, etc. Since the SO_2 concentration in his plant was far below the MAC, the group felt that other factors must be responsible for the discomfort of the employees in his plant.

There is no special cylinder valve outlet thread for breathing air. The outlet connections described in American Standard B 57.1 are arranged so that each connection is used for a group of gases rather than for an individual gas. The exception to this rule is Connection 540 *(.903"—14-R.H.—ext.) which is used only* for oxygen, industrial and medical. Connection 580 which is recommended for water pumped (breathing) air, is also used for argon, helium, crypton, neon, nitrogen and Xenon when water-pumped.

Fetherston suggested that people interested in using small breathing air cylinders for deep sea diving etc., consider the adoption of the pin index system as used on small medical gas cylinders equipped with standard flush outlet cylinder valves. Two holes are drilled in the valve at specified locations for the particular gas that is in the cylinder. Matching pins are installed in the yoke connection so that only a matching yoke may be connected to a particular valve. The present system provides pin locations for eight different medical gases.

The familiar question of rocketing cylinders was raised. It was revealed that industry experience over the past 15 years *includes only two or three instances where* high pressure non-liquefied gas cylinders had apparently rocketed. The last instance occurred in Norway, a year or two ago. A cylinder valve is installed in such a way that it will shear off when struck with a sharp blow, leaving the valve inlet in the cylinder. The hole in the valve inlet is small, usually 3/16 to 1/4" which restricts the flow of gas so that the cylinder may move but will not rocket. However, the escaping gas or moving cylinder may injure nearby personnel and therefore, it is strongly recommended that valve protection caps be kept in place on the cylinders except when in use.

The question was asked if the functioning of a safety device would cause a cylinder to move. On high pressure industrial cylinders, the safety device discharge ports are designed so the flow of gas produces opposing forces. Thus a cylinder may fall over or move when a safety device functions but it will not cause dangerous propulsion. Acetylene and other low pressure cylinders will not move. However, the group agreed that cylinders should be secured at all times.

In handling a flammable gas cylinder which is involved in a fire, it is recommended that general fire fighting principles be followed. First, evacuate all personnel except those actively engaged in controlling the fire. Second, use water to cool exposed materials and the cylinder. If the flame is impinging upon structural steel or another cylinder, use a hose stream or other method to move the cylinder so that the flame does not impinge upon the steel or other cylinder. Do not extinguish the flame unless the flow of gas can be shut off because the escaping flammable gas might cause an explosive mixture which is to be feared far more than the burning of gas from a functioned safety device.

If a cylinder is involved in a fire, the user should bring this fact to the attention of the owner by attaching a tag to the cylinder valve. Fire might weaken the cylinder wall and therefore, the ICC requires that all fire damaged cylinders be retested before being charged with gas. Above all, do not try to hide the fact that a cylinder has been fire damaged by painting it.

Most compressed gas cylinders with the exception of acetylene must be periodically tested or inspected to requalify them for service. Oxygen and other high pressure cylinders are subjected to a non destructive hydrostatic test in such a manner that the permanent expansion resulting from the hydro test is measured. If the permanent expansion is below a certain limit the cylinder is suitable for continued use. Cylinders are not discarded or removed from service after a specified number of years. As long as a cylinder can pass the retest requirements it remains in service.

HELIUM IN "AIR" CYLINDER

"Is there a chance of getting nitrogen or other gas in a certified breathing air cylinder purchased with self contained breathing apparatus?" was asked. One member of the group reported that in 20 years experience of using several cylinders a year, only one such mistake had occurred. In this case the "air" cylinder was filled with helium.

Howard H. Fawcett, who presented a paper, "Living in the Air We Breathe," at the Chemical section of the Congress, mentioned that a similar mistake was made a short time ago. He recommended that "no cylinder should be put on a demand breathing apparatus or air supplied respirator, hood or suit, until the contents have been checked for purity." An orsat gas analyzer, or a Beckman paramagnetic oxygen analyzer are often used for this purpose.

A discussion on color coding of cylinders resulted from a request for information on color coding of cylinders in international service. The group indicated that color coding of cylinders was not desirable for many reasons including the fact there are more than 100 different compressed gases used in industry making it necessary to use up to four different colors on each cylinder. The only positive way to identify the contents of a cylinder is by the name of the gas printed on the label.

LIQUID OXYGEN CODE

Receiving departments should check cylinders as they are unloaded to be sure that the label is legible and intact on the cylinder. Unlabeled cylinders should be returned to the supplier without using the contents. Cylinders in international service should be labeled with both the name of the gas in the language of the country of origin and the chemical symbol of the gas. Details for labeling of cylinders are described in American Standard Z-48.1 "Method of Marking Portable Compressed Gas Containers to Identify the Material Contained." This standard is available from the Compressed Gas Assn., 11 West 42 Street, New York, N. Y.

At last year's meeting of this group, a member of the missile industry pointed

out that liquid oxygen is commonly referred to as LOX in the Missile and Rocket Industry. The oxygen manufacturers were not aware of this practice but felt that it should be discouraged because for many years the term LOX has stood for liquid oxygen explosives in which liquid oxygen is only a part. Also, tanks, sold under such trade names as LOX and LOXETTE, may be used for the storage and handling of many liquefied gases such as oxygen, nitrogen, argon, hydrogen, etc.

At that meeting the group suggested that the secretary of the International Acetylene Assn. take steps to discourage this usage. The secretary of the IAA wrote several letters to principals of the Rocket and Missile Industry. A safety engineer in the Air Force read the minutes of last year's meeting in the Chemical Section Safety Newsletter and contacted the IAA. Through his efforts, the Air Force has taken steps to discontinue the use of the term LOX. This was reported in the October 1957 issue of Missiles and Rockets in an article entitled "Liquid Oxygen Replaces LOX Abbreviation in USAF."

The Air Force is undertaking this action to prevent dangerous and possibly disastrous results of the use of the term LOX for liquid oxygen. The term LOX will be deleted from all USAF technical orders and contracts including re-identification to the Department of Defense that it also take steps to abolish the use of the term LOX.

A member of the group reported they had received a full tank car of helium, compressed in long tubes manifolded together. In attempting to open the single outlet valve, they twisted the stem off. He wanted to know how to release the pressure. It was the group's recommendation that the gas supplier be contacted in any case where the valve is found to be inoperative, whether it be on a tank car or individual cylinder.

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1958

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We hope our wholly satisfactory experience facing up to our noise problem encourages others to do likewise. If we can provide assistance from our experience, we shall be glad to do so.

TEXTILE SECTION

OFF-THE-JOB SAFETY PAYS FOR INDUSTRY

By JOHN M. McALPINE
Supervisor of Safety and Plant Protection, Calvert Plant, Celanese Corp. of America, Rock Hill, S. C.

Industry has made prodigious strides in safety during the past 25 years, reducing the accident rate from 31 to 7.

While industry was making such tremendous improvements in protecting the worker on the job, little or no thought was given to the worker once he left the plant grounds.

We have often heard the expression of hanging one's religion on the church door when leaving church each Sunday. Practically the same condition existed relative to safety. We talked safety on the job, day in and day out, always making some progress in reducing on-the-job accidents, but we said little or nothing about off-the-job hazards and their resultant effects.

For years we ignored the greatest source of accidents, "the home." Key men and women or families of such personnel were being injured and sometimes killed while going about their everyday work of keeping the home going. Their services were lost, new people had to be trained and as a result, production was affected and costs were increasing. Still, our efforts to control such accidents were either desultory or entirely neglected.

Finally, since the last World War and really within just the past few years, some men in industry have come to realize the shocking loss we were overlooking in not carrying our safety program off the job as well as at work. Now we are attempting to correct our most serious sources of injury—those occurring in the home and while enjoying the leisure time afforded by a 40-hour work week.

While watching a TV program lately, I noticed one of our largest manufacturers of electrical equipment gave all of its advertising time to safety off the job. They cited figures that, during 1958, there were nine million injuries, over half of which occurred at home. These did not include traffic accidents. It is almost unbelievable that such a situation exists, yet I am confident this particular organization would not make such a claim unless it were true.

With today's fad of "do-it-yourself", we are all performing jobs in or about the home that are strange and new to us and as a result we are unfamiliar with the various situations and inherent hazards. House painting, carpentry, plumbing, electrical installations, roofing, mowing lawns and hundreds of other such jobs fall into this category. Not too many years ago we were able to hire a handy man to perform many of the tasks we now do ourselves. For four or five dollars per month we could have a man or boy tend our garden and mow our lawns. Now it costs $1 to $1.50 per hour to employ such help and as a result, we attempt to save on this expense. I often wonder if the savings is realized or not.

A very dear friend built a new home and decided to landscape and terrace the yard as a home project. This was heavy work and frequently he would come to the office in the mornings tired and worn out, his hands badly blistered. While trying to complete his project, he suffered a heart attack which laid him up for months. Fortunately, he recovered. However, he must now lead an entirely different life. I wonder how much he saved trying to do it himself.

This is only one incident indicating the price paid for jobs performed at home. To me there is no question as to this being an off-the-job injury, a severe injury to the heart. Probably all of you here could recall similar incidents that have happened to friends or acquaintances.

Another type of accident that is becoming more and more frequent is that resulting from the use of the rotary type lawn mower. In a small town near our plant, a child was killed when struck by a stone hurled by the rotary blades of the mower. Many cases are on record of severe foot injuries to

operators of power mowers. However, here is a case where experience gained in industry can pay off—the use of safety shoes. In the short time we have been keeping records, we have at least 15 cases where safety shoes have prevented serious foot injuries because our employees were using shoes purchased at our plant shoe store.

We have organized a plant *off-the-job* safety committee to assist in publicizing off-the-job safety. Through this committee we plan to contact various organizations and groups in an effort to educate them as to the hazards around the home.

Our fire chief has a most informative demonstration and talk on fire hazards that are common in the home or in an industrial plant. During the past year he has appeared before 2,500 people, service clubs, PTA's, church organizations, etc. The interest displayed by the people of our community in this demonstration is astounding. We know of two fires that have been extinguished before they caused serious damage, because the owners of these properties attended these fire demonstrations and knew the extinguishing qualities of common baking soda and were thus able to extinguish the fire with this powder.

Such experiences as this are proof that *off-the-job safety* can be and *actually is* effective and is justified economically. Possibly there are some of you who can provide similar information to your respective communities. If so, you are missing a wonderful opportunity in helping an off-the-job safety program by neglecting such an approach.

During the past few weeks there seems to have been an epidemic of fires that have caused the death of many persons who today could possibly be alive had someone taken the effort to acquaint them with a few basic facts of fire prevention or fire extinguishment.

Possibly our best source of information concerning off-the-job accidents is our medical department. Here our nurses and our doctor hear at first-hand the histories of such accidents. Here we can learn the source and the cause of these accidents.

Just within the past month we were acquainted with a severe injury that occurred in the home of one of our employees. This female employee was preparing dinner in a pressure cooker and claimed the steam from the relief valve annoyed her, so she stopped the noise by plugging the relief valve with waxed paper. All of you know the answer—the cooker blew up and the housewife was badly burned around the face, shoulders and arms.

The visiting nurse for group insurance benefits is also an excellent source of information concerning off-the-job injuries. You should talk to her at frequent intervals to learn what she knows of injuries suffered in the home or elsewhere. Also, she can give you valuable information regarding conditions in the home of the average worker. So you see we do have a source of contacting the worker in his home.

I had not intended to discuss the problem of *off-the-job safety as it pertains to traffic accidents.* However, the situation has become so acute throughout the country that I feel morally bound to comment on this tragic situation.

Daily, we are bombarded with accident facts and figures concerning the number of traffic fatalities of our state and the whole United States; the National Safety Council continues to place spot announcements on radio and television. These announcements contain warnings, admonitions and *finally, instructions* on how to drive carefully. Our highways are cluttered with signs warning us to "Drive Slowly, Slow Down, Danger Curves, Etc." We have entire radio and television programs and motion pictures made to depict the hazards of highway travel, yet the toll keeps rising and rising. Why?

The automobile manufacturers are working to make automobiles safe even though you crash into a stone wall, or turn over—or crash into another auto. It may be this *is the wrong approach to accident prevention.* Safety belts do not stop an accident, safety doors do not stop an accident. We must approach the problem from a different angle if we are really going to make our highways safe and a place to enjoy. It could be that we are making pleasure cars too powerful. It could be that we are not requiring rigid enough driver examinations, it may be that mental tests are not sufficiently enlightening to disclose persons unsuited to drive a modern vehicle.

I do not know, but I do know that our highways are so hazardous that many persons dread using them to any great extent. Today we are being warned not to use the highway on holidays unless it is necessary. I can remember when holidays were the time when the entire family looked forward to such holidays for a day's drive, a picnic and a chance to get out into the country. Today I for one and many of my friends stay home on holidays to be free from the worry of holiday traffic.

There are many contributing factors to our high death rate on the highways—the great number of vehicles, the outmoded highway—but let me call to your attention the terrible number of traffic fatalities on the Pennsylvania superhighway which, to all intents and purposes, is one of the most modern in the country.

It is my belief that the problem demands a new approach and I think that approach is through the driver of the vehicle, not the use of safety belts, safer highways are other palliatives. Certainly safety belts will help *after an accident*, and superhighways will help make more room for more cars, but is that going to reduce the number of accidents?

The problem is great and we must all do our part to attempt a solution. Last year seven of our employees were killed in auto accidents, so far this year we have had two to lose their lives in traffic accidents.

We are trying to instill safety consciousness in our workers, in the families of our workers and in the citizens of our community. We help promote the President's Safe-Driving Day. We don't think we do enough as yet, but we plan to increase our publicity, our safety instruction and our general program for off-the-job safety.

During the year 1958 we had 34 injuries occurring off the job in comparison with 44 within our plants. We had 7 fatalities occurring off the job. None occurred at work. We had 5,094 days lost through off-the-job injuries compared to 1,747 on the job—and we did not count the time charge for fatalities occurring off the job. This year to date we have had 90 injuries off the job compared to 11 at work, plus 2 fatalities off the job.

I should like to again remind you that our home is not the haven we have been taught to believe. It is truly the most dangerous place we frequent during our normal 24-hour day. It need not be this way. However, if we continue in our present habit, it will continue to be the hazardous place it has been in the past. We must control this "do-it-yourself" urge at *least* to those chores we are able and experienced in performing. You know, there used to be a saying, "Man's work lasts till set of sun, but a woman's work is never done." Today the men have caught up with the women and now our work is never done.

There are many items we can take care of, or instruct our children to care for, in making our homes safe, such as keeping toys off stairs, out of poorly lighted halls, walkways, etc., fasten floor coverings. There are many items on the market to keep scatter rugs firm.

Make sure ladders are in good condition and firmly placed; don't use makeshifts for ladders. Use care in operating a power mower and invest in a pair of safety shoes to wear when using such a tool. Don't overtax your heart; learn to relax and enjoy your home. Make it a haven from danger and enjoy every moment you can spend in it.

Finally, when driving on our highways, make your motto "Be Courteous." It doesn't cost a cent, and it can mean the saving of a *life.* I know it gets exasperating to find yourself back of a large tractor-trailer on a hill, but just realize there is a top to the hill and it will not be long until you get to a place where you may pass safely.

MARKED

NATIONAL SAFETY CONGRESS TRANSACTIONS 1960

VOL. 1

GENERAL SESSIONS

NATIONAL SAFETY COUNCIL
425 NO. MICHIGAN AVENUE • CHICAGO 11, ILLINOIS

PLAINTIFF'S EXHIBIT
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third degree burns on the right arm, right side of his chest and on his right foot. The employee was on a 10 foot pipe rack, without the benefit of a scaffold, when this accident occurred. He recovered and was back to work in approximately two weeks.

After this accident, all of the new employees were cautioned in the handling of ammonium nitrate and the accident was explained to them.

Two days later, the same conditions existed; and another new employee decided he would play it safe and disconnect the hose by tying a 15 foot section of wire to the quick coupling on the end of the hose while standing on the ground. This he did. The pressure in the unitrace line was great enough to cause the hose to whip back and forth, spraying the employee on the neck, shoulders, and arms, with hot ammonium nitrate. In addition to performing an unsafe act, his wire was not long enough. This employee was off for approximately two weeks before returning to work.

To remedy the cause of these accidents, explicit instructions were given, and the necessary drain valves were installed in the line.

After the above two accidents, all safety devices, including safety showers, were installed before any additional equipment was put into service. This was done ahead of process piping and construction.

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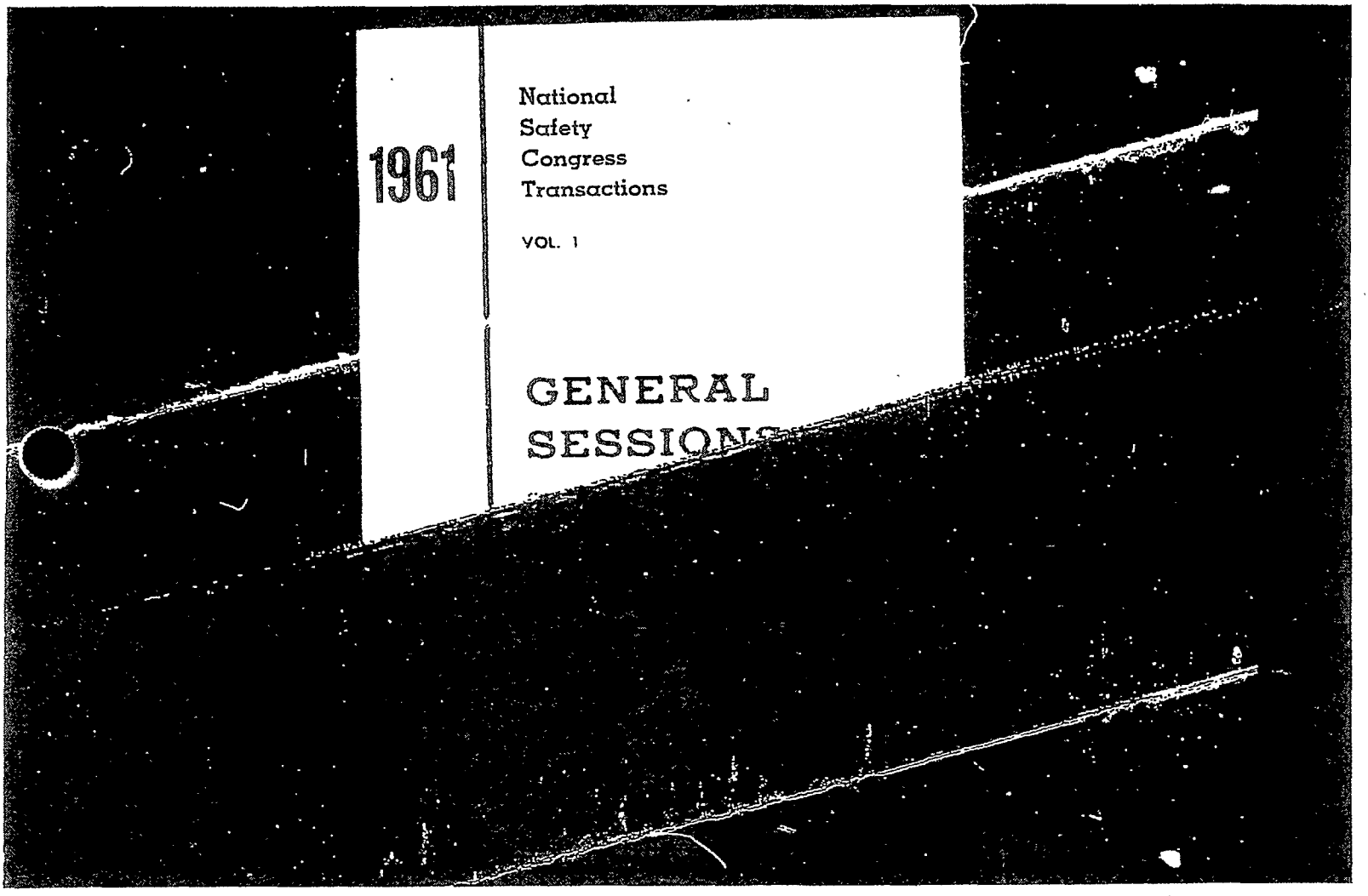
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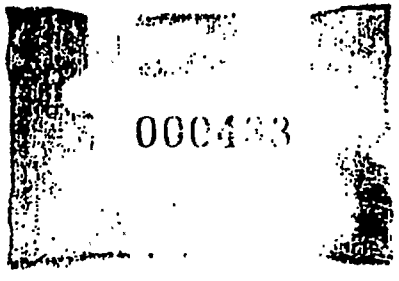
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Beryllium

Beryllium metal is being used quite extensively in the aviation and missile industries. Exposure to minute quantities of fume or dust from this metal may also cause an acute chemical pneumonitis. The maximum allowable concentration is 0.002 milligrams per cubic meter of air and concentrations as low as 0.025 milligrams per cubic meter for thirty (30) minutes are hazardous. The toxicity of this metal can be attested to by the reports of non-occupational illness caused as a result of air pollution or home contamination resulting from dust carried home on the employee's work clothes.

Recommended control procedures are to enclose beryllium machining and finishing processes as much as possible and to ventilate by means of a local exhaust system.

Carbon Monoxide

From the time man first encountered fire to the present, when the automobile contributes gas to his environment, carbon monoxide has been with us as an insidious killer. You can suspect its presence wherever there is fire, but don't be fooled into believing that just because there is a lot of air present that carbon monoxide will not be formed. To illustrate this point, take the burning of newspaper in excess air as an example. According to the experimental work performed by Easton, the following analysis of the products of combustion was found.

Carbon Dioxide	7.6%
Carbon Monoxide	6.2%
Oxygen	7.7%
Nitrogen	77.6%
Unsaturated Hydro-carbons	1.2%

The maximum allowable concentration for carbon monoxide is 100 parts per million; the concentration obtained by the burning of newspaper in excess air was 62,000 parts per million, enough to kill a man in less than five (5) minutes of exposure. Sources of this gas are smoke from a coal fire, flue gas from boilers and house heaters, gas from charcoal braziers and from coke-burning salamanders, and whenever a flame impinges upon a cold surface—just to mention a few.

Carbon monoxide is not a protoplasmic tissue poison. Were it not for its affinity for the hemoglobin of the blood, it would be classified with the simple asphyxiants such as nitrogen and hydrogen.

For some unknown and unfortunate reason, the hemoglobin's affinity for carbon monoxide is approximately 300 times greater than its affinity for oxygen. Its chief mode of action is to combine chemically with the hemoglobin and thereby deprive the body of its respiratory function. There is no further change in the system. The carbon monoxide remains thus combined until the victim is removed from the contaminated atmosphere to fresh air where the chemical process is completely reversed; that is, the hemoglobin gives off the carbon monoxide and takes on oxygen.

There are no cumulative effects from carbon monoxide for it is not a cumulative poison. The misconception expressed as "chronic carbon monoxide poisoning" is probably based on cases where there has been prolonged asphyxia which has damaged the brain too severely for complete recovery but not sufficiently enough to kill the victim. This same brain damage will result regardless of what the circumstances are that caused a deficiency in the supply of oxygen to the brain cells.

Plastics

Polyurethane foams and epoxy resins are finding wider use in numerous applications. The diisocyanates used in the production of the urethane foams are upper respiratory irritants and extreme sensitizers. Persons who have once become sensitized to these materials develop severe asthmatic attacks if they should again be exposed to extremely minute quantities of the material. Exposure to large initial concentrations will also result in an asthma-like syndrome. As a rule once a person has become sensitized, he can no longer work with or in the vicinity of this material. The best control measures for protection against exposure to the diisocyanates is to put in a well-engineered ventilation system before operations begin.

The amine hardeners used in the epoxy resin system are the principle cause of dermatological manifestations resulting from contact with these materials. We have a great deal of difficulty in trying to convince people of the importance of wearing adequate protective equipment in order to prevent skin contact with subsequent sensitization. They are inclined to ignore the warnings because in many cases the skin reactions do not appear until several months after a person has started working with the resin. Once a reaction has developed, they must exercise even greater care then required initially in order to prevent a recurrence.

High Energy Fuels

The race for missile supremacy and the conquering of space has confronted us with increased problems of exposure to high energy fuels and their decomposition products. Among these are hydrazine and the boranes — diborane, pentaborane and decaborane.

Hydrazine finds its use as a propellant fuel, either alone or with other compounds such as nitric acid, hydrogen peroxide or oxygen. It has a maximum allowable concentration of one (1) part per million, and in addition to the inhalation hazard, the material is absorbed through the skin. It is primarily a central nervous system stimulant causing excitement, convulsions and cyanosis.

Diborane is a gas at room temperature and has a maximum allowable concentration of 0.1 part per million. Inhalation produces congestion, edema and hemorrhage in the lungs. Its toxicity is comparable to that of phosgene.

Pentaborane is a volatile liquid with a tentative maximum allowable concentration

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.005 part per million; however, it is [illegible] that the exposure be kept as low as possible since no such [illegible] therapeutic agent has yet been developed for this compound.

Decaborane is a solid having a tentative maximum allowable concentration of 0.05 part per million. Both decaborane and pentaborane attack the central nervous system. Protection is best afforded by the use of air-supplied respirators or cartridge-type respirators that are specifically designed and designated for protection against these compounds.

In concluding this brief discussion, may I point out to you that the services of your local, state, and federal health agencies are always available to you. Should you desire information on the potential health hazard associated with any material or process to which you or your associates are exposed in your particular place of work, feel free to contact any one of them for assistance in evaluating the problem.

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OCCUPATIONAL HEALTH HAZARDS — MEDICAL ASPECTS

By HERBERT K. ABRAMS, M.D.
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I would like to quote from a famous writer his description of a "modern" community:

It was a town of red brick, or of brick that would have been red if the smoke and ashes had allowed it; but as matters stood it was a town of unnatural red and black like the painted face of a savage. It was a town of machinery and tall chimneys, out of which interminable serpents of smoke trailed themselves for ever and ever, and never got uncoiled. It had a black canal in it, and a river that ran purple with ill-smelling dye, and vast piles of buildings full of windows where there was a rattling and a trembling all day long, and where the piston of the steam engine worked monotonously up and down, like the head of an elephant in a state of melancholy madness. It contained several large streets all very like one another, and many small streets still more like one another, inhabited by people equally like one another, who all went in and out at the same hours, with the same sound upon the same pavements, to do the same work, and to whom every day was the same as yesterday and tomorrow, and every year the counterpart of the last and the next. . . .

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On every side, and as far as the eye could see into the heavy distance, tall chimneys, crowding on each other, and presenting that endless repetition of the same dull, ugly form, which is the horror of oppressive dreams, poured out their plague of smoke, obscured the light, and made foul the melancholy air. Strange engines spun and writhed like tortured creatures; clanking their iron chains, shrieking in their rapid whirl from time to time as though in torment unendurable, and making the ground tremble with their agonies. . . .[1]

Before you try to guess which city this is, let me tell you. Charles Dickens wrote this in his book *Hard Times*, published in 1854, describing a typical city in England during the years of the industrial revolution (1760-1830). The description sounds too familiar for comfort to us in America in 1961, at a time when we are going through another industrial revolution: automation, atomic energy, space travel, and many powerful new chemicals. They are exciting developments. They offer a promise of a wonderful world of tomorrow. However, they also pose serious threats to our health and well-being, unless they are properly controlled.

We must ask ourselves whether we are better prepared to meet these threats than the English were 150 years ago. Certainly, we are better prepared technically. In 1800, except in a few instances, little was known about the health aspects of exposure to chemicals, to ionizing radiation, or the efferts of long hours of work, poor lighting and ventilation. Today, however, our technical knowledge is sufficient, so that we can say with assurance that we know how to use any chemical with safety. We know how to set up proper protective measures to make every job safe.

The big question is, "Are we utilizing this knowledge?"

Perhaps you who represent workers in industry know the answer better than I do. Let me give you only two examples that will help provide the answer. In Illinois, in 1958, there was found "a drug packaging plant where 103 employees were subjected to a full body fluoroscopic examination each day as they left the plant as a check against pilferage. During the examination, the entire body from the top of the head to the bottom of the shoes was exposed to ionizing radiation. The firm had practiced this procedure on all employees for some 12 years, but discontinued it when advised of the hazards involved." I am quoting from the Report of the Atomic Power Investigating Commission to the 71st General Assembly, State of Illinois, March, 1959.[2]

In the same report, the study found that:

> Gross contamination and excessive levels of radiation typify nearly all radium processing installations in Illinois included in the survey. These conditions result from a lack of adequate shielding of proper routing of materials, as well as poor housekeeping within the plant, as noted by the contaminated paper and rags littering the floors, the lack of local exhaust ventilation and presence of contamination in eating areas. In addition, it was noted that labels on containers of radium-luminous compounds do not contain information as to the quantity of radioactivity included. In all radium plants surveyed, little or no use was made of personnel monitoring devices, such as film badges and, therefore, there is no adequate record of radiation exposures received by working personnel.[3]

This was Illinois, 1958—thirty years after the tragedy of the girls who painted watch dials: they pointed the brushes containing radium paint with their lips, and later died of bone cancer.

The role of environment on health grows in importance as we gradually control the infectious disease agents that caused the plagues of old, and as the chemical and physical hazards of our industrial environment become ever more important determinants of our health and our diseases. A recent report of the Public Health Service made for the House committee on appropriations states: "After hearing the evidence, the members of the subcommittee concluded that the health hazards resulting from changes in the environment are far greater than is generally realized and that all levels of government, industries, and research and educational institutions need to step up their efforts to deal with the problem."[4]

The number of chemical materials man is being exposed to is increasing constantly. Over 600 chemicals are currently being added to food; over 600 million pounds of pesticides are used annually, in the United States. Approximately 500 new chemicals are introduced on the United States market each year.

The occupational environment is the basic element in our total environment. Our occupations largely determine how and where we as individuals will live, and, indirectly or directly, may actually influence our life expectancy and our mode of death. Our industries, in addition to affecting the immediate eight-hour working environment, also largely account for the chemical and physical contaminants in the air we breathe, the water we drink, and in the food we eat.

One example will illustrate: recent studies show that people living in manufacturing areas experienced higher death rates than residents of non-manufacturing areas. The difference was greatest for cancer, and tuberculosis of the respiratory tract (mainly of the lungs), and for various forms of heart disease.[4]

Air pollution was a major factor in causing this greater mortality, but socio-economic conditions also played an important role.

Occupational Diseases

Occupational disease hazards may be classified in various ways. For example, by the type of agent which causes the disease: chemicals, in the form of liquids, dusts, gases, fumes and vapors; physical agents, such as noise, ionizing radiation, abnormal temperatures and pressures, vibration, and physical strain; infectious disease agents, such as the germ that causes brucellosis in meat-packing house workers and farmers.

Or occupational diseases can be studied according to the part of the body affected or the kind of disease. For example, many toxic chemicals may attack the skin, causing an inflammation which we call dermatitis. These or other chemicals may affect the lungs, the liver, the kidneys, the bones, or various combinations of organs of the body, and, in many cases, the entire system.

Occupational diseases may be acute and temporary, or may be chronic and long-lasting. Brief exposures to certain chemicals may produce symptoms that are of short duration, and the individual recovers quickly. A good example of this is metal fume fever, arising from inhalation of the fumes produced when certain metals are heated to temperatures above the melting point. Among the metals which can cause this are zinc, copper, magnesium, cadmium, iron, manganese, and others.

More important, however, are the chronic diseases of industry. These are the diseases of relatively long duration arising usually from long-continued exposure to relatively small amounts of toxic chemicals. Sometimes these diseases do not develop [illegible] until long after, in many cases [illegible] the exposure has stopped. A good example of this is beryllium, a metal which may result in serious and fatal lung disease up to 15 or more years after breathing the contaminated dust or fumes.

We must remember that diseases, like everything else affecting living things, cannot be put into rigid categories. Not all chronic occupational diseases need to result from long-continued exposure. Only a brief exposure to a large dose of ionizing radiation (X-ray or radioactive chemicals) may result in cancer. Similarly, a brief exposure to a sufficient dose of carbon tetrachloride may result in chronic kidney disease or liver disease. In other words, there are many variations and combinations of these conditions.

To attempt a detailed listing of all of the chemicals and metals which can cause disease would only be disturbing and confusing, and we would be in danger of not seeing the forest for the trees. Every industrial chemical is dangerous. It is merely a matter of determining how dangerous it is and establishing procedures for protecting against it. The time is past when "experts" can stand before a group of workers, or, for that matter, a group of physicians and scientists, and say without evidence that this or that chemical when absorbed into the body is harmless. I recall only a few years ago attending meetings of industrial physicians and being shown X-ray pictures of lungs of coal miners, black with inhaled coal dust, and being told that this dust was harmless. Yet, long before that time, British scientists had demonstrated that coal dust can cause disabling lung disease in miners. We in the United States were merely slow to accept the evidence.

Diseases of the Lung

The respiratory system (lungs, bronchi, and larynx) is the most frequent site of chronic diseases caused by industrial poisons. For a long time, we have recognized that silica dust, as it is inhaled by the metal miner, the foundry worker, the pottery worker, the tunnel digger and others, causes a disabling and often fatal disease called 'silicosis.' Similarly, we know that asbestos dust causes a serious lung disease called

'asbestosis.' And, there is a lung disease found in workers in the manufacture of alumina abrasives, called 'Shaver's disease' (after Dr. Shaver who described it). The dust has high concentrations of alumina and silica. Diatomaceous earth, a form of free silica, similarly causes serious lung disease. And there is byssinosis, resulting from the inhalation of cotton dust. Until a handful of years ago, some of the experts insisted that many dusts when inhaled into the lungs were inert; that is, they produced no effect on the body. However, as we learn more, we find that these so-called "nuisance" dusts are also capable of causing disease. For example, talc, corundum, feldspar, graphite, porcelain, barita, cement, mica, slate, kaolin, and many others.

Even farmers, as well as grain handlers in the holds of ships, suffer from a respiratory disability when inhaling large amounts of grain dust. They develop chronic bronchitis with shortness of breath, cough, etc. Chronic bronchitis can result from inhalation of irritating dusts, fumes and gases: for example; phosphorus chloride and other volatile chloride compounds, acid fumes, phosgene, nitrous gases, aldehydes, solvents and other chemicals.

One of the leading toxicologists in the country, Dr. Herbert Stokinger, of the Public Health Service, points out that:

> . . . our experience with occupational lung diseases makes it difficult to escape the conclusion that *all dusts*, irrespective of their nature, if breathed in sufficient quantity and for sufficient time, may cause profound damage to the lung, and emphasizes the desirability of the physician's obtaining an accurate and thorough history on individuals suspected of pulmonary disease.[1]

Other Chronic Diseases

Let me discuss a few more of the chronic disease hazards, since these are the chief occupational health problems of the present day. The chlorinated hydrocarbons, such as carbon tetrachloride, represent a large group of chemicals used in industry. These can damage the liver and the kidneys. The chemicals known as aromatic amines, represented by beta naphthylamine, used in the manufacture of dye and other commodities, have been proven to cause cancer of the urinary bladder. The central nervous system—that is, the brain and spinal cord -- can be affected by many chemicals. Tetraethyl lead causes severe brain disease called encephalopathy. Manganese, one of the important industrial metals, causes a disease that is remarkably similar to multiple sclerosis. Carbon disulphide may cause severe nervous system effects, affecting the nerves, muscles, and brain.

Serious and sometimes fatal blood diseases may be caused by exposure to benzol. Of course, we know that ionizing radiation in any form—whether through exposure to X-rays or radioactive chemicals—may cause fatal blood diseases as well as various types of cancer. The bones can be affected by exposure to radioactive chemicals, fluorides, phosphorous, and other chemicals. Cadmium affects the lungs and kidneys.

The heart may be affected by the metal known as antimony, and possibly by nitroglycerin, and there have been a number of reports that the heart may also be affected by brucellosis infection, which occurs among slaughter house workers and farmers.

Nitroglycerin and related chemicals used in the manufacture of dynamite and other explosives make an interesting story and illustrate some of the problems in occupational medicine. Workers have been exposed to this group of chemicals for many years. They have known for many years the severe headaches this chemical causes. For years, also, we have heard reports of sudden deaths among workers exposed to nitroglycerin. We do know that this chemical has a powerful effect on the body. It causes profound reduction in blood pressure, severe headaches, palpitation of the heart, nausea and vomiting, fainting, dizziness, and other symptoms. It can also cause skin inflammation. Whether it can cause heart disease is disputed. Even though we have known this chemical for many years, there has been insufficient investigation of the health hazards, and inadequate preventive measures.

Cancer

Occupational cancer is one of our most serious problems. It also provides us with a remarkable opportunity to study cancer in general. The first breakthrough in the mystery of cancer came with the discovery of an occupational cancer. In 1775, in England, Dr. Percival Pott called attention to soot as a cause of cancer of the scrotum in chimney sweeps. These were little boys who climbed into the chimneys to clean them out. Years after working in this occupation, they died of cancer of the scrotum, which was traced to the soot which penetrated their clothing. Similarly, for years we have known that an excessive number of uranium miners in Europe have died of lung cancer. (Recent studies in our own uranium mines reveal dangerously high exposures.')

Since then numerous other chemicals, in addition to ionizing radiation, have been demonstrated to be capable of causing, or contributing to the development of, cancer in various parts of the body. Some examples are beta naphthalamine, which I mentioned earlier, causing cancer of the urinary bladder, coal tars which can cause cancer of the skin, chromates which cause cancer of the lung, and many others. Recent studies have focused suspicion of lung cancer hazards in the work of welders, sheet metal workers and other metal workers.

Skin Diseases

Skin diseases are, as you know, the most frequent type of occupational disease which we see. Most of them result from direct irritation by chemical or physical agents. A smaller number result from an allergic reaction to a chemical. Almost any chemical contact can result in dermatitis. Many of the new chemicals are causing skin troubles. For example, the epoxy resins: These materials are being widely used in electronics, automotives, pattern-making, die-casting, aircraft, and other trades—for surface coatings and paints, molding compounds, various plastics, and electrical insulation. Another group of chemicals which causes skin disease are the chromates. Chrome ulcerations of the skin are well known. The chlorinated hydrocarbons also may cause skin diseases. One of them is called 'chloracne' because it resembles acne. Machinists and metal workers often get a dermatitis from cutting oils. Coal tars produce skin changes, some of which may turn into cancer. There are a host of others too numerous to mention.

Protection

These are only a few examples of the occupational disease hazards arising from contact with chemicals. The alert worker will become acquainted with the materials he is handling and the process he is using, so that he can help to protect himself and his fellows. If he should suffer excessive exposure to some harmful material, he will know what to tell the doctor who examines him. The alert doctor will be able to correlate the occupational history with the physical findings and symptoms and decide whether the patient is suffering from an occupational disease.

Very few occupational diseases produce such characteristic symptoms that they can be readily identified as an occupational disease. After all, the body can react to harmful stimuli only in a limited number of ways. For example, a worker may have severe pains in his abdomen. These might be caused by appendicitis or by lead poisoning. Leukemia may result from unknown causes or from exposure to X-rays. A person suffering a certain type of paralysis may have multiple sclerosis, a disease of as yet unknown cause, or it could be manganese poisoning. The person who has a cough, shortness of breath, and is losing weight, may have tuberculosis, silicosis, berylliosis or cancer of the lungs. A history including occupational history and a thorough examination is the only way of telling those conditions apart.

Prevention

All occupational diseases are preventable. If we were doing our job right, we would have nothing to talk about today. The fact is that unknown numbers of people are suffering from a great variety of occupational diseases because we are not adequately protecting against them. What are the protective measures which we should follow?

(1) *Education:* Employees should be given adequate training for their jobs, so that they understand the process, know the materials they are handling, and, therefore, can protect themselves and other workers from injury.

Key employees should be instructed in first aid. Management and labor both have responsibilities here. Shop health and safety committees can help in the health education of workers. *There is no substitute for knowledge.*

(2) *Protection of the environment:* This means from the air of harmful dusts, fumes, gases, vapors. This is accomplished by means of engineering measures, such as exhaust ventilation, enclosure of hazardous processes, wetting down methods for suppression of

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dusts, and substitution of less harmful for dangerous materials. Good lighting and reduction of noise, etc. are other environmental problems that the engineer can help to solve.

Only when engineering measures are not possible should respirators or other personal protective devices be depended on for protection against inhaling of harmful materials.

(3) *Good housekeeping and sanitary place of work:* This means a clean place of work, free of dirt and dust, and accident hazards. There should be adequate toilet, washing, shower, locker and eating facilities. Hand washing alone can often prevent dermatitis and other diseases. All containers of chemicals should be properly labeled.

(4) *Personal protective devices:* Wherever necessary, management should supply workers with respirators for protection against noxious dusts, fumes and gases in the air; suitable gloves and work clothing for protection from harmful chemicals; hard-topped shoes and hats for protection from falling objects; safety goggles, etc.

(5) *Medical protection:* This includes first aid facilities and a medical department. Every worker should have a periodic physical examination, not for the purpose of disqualifying him for work, but for the purpose of detecting disease early so that prompt measures can be taken to protect his health. The physician has an ethical obligation to inform the worker, or his family of any finding important to his health.

In addition to first aid and medical care for work injuries, all workers and their families should have access to modern medical care. Unions throughout the nation are obtaining such care through collective bargaining. Union health centers and other plans, such as Health Insurance Plan of Greater New York and the cooperative health plans, are attempting to bring good care, including preventive medicine, to working people.

(6) *Plant health and safety committees:* Every place of work should have a committee of representatives of the workers concerned with the health protection of the men and women in the plant. This committee should have authority to make periodic inspections of the plant and make recommendations to management. The committee should meet regularly with the plant physician, the nursing staff, the plant safety and industrial hygiene engineers, and with other representatives of management to discuss health and safety problems and to plan programs of education of the workers in these problems.

(7) *Government safety and industrial hygiene agencies:* These agencies should be called upon for help, whenever the union believes that management is not adequately providing health and safety measures in any particular problem.

How We Are Doing Our Job

How well are we doing in protecting our workers? Let me cite a few facts. The prevalence and incidence of occupational diseases in the United States is unknown, because in many states there is no reporting of occupational diseases. And, in those states where there is reporting, it is incomplete and not uniform. Moreover, we know that numerous occupational diseases are not recognized because of medical ignorance, deficiency in medical education, deficiencies in workmen's compensation laws and health and safety laws.

Health services in many private industrial plants are inadequate, and most workers are employed in small plants where such services are not provided. According to the Public Health Service, 90 per cent of the labor force is not receiving proper industrial hygiene and health services.

The governmental agencies, federal, state and local, which are charged with responsibility for protecting the health of workers, are for the most part grossly inadequate in their resources and services. They suffer from lack of funds, personnel and even from lack of authority. At least seven of our states have no occupational health units in their health or labor departments, and in all of the state occupational health agencies in the entire country, there are less than 40 physicians employed. There is no uniformity of industrial health codes and standards, and the states differ in the hazards regulated and in their regulations for the same hazards.

There is a serious and growing shortage of physicians and other health personnel both in and out of industry. Dr. Harold J. Magnuson, Chief of the Division of Occupational Health of the U. S. Public Health

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Service, estimates that by 1970, industry will need 4800 physicians, but is expected to have only 2900; while 35,000 industrial nurses will be needed, but only 26,000 are expected; and 3400 industrial hygienists will be needed, but only 1600 are expected.

Workmen's Compensation

Good workmen's compensation laws are basic to the health of industrial workers. Without strong workmen's compensation laws, it is difficult to see how we can ever have really effective implementation of our industrial health measures. The fact is that although the workmen's compensation laws are the earliest form of social legislation in the United States, they are in almost all cases hopelessly behind the times. They are inadequate in their provisions for compensation, for medical care and rehabilitation, and most of them have not been brought up to date to permit equitable recognition and compensation for the injuries inflicted by radiation and chemical hazards which cause chronic diseases, usually after long latent periods between exposure and the first symptoms of disease.

Two states still have no occupational disease coverage. Nineteen state laws cover only specified diseases. Most of the laws exclude farm work, domestic work and casual employment. In over half the states, employees in small establishments which have less than a specified number of employees are excluded, and in 12 states the laws apply mainly to a list of "hazardous" employments. Many white collar workers are today excluded from the workmen's compensation laws.

Research

The level of our research in occupational health is correspondingly low. Research is largely in the hands of private industry, and it is guided substantially by the economic needs of the particular industry. Even where research is done in universities, much of this is subsidized for special needs by private industry. Governmental agencies sporadically have made excellent contributions, but their resources are chronically inadequate. There is an urgent need for a system of research and consultation facilities in various parts of the country where workers and employers alike can go for scientific solutions to their problems.

This year, a subcommittee of the House Committee on Appropriations under Congressman Fogarty conducted hearings on these problems. These are published in a "Report on Environmental Health Problems," available through the Government Printing Office.[1] It is interesting reading. These hearings raised hope that better appropriations would be made to the Public Health Service and other agencies for an expansion of services in the environmental health field.

In the meantime, there is a dangerous vacuum in the supervision of hazards from ionizing radiation as differences prevail among the interested agencies, AEC, U. S. Public Health Service and the states, over jurisdiction in this field. At the moment, controls in this field are a patchwork with good programs in a few states like New York and California, but poor or almost non-existent programs in most others.

The implications of all this should be obvious. Occupational health and workmen's compensation vitally and directly affect the health and life of working people. Yet the unions so far, for the most part, seem to be apathetic about the new [illegible] unions are deeply involved in [illegible] ance, for the care of non-occupational diseases, perhaps there will be a resurgence of interest in the environmental factors which affect our health.

A few unions have begun to help themselves. Some have negotiated clauses in their collective bargaining agreements embodying a number of the preventive measures I outlined earlier, and have also asserted the union's right to bring expert consultants into the plant.

The United Auto Workers has a department of occupational health, staffed by two experts in safety and industrial hygiene. The International Association of Machinists has a medical consultant. The International Chemical Workers' Union also has a medical consultant and recently appointed a staff safety man. These people can be of great help to workers in providing them with expert knowledge and honest information. Obviously, however, every union cannot and should not hire its own corps of experts and set up its own research laboratories. We are dealing with big social problems, and they must be met socially.

Professor of Sociology of Columbia University, C. Wright Mills, defines the issue in this way:

No moral endeavor, no political orientation, no human study that does not pay close attention to man at work, can possibly be adequate for our time. For work is affected by and in turn affects all that man is and all that he might become. The question we must ask of any society or of any social program is what kinds of men and women does it select, encourage, create? And, in terms of this human evaluation, the most important question we can ask is whether work is a void in which men sacrifice themselves or whether work is a central feature of a style of life in which man may realize himself. . . .'

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SOME OBSERVATIONS ON OCCUPATIONAL DERMATOSES

By PAUL P. BOSWELL, M.D.
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Incidence of Industrial Skin Diseases

While there are at present no reliable statistics on the incidence of occupational dermatoses, their frequency is undisputed. Indeed, in World War II evidence indicates that there were more skin casualties than all other battle casualties in this very specialized occupation of soldiering.

In England, a three year study done between 1930 and 1932 inclusively, more than 72 per cent of all occupational diseases were found to be industrial or occupational dermatoses.

Reports from the compensation boards in seven states in this country indicated that 65 per cent of all compensible cases were occupational dermatoses. In a fashion more understandable to those of us accustomed to cost and taxes, this means an estimated loss of more than ten weeks per year with an annual cost of approximately one million dollars. This, in itself, a staggering figure.

Anatomy and Function of the Skin

With these brief statistics, it is well to ask something of their body area, so easily disposed to such great measure of damage. And *again* it is felt that a most superficial look at the anatomy and function of the skin, as it is related to this question, is indicated especially for those not related to the medical sciences.

It is not always realized that the skin is one of the most important organs of the body. In its embryonic development, it represents the first of the three primary or basis tissues formed, the ectoderm. And from this ectoderm the largest sensory organ is developed, the brain. So the skin is not only a prologue to the brain, but remains the next largest sensory organ.

The skin is an organ, a very complex organ, constituting about one sixteenth of the total body weight. It contains, within its comparatively thin structure, muscles, blood vessels, nerves, glands, specialized cells such as those that produce pigment and appendages such as nails and hair.

With over-simplification, we can divide the skin in two major layers—an inner layer, called the corium and an outer layer called epithelium. The inner layer is tough, elastic and resilient, and its chief function is to protect against normal and everyday injuries the more susceptible inner organs, and this is the skin layer which, on tanning, produces leather.

The epithelium, or outer layer, likewise protects by means of its outermost, insensitive, cornified layer, its oil gland and sweat gland secretion, and by means of pigment content. These elements are present in all normal skin and vary only by degree or quantity.

Of the many functions of the skin, the following are of particular pertinence to this discussion:

(1) It protects the under-lying tissues of the body by the physical means of resilience and elasticity.

(2) It protects by means of the relatively insensitive outer "horny" layer of the epidermis by its resistance to noxious substances.

(3) It protects the integument from actinic and other physical radiations by means of its pigments.

(4) It receives and transmits sensations of many types to the central nervous systems such as pain, heat and cold.

(5) It regulates body heat so that extremes of external temperature changes can be neutralized.

(6) It secretes water and some waste products.

(7) Finally, it has a small role in respiration and gaseous interchanges.

All of these functions are constantly being modified by internal and external influences designed to allow man to maintain some constancy in an ever changing environment.

Historical Background of Industrial Diseases

From a historical point of view, injuries suffered by the skin were known but not favored in medical writings for many years. Not until 1700 when Ramazzine published his *Treatise* was formal recognition achieved and many of his observations still hold true today.

In 1775, Percival Potts noted and described the chimney sweep cancer of the scrotum, as previously mentioned by Dr. Abrams.

Not until the early part of the nineteenth century were added interests and contributions made to this subject. Their English, French and Germans began to describe the occupational dermatoses of their era.

Not until World War I did American dermatologists begin their prolific and significant studies. At this time there was an intense revival and expansion of the chemical industries and many new areas in the field of industrial dermatoses had to be explained. These new areas are still being met with even today.

In 1928, the United States Public Health Service organized the Office of Dermatosis Investigation, which is exclusively concerned with occupational and other forms of contact dermatitis. This, in part, has led to formulation of laws in the majority of states designed to compensate workers for occupational diseases.

Predisposing Causes of Occupational Diseases

It is almost impossible to classify clearly all the professional and occupational damages to which skin is subjected. The new chemicals, the complexities of manufacture and the wide usages and the resultant chemical products increase this difficulty.

However, certain factors remain constant. I should like to summarize some of these among the predisposing factors that play an important role:

First—Illustrating the protective role of epidermal pigment, it is an accepted if not proven fact that negroes are less susceptible to certain skin irritants than other races. Thus they are the choice employees as grinders and dyers in dye factories, where irritating dusts as well as dyes are the major hazards. This is likewise true where solvents are the irritating factor as in dry-cleaning establishments. However, oils and their by-products are the chief irritants of negroes and an increase in dermatosis occurs in negroes chiefly in the form of oil acne.

Secondly—Types of skin vary markedly in individuals as well as in races. The thin, blond-skinned individual has trouble obtaining employment in those industries that bring them in contact with potential irritants and, I may add, if those industries' pre-employment examinations are adequate.

Workers with thick oily skin can tolerate the action of fat solvents, such as soap,

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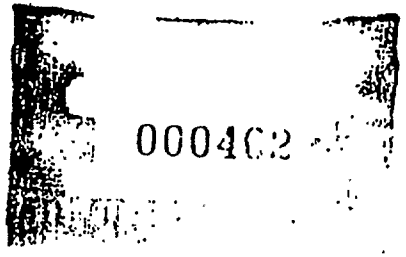
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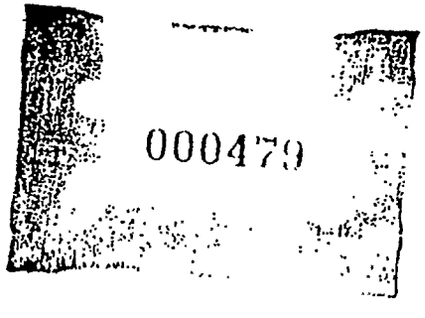
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INDUSTRIAL HYGIENE

By HENRY F. SMYTH, JR.
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Do you often see an industrial hygienist in your work place? They are not very abundant. In the United States there is one for about 40,000 employed persons, and there are even fewer in the rest of the world. We have more corporation presidents than we have industrial hygienists. An industrial hygienist need not be conspicuous when he is at work. There might have been one doing his job in your shop last week without your seeing him. But whether you've seen him or not, it is likely that you will live longer and be more useful if an industrial hygienist has looked over your shop, made recommendations to management about your working conditions, convinced them, and seen that his recommendations were carried out.

There is some disagreement about the name "industrial hygiene" and the professional title "industrial hygienist." On this morning's program Floyd Van Atta's remarks are titled occupational health, although his own title is industrial hygienist. My remarks are titled industrial hygiene, but the department in which I work is identified as chemical hygiene. Don Fowler is going to talk about industrial health, but his own title is industrial hygienist. An even wider variety of names might have appeared - environmental hygiene, or environmental sanitation would be considered appropriate by some people.

All of these names mean the same thing, the promotion of efficient, useful work with possibly harmful materials, without injury or spoiling. There is some precedent for the physician speaking of his activities as directed toward health, while the engineer or chemist works at hygiene.

It seems to me that disability or disease must have been caused by occupation ever since mankind became sufficiently social for the division of labor, for specialization. Possibly the paleolithic makers of flint arrow heads suffered from silicosis half a million years ago. We know that some industrial diseases were recognized a long time ago. Writing in the fourth century before Christ, Hippocrates, the father of medicine, discussed the effects of lead poisoning among miners and metallurgical workers.

An early example of the preventive efforts we call industrial hygiene can be found in Pliny's description of industrial operations during the first century after Christ. He relates that workers refining mercury put bladders over the face to avoid breathing the dust. Agricola, describing the mining industry of the fifteen hundreds, related that some women in the Carpathian mountains had as many as seven husbands during their lifetime, the men dying of lung diseases from the dust they breathed in the mines.[1] He described machines which were sometimes used for forcing fresh air down into the mines to control temperature and humidity, and to reduce the breathing of dust.

The first comprehensive treatise on occupational diseases was written in 1700 by Bernardin Ramazzini, a physician of Modena, in Italy. He paints a rather dark picture of the health of workers, as follows:

> Various and manifold is the harvest of diseases reaped by certain workers from the crafts and trades that they pursue; all the profit that they get is fatal injury to their health. That crop germinates mostly, I think, from two causes. The first and most potent is the harmful character of the materials that they handle, for these emit noxious vapors and very fine particles insinuate to human beings and induce particular diseases; the second cause I ascribe to certain violent and irregular motions and unnatural postures of the body, by reason of which the natural structure of the vital machine is so impaired that serious diseases gradually develop therefrom.[2]

After discussing earlier treatises which mention troubles of miners, he writes:

> We should not assume that miners in the mines nowadays are really better treated, for though they are well protected with clothes and nourished by suitable food, they come up into the untainted open air looking as ghastly as the retinue of the god of the underworld because of their stay in those foul dark places. Whatever metal they mine, they incite dreadful diseases which too often mock at every remedy, even supposing that some suitable remedy is duly prescribed; though it would seem to be a question whether it can be considered a pious duty to administer medical aid—and thus prolong their lives to the bitter end.[3]

Although Ramazzini's book is primarily about the recognition and treatment of diseases caused by the occupations, scattered through it are descriptions of actions taken to prevent disease, such as: turning the face away from a source of dust or vapor, wearing a mask of bladder or glass to reduce inhalation of dust, working only short shifts in hot or particularly dusty locations, provision of fans to blow cool clean air over the workers, and provision of clean clothing to reduce the lead exposure of painters. It is not clear whether these precautions, which are among those now recommended by industrial hygienists, were devised by workers trying to increase their own comfort and safety, or by supervisers trying to obtain greater production. In any event, it is only recently that industrial hygiene has been the full-time concern of specifically designated and trained people.

Today the requirements of industry bring an adult worker for one-fourth of his life into a substantially constant environment, where hour after hour and day after day he performs the same task, often with the possibility of contacting and absorbing the chemicals with which he works. He handles not only the traditional dangerous materials of the medieval artisan, but also many newly created materials. Some, he uses in quantities which would have been incredible a few centuries ago; the total number of industrial workers today would have been incredible then, too.

It might be thought that the industrialization of trades would have increased the frequency of injuries from chemicals but such is not the case, largely because of the body of principles and experience known as *industrial hygiene*. The assembly of workers into factories where large groups handle the same materials for long periods can actually be beneficial to health, compared to conditions in the shops of the artisans. Problems are created but others are solved. Workers using potentially dangerous chemicals are now accessible to careful medical observation for the detection of adverse response at stages where the effects are still reversible.

Supervision is available for instruction in safe working methods. Installations are planned for safe operation and, when no other means will serve, protective equipment is provided and maintained by experts. Today the industrial worker is much less likely to be injured than was his ancient fore-runner in similar occupations. But the situation of today does not justify complacency. Much remains to be done. In particular, agricultural workers, maintenance and repair men have not benefitted in proportion to those in factories. Methods of communicating what is known have not been devised to reach these workers. Improvements in the health of workers are almost proportional to the size of the groups in which they labor.

The thing which was not done in Ramazzini's time, or until very recently, is to identify and measure each possibly injurious contaminant and stress in the working environment. With measurement it becomes possible to compare exposures in different shops doing similar work, and to maintain useful records of experience. By comparison of present measurements with recorded experience, or with the conclusions of research on new substances and situations, the industrial hygienist tries to anticipate and prevent harmful conditions. He applies controls to potentially injurious situations, in order to prevent the occurrence of injury or of discomfort sufficient to reduce working efficiency.

The accumulation of experience (records of measurements of substances and stresses in work places, related to the presence or absence of effects on health) has verified our conviction, that any substance or process can be safely utilized in industry, if its use is sufficiently important to be worth the cost of protecting the workers. This is the basic viewpoint of industrial hygiene; that anything can be safely used. The costs involved may be that of equipment, such as for ventilation, or it may be that of decreased productivity, perhaps because of the inefficiency of operation through remote controls, or when burdened with protective clothing, masks, or respirators.

The demand for persons trained to be industrial hygienists arose because of the *passage of workmen's compensation laws*. These laws could never have been written or enforced if people had not begun to lose the self-centered attitudes of the jungle. If men of good will had not become common in all walks of life. It had to become accepted that the employer has a responsibility to see that the work he pays for can be done in reasonable comfort, without undue

to the worker. The new laws implemented the already agreed upon responsibilities. The employer needed a specialist to help him discharge his responsibilities; governmental agencies needed specialists to guide some employers and to monitor all. Thus arose the need which the industrial hygienist fills.

The name "industrial hygiene" was sufficiently well-known early in this century for the American *Public Health Association* to establish an Industrial Hygiene Section in 1914, for the U.S. Public Health Service to use it as part of the name of a division in 1915, and for the Journal of Industrial Hygiene to be founded in 1919. Industrial hygienists had a sufficient sense of common interest and unique purpose to establish the American Conference of Governmental Industrial Hygienists in 1938, and the American Industrial Hygiene Association in 1939.

The members of these organizations now regard themselves as constituting a profession. Like the older professions, they are taking various steps to assert their professional status. Through technical committees they are collecting, organizing and publishing for themselves the facts which they utilize in their activities. Through a certifying board they are conferring recognition as colleagues of demonstrated competence, hoping thereby to discourage the activities of incompetent pretenders. They are taking steps to set the standards for the education of their successors.

One distinction between a craft or trade and a profession is that the practitioners of a profession feel that their work is devoted in part to some high purpose in the public interest. The lawyer feels that his profession works for justice, the journalist for truth, the physician for individual health. Industrial hygiene is one of several non-medical professions which work together for public health; it concentrates on the not insignificant area of occupational health, on the control of the industrial environment to allow efficient and healthful work. Industrial hygiene has recently been defined as the science and art devoted to the recognition, evaluation, and control of those environmental factors or stresses, arising in or from the work place, which may cause sickness, impaired health and well-being, or significant discomfort and inefficiency among workers or among the citizens of the community."[1]

The industrial hygienist is one member of the group whose joint efforts are required for the maintenance of occupational health. Others of the group are the physician, the nurse and the worker himself. Each has his unique responsibilities, and one cannot perform the functions of another. The industrial hygienist studies the work operations and processes; he knows all of the materials and equipment used, the products and byproducts, and their possibilities for injury to health. He measures the magnitude of the exposure of workers, or of the public, to possibly harmful substances or influences, or to nuisances. He is particularly attentive to:

1. Vapors, gases, mists or dusts in the atmosphere—both those which may be injurious and those which are only unpleasant.

2. Temperature, humidity and air movement.

3. Noise—both audible and supersonic—and vibration.

4. Radiations such as short radio waves, heat, light, ultra violet, x-rays, and those from nuclear decay.

The industrial hygienist likewise considers the less measurable conditions of the work itself, such as:

1. Physiological stresses from physical exertion and abnormal postures.

2. Psychological stresses from monotony or tension.

The industrial hygienist may analyze blood, urine, expired air, fingernails, hair, and like biological materials, when this will assist in determining the amounts of substances which the worker meets in the working environment as an index of the need for control, or of the success of controls already instituted. Similar tests which may be done to determine the state of health of the individual worker are the responsibility of the physician.

The hygienist interprets the results of his examinations in terms of the ability of the working environment, or of the working methods, to reduce efficiency, to impair health or to create nuisances. The data with which he compares his results to judge whether tolerable or undesirable conditions exist are the accumulated and recorded experiences of industrial hygienists, occupational physicians and research workers in the medical

sciences. Figures relating to the concentrations of substances that may be inhaled at work without effect are known as threshold limits.

I am not certain that industrial hygienists have sufficient agreement concerning their objectives to offer a sound guide to those who decide upon threshold limit values. I quoted an official definition of industrial hygiene to the effect that it is devoted to the control of factors that may cause impaired health among workers. I wonder if this implies the full WHO definition of health as the state of complete physical, mental and social well-being, not merely the absence of disease or infirmity? Furthermore, does industrial hygiene aim to protect every single working person, no matter how susceptible he may be? Or does it aim to prevent injury to 95 per cent of the working population, relying upon pre-employment examination by the occupational physician to keep the 5 per cent of most susceptible persons out of the working area? Until we have agreement on this point, we will have uncertainty among those trying to decide on safe exposure value.

I myself think that industrial hygiene aims to control exposure to the extent that almost no workman can suffer discomfort or adverse effect, and that effects in the most susceptible develop so slowly that they will be detected by the alert occupational physician before they are irreversible. The degree of control the rest of the world expects is illustrated by a possibly true story one hears from various sources. The foreign production engineer was being shown through an American storage battery plant. It was cool, scrupulously clean, without a trace of visible dust, windows sparkled, and workmen were dressed in absolutely clean white coveralls, caps and gloves. The visitor looked about in amazement. He said he had seen nothing like it at home, for after-all, "making lead batteries is not a tea party."

The industrial hygienist should report his conclusions directly to management. At times, his recommendations for new installations or changes in working procedures to reduce unhealthy stresses will be feasible without undue expense or reduction in productivity. In the most desirable situation, his assignment has been the study of blueprints for the construction of a new work place. In [illegible] instance, he may suggest modifications in layout which will allow control of possible hazards to health more economically than would be possible in a already constructed shop.

In regard to toxic substances required in the operation, the recommendation will consist of suggesting some way in which the amount of substance reaching the worker can be reduced, without reducing the output of the shop. This might be as simple as furnishing a cover for a vat of volatile solvent, to reduce vapors in the air, or providing a bland hand cleaner so that the worker can wash without using a harmful and expensive solvent. It might be as complex as installation of local exhaust ventilation to remove vapors or dusts at their source, before they can be breathed. As a last resort, efficiency of work may have to be threatened by recommending respirators and protective clothing.

I have been speaking as if industrial hygiene is practiced by a single man who knows all the answers himself. In some organizations this is the case. A single person is engaged in the comprehensive practice of industrial hygiene. He may have been originally trained as a chemist, a physicist, an engineer or even as a biologist; but he is sufficiently experienced in other areas to handle all the parts of most any situation himself—he identifies suspicious substances or stresses; he measures environmental conditions; he plans and recommends control measures; he monitors their continued successful operation. At times he encounters conditions which he realizes could be handled better by others, and then he secures specialized consultation.

In other organizations, industrial hygiene is handled by a group. One man, who specializes in the acoustical aspects of industrial hygiene, will be measuring noise levels, the distribution in octave bands, and may be recommending control measures. Another man may practice the air pollution aspect, primarily concerned with monitoring and controlling the air borne wastes of the plant that reach the surrounding areas. Another may concentrate on the chemical aspect, recognizing and measuring gases, vapors and dusts in the environment. An engineering specialist may be primarily concerned with illumination, with heat and with ventilation to control exposure to substances. A [illegible] in the radiological area may be concerned with the invisible, but harmful, forces of x-ray and the newer nuclear degenerative both monitoring and control. Still another hygienist may practice the toxicological aspects, the effects of foreign substances on the body—ordinarily divided into toxicology, physiology, pathology, biochemistry and the like.

Different organizations may find it necessary or practical to utilize different combinations of these specialists within a specialty, depending on the possible hazards of the industrial operations being carried out. The profession regards a man whose experience has been almost entirely confined to one aspect of industrial hygiene as being every bit as qualified, as distinguished, as the man whose experience has been in the comprehensive practice of industrial hygiene. The latter may be personally familiar with a wider variety of possibly injurious factors in industry, but the former has a more detailed personal knowledge of a narrower range of factors.

I have tried to give you some idea of what industrial hygiene is, and what the industrial hygienist does to control the hazards and stresses of industrial operations. Like everyone else in modern civilization, the industrial hygienist is one of a team, and this team's success is related to the degree to which its members work together.

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INDUSTRIAL HEALTH ASPECTS OF LEAD COMPOUNDS

By DON G. FOWLER
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Many years ago and up until the early twenties in this country, the use of lead was extra hazardous in industry and poisonings were the rule. They were expected. Such is no longer the case. I am proud to be a member of the profession which had a great deal to do with the reversal of this situation. But we industrial hygienists were not alone in our efforts at reversing the lead poisoning trend, for this job was a good example of cooperation by industrial physicians, toxicologists and hygienists. Perhaps the key effort was that of toxicology, and as we proceed further we will understand better the reason for saying so.

Due to time limits, it will not be possible to cover in a complete manner all of the various lead-using industries and the various control methods required to prevent undue human exposure. Therefore, we will discuss some of our knowledge of the effect of lead on the human system with special reference to industrial exposure, and then proceed to a philosophy of control for human exposure in industry which should apply generally.

Toxicology

Because lead exists everywhere and in all biological organisms of which we have knowledge, its control in the human system consists first in the recognition in quantitative manner of what is normal or usual and, following this, the measurement quantitatively of the additional body burden imposed by the particular exposure. Generally, toxicologists work with small experimental animals such as rats, guinea pigs and rabbits. This is necessary because they must overexpose in order to determine toxic ranges from harmless to harmful. Ideally, of course, toxicologists should be able to work with human beings since the effect of the material under investigation always must be related to a human and it is well known that no experimental animal approximates sufficiently the human reaction.

PLAINTIFF'S EXHIBIT
NSC-26

DUSTS, FUMES, AND MISTS IN INDUSTRY

DEPOSITION EXHIBIT
#17

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Introduction

1. Industrial dusts, mists, and fumes, their hazards and their control, are discussed in this data sheet.* The general principles presented can be applied to evaluate most industrial situations involving these air contaminants and to determine the need for controls. This data sheet is intended to guide employers, plant safety engineers, personnel managers, and supervisors.

2. A plant manager who believes that he has a toxic or irritating dust problem should consult a competent industrial hygienist. Such help may be obtained from his own company, insurance carrier, private consultants, or state health or labor agency.

3. To protect the health of employees who work where a dust, fume, or mist created by a manufacturing process is released into the atmosphere, a control program may be required. In such a case, three steps must be taken:

a. The properties of the specific dust, fume, or mist and its possible physiological effects on employees must be ascertained.

*This data sheet covers toxic and irritating air contaminants encountered in industry. It does *not* include a discussion of the explosive properties of such airborne particulate matter.

This data sheet is one of a series published by the National Safety Council, reflecting experience from many sources. Not every acceptable safety procedure in this field is necessarily included. This data sheet should not be confused with American Safety Standards, federal laws, insurance requirements, state laws, rules, regulations or municipal ordinances.

b. The particular exposure must be evaluated by dust counts or by chemical analyses of air samples, and a step-by-step analysis of the operations must be made to find the areas where employees are exposed to hazardous amounts of the material. The operational analysis also should determine how the dust, fume, or mist is dispersed.

c. Appropriate methods of control must be provided where indicated. The type and extent of controls will depend upon the physical, chemical, and toxic properties of the dust, fume, or mist, the evaluation made of the exposure, and the operation that disperses the contaminant. The extensive controls needed for lead oxide dust, for example, would not be needed for limestone dust, since much greater quantities of limestone dust can be tolerated.

4. Except for the skin diseases, most occupational diseases are acquired by inhalation of material. Lung tissue is by far the most efficient medium the body possesses for absorbing materials. In addition, the surface area of this lung tissue averages 55 square meters or about 590 square feet.

5. Certain dusts that reach the lungs can pass directly into the blood stream and be absorbed over a long period of time. Others may stay in the lungs and set up local irritant or damaging action.

6. Toxic and irritant dusts can also be ingested in amounts that may cause trouble. If toxic dust swallowed with food or saliva is not soluble in body fluids, it is eliminated directly through the intestinal tract. Toxic materials that are readily soluble in body fluids can be absorbed in the digestive system and picked up by the blood.

7. A third way in which toxic and irritant substances may enter the system is skin absorption. Many organic compounds, such as TNT, cyanides, and most aromatic amines, amides, and phenols, can produce systemic poisoning by direct contact with the skin. Contact of toxic and irritant dusts with the skin also may result in skin irritation.

8. As compared to inhalation,

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23. Dust particles are, of course, attracted by gravity. Their settling rate through still air will vary with their size, density, and shape. Microscopically small particles settle out more slowly than larger particles because of their relatively minor density and because of their being influenced by Brownian movement. Mineral particles larger than 10 microns will settle out relatively fast. The estimated settling rates for silica dusts in still air are given in Table I.

TABLE I. SETTLING RATES FOR SILICA DUSTS

Size in Microns	Time to Fall 1 Foot (minutes)
0.25	590.0
0.50	187.0
1.00	54.0
2.00	14.5
5.00	2.5

24. Most of the particles in airborne industrial dusts are small. Because of air currents, the fine particles in dust clouds at an operation will remain suspended in the workroom air for relatively long periods of time. The smaller dust particles, moreover, will travel farther away from their point of origin than will the larger particles so that the farther dust is from its source, the greater the percentage of small particles it contains.

Inhalation of Dusts, Fumes, and Mists

25. With the exception of such fibrous materials as asbestos, dust particles must usually be smaller than 5 microns in order to enter the alveoli or inner recesses of the lungs. Although a few particles up to 10 microns in size may enter the lungs occasionally, nearly all the larger particles are trapped in the nasal passages, throat, larynx, trachea, and bronchi, from which they are expectorated or swallowed into the digestive tract.

26. When larger particles of certain toxic dusts are trapped in the upper respiratory passages, they can be absorbed by the body fluids in the nasal passages and in the nated. Hence the final toxic effects of larger dust particles may be delayed. The larger particles of irritant dusts can cause immediate effects in the upper respiratory system.

27. Ragweed pollen, which varies from 18 to 25 microns in diameter can cause hay fever from its action in the upper respiratory system. This type of dust and other allergenic types, as well as bacterial and irritant dusts, can cause difficulty even in the larger air-borne sizes.

28. When dust-laden air is inhaled, some of the larger particles are trapped by the hairs in the nose. Other dust particles are removed from the air as it passes over the moist mucous membranes of the nose, throat, and other portions of the upper respiratory system.

29. The bronchi and other respiratory passages are covered with a large number of tiny, hairlike *cilia* or microscopic whiplashes, which aid in the removal of dust trapped on these moist surfaces. The cilia, all bending in one direction, make a fast stroke toward the mouth and a slower return stroke. This action tends to push mucous and deposited dust upward to the mouth so that the particles can be expectorated or swallowed.

Retention of dust

30. Many studies have been made in an effort to determine the amount of dust that is retained in the lungs, but there is no simple answer to this question. It has been shown that the size of the dust particles, the rate of respiration, the density of the dust in the air, the efficiency of the dust-catching mechanism, and probably many other factors are involved.

Sizes of particles inhaled

31. Although an occasional dust particle of larger size will enter the lungs, particles less than 3 microns in diameter are the most likely to do so and thus have the greatest opportunity to cause a physiological reaction. In silicotic lungs, for example, dust particles under 3 microns greatly outnumber larger ones, and many particles are less than 1 micron.

32. In the case of very fine fibrous asbestos dust, an exception occurs in the size of particles inhaled. Many fibers up to 100 microns long have been found in the lungs

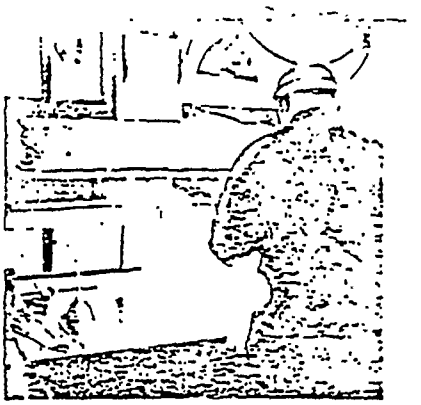


Figure 2. Metal volatilized by the heat of welding later condenses to form a fume. On this bench-welding installation, fumes are removed at their point of origin by a properly located local exhaust installation. (Courtesy American Foundrymen's Society)

of asbestos workers at autopsy. A typical fibrosis caused by asbestos is produced by fibers ranging from 20 to 50 microns in length, but only a few microns wide.

Physiological effects

33. The physiological reactions caused by the inhalation of airborne particulate matter will vary with different types of dusts, fumes, and mists. The reactions include:

a. The cardiopulmonary reaction which consists of the pneumoconioses, such as *silicosis* and *asbestosis*. In certain cases, specific types of lung pathology result, and the heart may be affected (cor pulmonale) when the fibrosis is advanced. In other cases, there is mainly just an accumulation of a relatively inert dust in the lungs.

b. The systemic reactions which are caused by toxic dusts of such elements as lead, manganese, cadmium, and mercury, by their compounds, and by certain organic compounds.

c. Metal fume fever which results from the inhalation of finely divided and freshly generated fume of zinc or possibly of magnesium or of their oxides. This is a transient condition.

d. Allergic and sensitization reactions which may be caused by inhalation of, or skin contact with, such materials as organic dusts from flour, grains, and some woods and dusts of a few organic and inorganic chemicals.

e. Bacterial and fungus infections which occur from inhalation of dusts containing active organisms, such as wool or fur dust contain-

TABLE II. SELECTED PULMONARY DUSTS (Cont'd.)

SILICATES

(Compounds made up of silicon, oxygen, and one or more metals with or without hydrogen. These dusts cause nonspecific dust reactions, but generally do not interfere with pulmonary function or result in disability.)

Fuller's earth	A hydrated silica—alumina compound, associated with ferric oxide. Used as a filter medium and as a catalyst and catalyst carrier and in cosmetics and insecticides.	50 mppcf †
Kaolin	A type of clay composed of mixed silicates and used for refractories, ceramics, tile, and stoneware.	50 mppcf
Mica	A large group of silicates of varying composition, but similar in physical properties. All have excellent cleavage and can be split into very thin sheets. Used in electrical insulation.	20 mppcf
Portland cement	Fine powder containing compounds of lime, alumina, silica, and iron oxide. Used as construction material.	50 mppcf
Silicon carbide (Carborundum)	Bluish-black, very hard crystals. Used as abrasive and refractory material.	50 mppcf
Talc	A hydrous magnesium silicate used in ceramics, cosmetics, paint, and pharmaceuticals, and as a filler in soap, putty, and plaster.	20 mppcf
Vermiculite	An expanded mica (hydrated magnesium-aluminum-iron silicate). Used in lightweight aggregates, insulation, fertilizer, and soil conditioners, as a filler in rubber and paints, and as a catalyst carrier.	50 mppcf

†Threshold limits given for substances in "Silicates" group are for compounds containing *less* than 1 per cent crystalline silica. For compounds containing more than 1 per cent *silica*, calculate *threshold limit from formula*: $\frac{250}{\% SiO_2 + 5}$

ing anthrax spores or wood bark or grain dust containing parasitic fungi.

f. Irritation of the nose and throat, which is caused by acid, alkali, or other irritating dusts or mists. Some dusts such as soluble chromate dusts may cause ulceration of the nasal passages or even lung cancer.

g. Damage to internal tissues, which may result from inhaled radioactive materials such as radium and its daughter products and from other radioisotopes that emit highly ionizing radiation.

Pneumoconioses

34. *Pneumoconiosis* comes from three Greek words that mean "lung," "dust," and "abnormal condition." The present generally accepted meaning of the word is merely "dusty lung." The kind of dust inhaled *determines* the type of condition or injury. A number of organic dusts are capable of producting lung diseases, but not all these diseases are classified as pneumoconioses because they are not all a "dusty condition" of the lung.

35. In very rare cases, enough dust had been inhaled to cause mechanical blockage of the air spaces. Flour dust has been known to cause this condition. Some dusts may be essentially inert and remain in the lungs indefinitely with no recognizable irritation, and a few like limestone dust may be gradually dissolved and eliminated without harm.

Silicosis

36. The most important lung disease caused by the inhalation of mineral dust is *silicosis*—well-known in industries where crystalline free silica dust is present, such as foundries, glass manufacturing, granite cutting, mining, and tunneling in quartz rock. It is found throughout the world, and in the past it has had many names, such as miner's asthma, grinder's consumption, miner's phthisis, potter's rot, and stonemason's disease. The same occupational disease, however, is meant by all these names, and it is caused by dust from crystalline free silica, usually quartz (see Table II).

37. Although considerable progress has been made in dust control in industry, men still develop silicosis in plants and on jobs where dust control is not adequate. Engineering control is still the basic means of preventing this disease, and dust control equipment and procedures must be carefully maintained.

38. *Definition.* Silicosis has been defined as "a disease due to breathing air containing silica (SiO_2) characterized *anatomically* by generalized fibrotic changes and the development of miliary nodulation in both lungs, and *clinically* by shortness of breath, decreased chest expansion, lessened capacity for work, absence of fever, increased susceptibility to tuberculosis (some or all of which symptoms may be present), and by characteristic X-ray findings."*

39. *Factors of influence.* Silicosis has been known to manifest itself after widely differing periods of exposure to silica dust. Apparently, development of the disease depends upon:

a. The amount and kind of dust inhaled.
b. The percentage of free silica contained in the dust.
c. The form of the silica.
d. The size of the particles inhaled
e. The duration of the exposure.

*"Report (Joint) of the Committee on Pneumoconiosis and the Committee on Standard Practices in Compensation of Occupational Diseases." *Year Book* 1933 American Public Health Association, 1790 Broadway, New York 19 p 100.

physiological effects of these products have not been well defined. Until more experience with human beings is available, it is believed these products should be handled with care.

57. *Free silica and silicates.* Free silica is uncombined silicon dioxide (SiO_2). Silicates contain silicon and oxygen combined with other elements in a more complex molecule. Analyses of minerals, particularly in geological reports, are sometimes reported as percentages of oxides, which may include SiO_2, Al_2O_3, K_2O, Fe_2O_3. The SiO_2 reported in such chemical analyses is the total of the silicon dioxide present, both the free silica (if present), and the silica combined in the mineral. Such analyses are not reliable indications of the silicosis potential of the material.

58. It is uncombined or free silica that is most important in industrial dust exposure. So that an exposure can be properly evaluated, the percentage of uncombined silica must be determined by petrographic analysis using a polarizing microscope or, preferably, by X-ray diffraction analyses and special analytical chemical procedures.

59. There has been some experimental evidence that some dusts may tend to inhibit the action of silica on the body, but this inhibiting action is so slight and uncertain that it must be discounted in practice. In fact, there also is evidence that the nonsiliceous components of a dust mixture containing free silica may provoke a disabling condition more severe than that caused by the silica acting alone.

60. With the exception of asbestos and some talcs, the silicate dusts do not ordinarily cause a serious disabling lung condition such as is produced by free silica. Much higher levels of silicate dusts than of free silica dust can be tolerated.

61. In many industries, men have worked with silicate dusts that contained no free silica without development of disability or of nodulation in the lungs. The X-ray may show shadows indicating dust deposits in the lungs, but the pneumoconiosis is essentially harmless. However, partially disabling pneumoconioses have been reported where men have worked for long periods of time in very high concentrations of certain silicate dusts.

62. Disabling pneumoconioses from exposure to abnormally high concentrations of mica, tremolite talc, and kaolin dusts have been described in the literature. The clinical signs are not the same for these silicate dusts as for free silica, but the symptoms can be marked.

63. The body does not have adequate defense against indiscriminate amounts of dust of any kind. Therefore, although specific symptoms have not been described for many mineral dusts, the general experience would indicate that dust levels should be kept within threshold limit values or below (Table II).

Asbestosis

64. Asbestos is a general term applied to several minerals having a fibrous character. These asbestos minerals are hydrated silicates of magnesium with variable amounts of iron, calcium, sodium, potassium, and aluminum present as impurities.

65. Asbestos when inhaled produces fibrous tissue in the lungs of both men and animals. It has been shown that fibers of asbestos must be present for the production of *asbestosis.* Other silicate minerals of the same chemical composition but nonfibrous in form produce no reaction or a relatively mild reaction, but not the severe reaction of fibrous asbestos dust.

66. These facts lead to the conclusion that asbestosis is mainly the result of physical irritation of the lung tisssue and not of a chemical action, which is thought to be one of the causes of silicosis. It is suspected that lung cancer may be induced by asbestos. However, there is no impressive amount of evidence to support this assumption.

67. The fine air-borne fibers of asbestos can pass through the upper respiratory tract to the lower parts of the lungs to cause irritation and to form "asbestos bodies" where the fibers are encapsulated. This diffuse fibrosis probably begins as a "collar" about the terminal bronchioles. There is evidence that other minerals having a fibrous character can produce a reaction similar to that of asbestos. Fiber glass, however, does not produce such a reaction.

68. Following a study by the U. S. Public Health Service of the asbestos textile industry,* it was recommended that the dust concentration be kept at less than 5 mppcf to prevent asbestosis. Evaluation of an exposure to abestos dust is based on the *total* amount of dust because it has proved out in practice that if the fine dust is kept below the suggested threshold limit, the concentration of injurious fibers will also be kept within safe limits.

Talcosis

69. As used in industry, "talc" is a very general term. To the geologist, talc is a hydrous magnesium silicate, which may be a relatively pure mineral or may be mixed with tremolite or with dolomite depending upon where it is mined. The term "talc" is applied commercially to carbonate mixtures that have the same general feel and physical properties; it also is applied to pyrophyllite, a hydrous aluminum silicate, which frequently is mixed with a high percentage of quartz. The free silica generally found with pyrophyllite can cause silicosis. It is therefore essential to know which talc is being used in order to evaluate a specific dust exposure.

70. *Talcosis* is usually associated with tremolite talc. This disease produces changes in the lungs and symptoms similar to those of asbestosis.

Anthracosilicosis

71. *Anthracosilicosis*, a complex form of pneumoconiosis, is a chronic disease caused by breathing air containing dust that has free silica as one of its components and that is generated in the various processes involved in mining and preparing anthracite (hard coal)** and, to a lesser degree, bituminous coal.

72. The disease is characterized anatomically by generalized fibrotic changes throughout both lungs and by the presence of excessive amounts

*Dreesen, W. C., Dalla Valle, J. M., Edwards, T. I., Miller, J. W., and Sayers, R. R., *A Study of Asbestosis in the Asbestos Textile Industry*, U. S. Public Health Bulletin No. 241, U. S. Public Health Service, Washington 25, D. C. 1938.

**Anthracosilicosis among Hard-Coal Miners, U. S. Public Health Bulletin No 221, U. S. Public Health Service, Washington 25, D. C., 1935.

TABLE III. SELECTED TOXIC DUSTS AND FUMES (Continued)

Substance	Description and Effects	Threshold Limit in Milligrams per Cubic Meter of Air*
Manganese	Silvery gray metal. Hazardous from inhalation of fumes or dust.	5.0
Pentachlorophenol	Dark-colored flakes. Harmful dust. Emits toxic fumes when heated.	0.5 (skin**)
Phosphorus (yellow)	Poisonous mainly by inhalation. Severe burn hazard from skin contact.	0.1
Picric acid	Yellow crystals or liquid. Explosive—particularly metallic salts. Emits toxic fumes on decomposition.	0.1 (skin**)
Selenium compounds	Toxicity varies somewhat according to the solubility of the specific compound. Often causes contact dermatitis.	0.1
Sodium hydroxide	White, deliquescent pieces or lumps. Has severe action upon all body tissue.	2.0
Tellurium	Similar to selenium chemically and in physiological effects.	0.1
Titanium dioxide	White to black powder. Considered in the nuisance category.	15.0
Trinitrotoluene	Colorless to yellow monoclinic crystals. Emits toxic fumes of oxides of nitrogen when heated to decomposition. Highly poisonous explosive.	1.5 (skin**)
Uranium	Highly toxic and a radiation hazard that requires special consideration.	0.05 (soluble compounds) 0.25 (insoluble compounds)
Vanadium pentoxide	Yellow to red crystals. Acts chiefly as an irritant to the conjunctiva and respiratory tract.	0.5 (dust) 0.1 (fume)
Zinc oxide fume	Amorphous white or yellow powder. The powder is essentially nontoxic, but freshly generated fume may cause metal fume fever.	5.0
Zirconium compounds	Most compounds are insoluble and have low toxicity.	5.0

*These threshold limit values were adopted by the American Conference of Governmental Industrial Hygienists in 1962.

**The word "skin" in this table indicates that the substance can penetrate the skin to contribute to the exposure.

of the individual, may be alarming in a general X-ray screening program. On clinical examination of individuals showing the X-ray markings, however, often no disability or symptom can be found.

81. These shadows are frequently encountered when the dusts contain atoms of relatively high molecular weight because the heavier atoms are fairly opaque to X-rays. Insoluble barium dusts and tin oxide dusts, for example, can show very marked shadows on X-ray films without producing signs of significant pathology (barium dust that is soluble in the body fluids can give a toxic reaction).

82. Iron oxide, particularly excessive fume from welding operations, may produce *siderosis* with a pigmentation of the lungs (black in welders and red in iron ore miners) without disability. The X-ray shadows produced by the iron oxide in the lungs are somewhat similar to the shadows from silicosis. Because of this similarity, differential diagnosis is often difficult, and heavy exposures to iron oxide dust and fume may lead to medicolegal problems. It is therefore important to control iron oxide exposures even though siderosis is not disabling.

83. Limestone, marble, lime, gypsum, and portland cement dusts apparently have no serious effect even after long exposures. Also, many silicates and other minerals have not caused impairment in individuals inhaling the dusts, and the resulting pneumoconioses are generally classed as benign.

Toxic Dusts and Fumes

84. Systemic reactions are caused by toxic dusts and fumes of various elements and their compounds and by certain organic compounds. All metallic fumes are irritating, especially when freshly generated. Industrially important metals and their compounds that can have a toxic effect when the dust or fume is inhaled include arsenic, antimony, cadmium, chromium, lead, manganese, mercury, selenium, tellurium, thallium, uranium, and a few others.*

85. The effect of some metals, such as magnesium and zinc, appears to be transient. Only limited data are available on the exotic and rare earth metals.

86. Although the dusts and fumes from metals with low toxicity do not need as much attention as the dusts and fumes from highly toxic metals, they should not be neglected or disregarded. The metals with low toxicity are controlled more readily because greater amounts can be tolerated, but their dusts and fumes should be kept at reasonable levels since excessive amounts of any of them can be harmful (Table III).

Lead poisoning

87. Although extremely severe cases of lead poisoning are rare in industry today, lead exposures must be controlled to prevent even the moderate symptoms, which can be

*See the following National Safety Council Data Sheets: *Antimony and Its Compounds*, 408, *Arsenic and Its Inorganic Compounds*, 499; *Cadmium* 312, *Lead*, 443; *Magnesium*, 426, *Manganese*, 306, *Mercury*, 203, *Titanium* 485, *Zinc and Zinc Oxide*, 267, *Zirconium Powder* 382.

[illegible] from the [illegible] of bacteria and fungi exists in several industries. Pulmonary anthrax from the inhalation of dust containing anthrax spores has occurred among employees engaged in the handling of wool and the crushing of bones from infected animals.

105. Fungi (molds) growing on grain have been found in sputum of workmen shoveling the grain and are believed to be the cause of outbreaks of respiratory disorders. Fungi found in sugar cane residues (bagasse) are believed to be part of the cause of *bagassosis*. Fungal spores formed under the bark of some trees have been blamed for respiratory difficulties among employees who debark dry logs.

106. Although the incidence of occupationally related bacterial and fungal infections is found to be relatively low, the respiratory effects can be troublesome and, in the case of pulmonary anthrax, even fatal. The basic methods of control are the same as those for the pneumoconiosis producing dusts, but sterilization and disinfection must be added.

Radioactive Dusts*

107. A radioactive contaminant may offer a chemical toxicity hazard in addition to an ionizing radiation exposure, and it may be present as a gas, dust, fume, or mist.

108. Radioactive contaminants taken into the body may be deposited in various organs where they constitute sources of internal radiation. The chemical characteristics of the radioactive contaminant or isotope determine the organ in which it will be deposited. The excretion rate is also dependent upon the chemical nature of the isotope; because the radioactive isotopes of an element follow the same metabolic process as do the stable isotopes of that element.

109. If a radioisotope has been deposited in the body, the internal exposure is regarded as continuous until the isotope is lost by radiological or biological decay. In some cases, exposures may last a lifetime.

110. Since radioisotopes are selectively taken up in individual organs, they may cause only localized irradiation. The radiosensitivity of the organ dictates the extent of the hazard of a particular radioactive substance. Solubility and particle size determine how much of the active material will gain access to and remain in the blood stream and various organs.

111. If radioactive air-borne contamination is known to be present, control measures are mandatory. If the presence of contamination is unknown but suspected, sampling must be done to determine whether or not air-borne concentrations of the radioisotope are below the threshold limit value.

112. Good personal hygiene and good operating techniques are much more important in the handling of radioactive materials than in the handling of most other materials used in industry.

113. Engineering controls for radioactive dusts are similar to those for other dusts and depend primarily upon capture at the point of generation. The difference lies in the fact that controls for radioactive dusts must be extremely efficient. Threshold limit values for radioactive particulate matter are very low, and in some cases 100 per cent efficiency in capture and retention is required.

Permissible Dustiness

114. Threshold limit values of mineral dusts and toxic dusts—that is, time-weighted average concentrations considered permissible for exposures of eight hours per day, five days per week—have been published by the American Conference of Governmental Industrial Hygienists. These values have been obtained from the experience of many groups in industry and from laboratory studies on animals. They are reviewed annually and changed as necessary on the basis of experience.

115. These values are set only as guides for the best practice and are not to be considered absolute values. There is reasonable assurance that occupational disease will not occur if exposures are kept below these levels. On the other hand, occupational disease is likely to develop in some people if the recommended levels are exceeded consistently.

116. The currently recommended threshold limits of particular dusts can be found in the most recently published ACGIH list, or the ACGIH can be consulted directly. Information on threshold limits also can be obtained from the National Safety Council, state occupational health agencies, the American Industrial Hygiene Association, and compensation insurance carriers.

117. No one knows the exact concentration at which men will start to develop silicosis, asbestosis, or lead poisoning. With some toxic dusts, however, experience has been wide enough to establish the present threshold limits as fairly reliable.

118. For example, if the level of lead in a workroom is kept below 0.2 mg/cu m, experience has shown that cases of lead intoxication will not occur. Experience also has shown that many men can tolerate lead levels well above 0.2 mg/cu m without signs of trouble.

Mineral dusts

119. In the United States, the threshold limits for mineral dusts are expressed in millions of particles per cubic foot of air (mppcf). The concentration of a mineral dust is determined by counting dust particles that are less than 10 microns in size in an aliquot sample after sampling a known volume of air in a known volume of liquid. In some European countries, mineral dusts are weighed, and permissible levels are expressed as milligrams of dust per cubic meter of air (mg/cu m). In England and some other areas, the number of particles per cubic centimeter is the current basis of measurement.

120. In comparing United States and foreign dust counts, it is helpful to keep in mind that 100 particles per cubic centimeter is equivalent to approximately 3 million particles per cubic foot.

121. It is difficult to compare dust counts with results obtained on the basis of weight. However, with either type of measurement, a threshold limit can be set as an objective. Experience has shown that maintaining dust levels below the recommended threshold limits has resulted in a great decrease in the incidence of occupational diseases.

122. Threshold limits are based on the percentage of free silica where this substance is the impor-

*For a detailed discussion of radioactivity and an extensive bibliography, see the chapter entitled "Ionizing Radiation" in the *Accident Prevention Manual for Industrial Operations*, published by the National Safety Council.

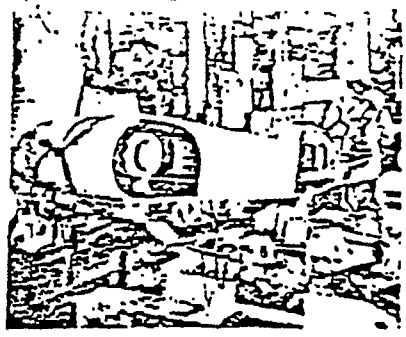


Figure 4. Since this swing-frame grinder is used in a variety of positions, the local exhaust system must be adjustable. The flexible duct (A) permits movement of the exhaust hood (B) as needed. (Courtesy American Foundrymen's Society)

nevertheless, should not be considered as a universal substitute for adequate local exhaust removal, elimination of the contaminant, or containment.

129. Many states and municipalities have dust control codes or ordinances with which employers must comply. In a few states, for instance, written approval of plans must be obtained before a local exhaust system is installed. Each employer should therefore know his state and municipal dust control requirements.

130. Each type of exposure must be considered separately. For example, a local exhaust system suitable for welding or cutting of steel might not be satisfactory for welding or cutting steel coated with red lead.

Local exhaust systems

131. A local exhaust system for the control of an industrial dust or fume traps the air contaminant near its source so that an operator standing at the process is not exposed to harmful concentrations. The system should be designed to enclose the process as completely as possible. This method usually is preferred to general ventilation, but should be used only when the contaminant cannot be controlled by isolation, process revision, or substitution of less harmful materials. Even though a process has been isolated, it may still require a local exhaust system.

132. A local exhaust system consists of four principal parts:

a. Hoods or other inlets, into which the air-borne contaminant is drawn.
b. Ducts, to carry the contaminated air to a central point.
c. Dust and fume collectors, to clean the air before it is discharged.
d. A fan and motor to keep the air moving through the system.

133. While each of these parts should be designed and installed to perform its required function with respect to the system as a whole, design of the exhaust hood demands the greatest care. The degree of control of dust at the point of generation or dispersion is determined by the shape of the hood or degree of enclosure, the location of the hood and its distance from the dust source, and the rate of flow of air into the hood. A poorly designed hood can make an exhaust system ineffective.

134. There is no standard hood. In every case, the hood must be designed to fit the specific operation and to make the exhaust effective without interfering with the operation (Figure 4). Among the factors to be considered are the natural air currents in the room and other exhausts or windows in the area.

135. The hood should be shaped to conform to the shape of the area of dust production so as to secure reasonably uniform air velocity over this area. A hood which does not enclose the process should be placed with its opening as close as possible to the point of generation of the dust or fume (Figure 5) because the velocity of the air in the zone of the hood influence is inversely proportional to the square of the distance from the face of the hood.

136. The hood opening, or part of it, should be located so as to receive directly dust that is thrown off along a well-designated path (Figure 6). The directional energy of the material can thus be used for its own capture. Air movement must always be past the employee, then over the dust source, and directly into the face of the hood.

137. The fan should be of sufficient capacity to maintain the required air capture velocity at the point of generation of the dust. Internal baffles should be installed to guide the air flow where it is most needed. Flanges should be provided wherever possible to reduce the air flow from areas where no dust is produced; that is, air-flow contours should be controlled.

138. Enough air must be supplied to the room from the outside to replace the air that is removed by the exhaust system. Otherwise, there will be interference with other exhaust systems in the area or with gas or oil flames in nearby furnaces. Great difficulty has occurred where an exhaust system caused a slightly negative pressure in a room containing a gas furnace. As a result air came down the furnace flue, and the area became contaminated with carbon monoxide from the furnace.

139. With small exhaust systems, air that is removed usually can be replaced by infiltration flow, but larger exhausts may need a positive air supply (Figure 7). An adequate supply of make-up air, tempered when necessary, is one of the most frequently overlooked fundamentals of ventilation. Air always should be supplied in quantities equal to or slightly in excess of the amounts exhausted.

140. The size of the ducts, the type and size of the dust collectors, and the type and size of the fan and motor (explosion-proof where necessary) are among the other factors which must be considered in the design of an exhaust system. Preventing ignition of a combustible

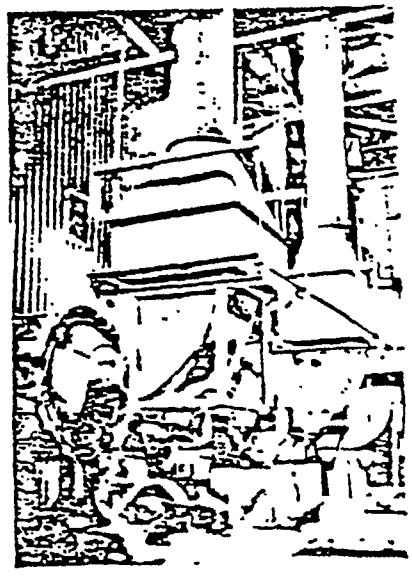


Figure 5. To achieve the proper exhaust air velocity, the hoods for these barrel furnaces can be positioned as close to the furnace opening as practical. Such positioning is made possible by mounting the hoods on a trolley suspended from an overhead track. (Courtesy American Brake Shoe Co.)

hygiene should not be overlooked. The periodic medical examinations provide a good opportunity for instruction of employees in various personal hygiene measures.

157. Good washing facilities, clean lunchrooms, and clean work clothes can help prevent additional, even though minor, exposure to toxic materials. Also, contaminated work clothes should not be taken home where a toxic dust could contaminate the home or expose other members of the family. These recommendations become mandatory where such materials as beryllium and radioisotopes are handled.

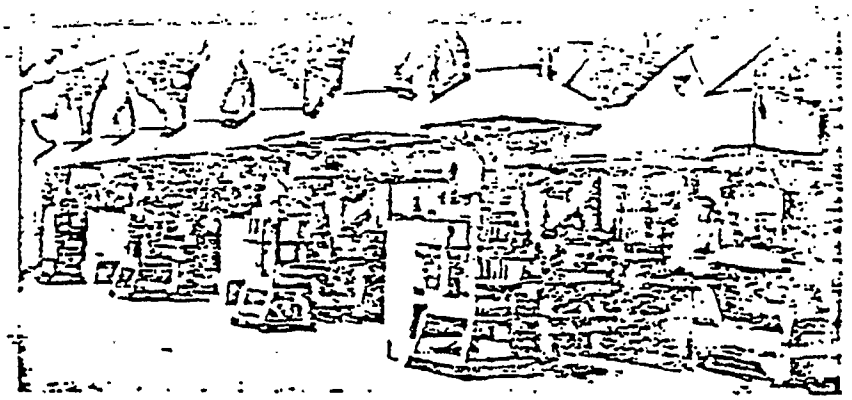


Figure 7. In this foundry, local exhaust hoods are installed over each station having a shell-molding machine and glue press. Adequate make-up air is supplied from ventilating duct situated between molding machines and presses. (Courtesy American Foundrymen's Society)

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1964

National Safety Congress
Transactions

Volume 5

CHEMICAL and FERTILIZER INDUSTRIES

NATIONAL SAFETY COUNCIL
425 N. Michigan Avenue
Chicago, Illinois 60611

52nd NATIONAL SAFETY CONGRESS

Papers delivered in the

CHEMICAL SESSIONS

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ORIENTATION FOR NEWCOMERS OR OTHERS INTERESTED IN CHEMICAL SAFETY: A DISCUSSION

Question from floor: In the slide illustrating safety ladders for the paper *Handling Hazardous New Chemicals*, there was a bar acting as a gate at the entrance to the top of the ladders. What causes the bar to close after opening?

Answer by David T. Smith: That's just a gravity return. We used to have them spring loaded but found those difficult to maintain as long as they were exposed to weather.

Question from floor: Does your company furnish safety shoes free to supervisors?

Answer: It is not company policy to subsidize safety shoes at its plants. However, at our location, we make many hazardous chemicals that we do not want employes taking home on their shoes. Other considerations enter also. Therefore, we subsidize safety shoes for all supervisors who enter production areas. That is, all of them, but at this plant only.

Question by J. Pralules: Grant Shibley, would you describe how the National Safety Council can help us with our work in safety?

Answer by Grant Shibley: (Description of the National Safety Council.) Come on in fellows, and meet us at the Council. Personal contact helps understanding.

Question by Ted Swenson of Helene Curtis: There is not much available on research and development safety. Can you help us with this?

Answer: The laboratory subsection of the Chemical Section meets on Thursday and you will be interested.

There is a lot of information on hazardous properties of materials. The National Safety Council publishes Data Sheet 486 (revised), *Chemical Safety References* covering this. I believe they also publish Safety Practices Pamphlet No. 60 on laboratory safety.

We have this problem of getting information for the newsletter. We would like to see articles written on "Safety in Reactions," "Spacing and Layout of Pilot Equipment," "Hazards of Working Alone," and "Handling New Chemicals."

Answer by Howard Fawcett: I have recently given a paper on chemical safety literature at a meeting of the American Chemical Society's Division of Chemical Literature. This was the first time that I know of that this subject was recognized as a separate branch of the literature by that Division. Steps will be taken now to categorize chemical literature under "Chemical Safety," where that heading is applicable. The paper has a lot of useful references for you people and if you write to me in Schenectady, I will mail any copies I have left.

The Manufacturing Chemists Association publishes a "Guide to Safety in Chemical Laboratories," 234 pages for $5.50. The Villanova Press, Villanova, Pennsylvania published a chemical laboratory safety pamphlet in 1963. This costs 75 cents.

I would like to take this opportunity to announce that W. S. Wood and I have the galley proofs in hand of a book we have just edited, to be published by the Interscience Division of John Wiley and Sons early in 1965. There are 520 pages in 31 chapters by various authors. The title is *Safety and Accident Prevention in Chemical Operations*. I want to give Bill Wood credit for yeoman service on this job. I mention this because I know you gentlemen are interested. We feel this book fills a gap in the literature and answers some of the questions that come up here.

Question by Bob Mills of General Cable: There was an article in the New York Times about the possibility of asbestos workers developing cancer. What are the facts about this hazard?

Answer by Dr. Floyd Van Arta: This question is about 25 years old. It has not been settled by any incontrovertible, definitive evidence of excessive cancer amongst asbestos workers. I suspect there may be something to this idea because of its persistence, but no completely thorough investigation has ever been made. One reason is that there is a better recognized hazard which also leads disability and death. That is asbestosis. If we make every effort to

eliminate asbestosis, it seems likely we will have done what we can to eliminate the cancer hazard also.

Question by a Safety Director: Gentlemen, we have 17 drums of hydrazine stored in a field at our facility, and I would like a suggestion on how to dispose of them. Unfortunately, these drums have lost their integrity.

Answer by H. H Fawcett: Hire somebody to remove the drums to a safe area. If no private contractors are willing to bid, call the Army Corps of Engineers. Actually, your supplier should be able to handle those drums.

Whoever moves the drums should take them out into a remote area and detonate them one by one. I have had the problem of getting rid of old gas cylinders which had been standing in various parts of the laboratory for years. They were unidentifiable and possibly dangerous. I took them out in a field and blew the valve off each with five turns of detonating fuse (Primacord), set off by blasting caps. I set them off one at a time.

Answer by Dave Smith: On that hydrazine you could also use special explosive caps, remotely exploded, which could detonate a drum.

Statement from floor: Mr Fawcett, when you set off those gas cylinders, you should have first dug a hole and set them upright in it. You were taking a chance of having them take off like a rocket when you knocked off the valve.

Answer by H. H. Fawcett: Yes, it is safest to set them in a hole.

Question from floor: Gentlemen, before we digress any further, I suggest that we haven't answered the question of the Safety Director of NASA in Atlanta. He isn't worried about *how* they destroy this stuff; he just wants somebody to get it out of his field *before* they blow it up.

Question by H. H. Fawcett: Did you call your supplier?

Answer by Safety Director: Our supplier refuses to deal with us any further on this matter. Also the Army Corps of Engineers and the Air Force have demurred from offering help or advice. Frankly, when I get back to my office on Thursday, I will be ready to consider any contract based on a reasonable proposal to get rid of this hydrazine, if it hasn't left by that time.

Answer by Dr. Floyd Van Atta: John Roche at Edgewood Arsenal would know as much about this problem as anybody. You can write to him. This illustrates a point that must be considered about handling any new chemical. That is, how are you going to dispose of hazardous products and by-products of your process. Here you see what happens when you don't make adequate provision.

Question from floor: I have come to this session three years in a row now, and this is the third time the general question of disposal has come up. We should have a session or some further discussion of the problem.

Question from floor: Mr. Chairman, there is another aspect of this question of securing information about obscure problems. We have often asked other organizations for answers and find that firms or societies do not wish to admit full hazards for business reasons, or they wish to maintain secrecy for its competitive advantage. Can the National Safety Council arrange meetings to develop this information without reference to specific sources. This may reduce some people's fear of talking.

Answer by J. Pralulos: Yes, next Thursday, we are conducting a series of conferences on safety in various subsections of the Chemical Section. We have group discussions on *Fine Chemicals, Acids and Heavy Chemicals, Laboratory Handling of Chemicals in Rocket & Missile Industry* and *High Pressure Processing*. The session on high pressure processes covers a typical area where few people want to be put on the record. You should join discussions that interest you.

Answer by Howard Fawcett: This is a problem because questions of safety people often impinge on process security. Often higher officers of large companies are more generous with such information than the lower ranks.

Statement by Grant Shibley: You can also write and ask us directly; we will try to get the answer for you. Our motto is, "There Are No Secrets in Safety." We have not had a lot of trouble getting information we needed for our publications.

You should attend discussion sessions. You can bring up your own questions there; and many points will be discussed in detail that will not be recorded in the notes or printed in the transactions.

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1964

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PLAINTIFF'S EXHIBIT
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for Industrial Operations

5th EDITION

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PLAINTIFF'S
EXHIBIT
1542(2)

PLAINTIFF'S EXHIBIT 1542(3)

velocity. This type of dispersion is known as dynamic projection and is a result of the kinetic energy of the particle's motion. As the mass of the particle decreases, however, a point will be reached when its kinetic energy (which is one-half the mass times the square of the velocity) is too small to overcome air resistance. The particle's forward velocity is thus minimized and it remains suspended in the containing air mass.

As a rough approximation, macroscopic particles (those visible to the naked eye) are considered to be dispersed by dynamic projection. Microscopic particles (those visible only through a microscope) are considered to have a mass so small that their movement is dependent on the containing air mass. Contaminants such as the larger dust particles, mists, and sprays, which are dispersed by dynamic projection, can cause external injury such as acid burns, eye damage, and dermatitis. The microscopic particles are dangerous to health if inhaled.

Separation in airborne dusts

Dust in the air may or may not have the same composition as its parent material. The determining factors are the particle size and density of each component in the original mixture, and the hardness of the materials (hard materials will resist the pulverizing action of a mechanical device).

For example, foundry molding sand contains a large percentage of free silica with a lower percentage of clays. Most of the clays consist of fine particles that can be airborne, but most of the free silica particles are too large to be airborne. The airborne dust, therefore, as compared with the original mixture, may contain a much higher percentage of clays and a much lower percentage of free silica.

Dust particles are, of course, attracted by gravity. Their settling rate through still air will vary with their size, density, and shape. Microscopic particles settle out more slowly than larger particles because of their relatively minor density and because of their being influenced by Brownian movement. Mineral particles larger than 10 μ will settle out relatively fast. The estimated settling rates for silica dusts in still air are given in Table 39-A.

Most of the particles in airborne industrial dusts are small. Because of air currents, the fine particles in dust clouds at an operation will remain suspended in the workroom air for relatively long periods of time. The smaller dust particles, moreover, will travel farther away from their point of origin than will the larger particles so that the farther dust is from its source, the greater the percentage of small particles it contains.

TABLE 39-A.

SETTLING RATES FOR SILICA DUSTS IN STILL AIR

Size (μ)	Time to Fall 1 ft (minutes)
0.25	590.0
0.50	187.0
1.00	54.0
2.00	14.5
5.00	2.5

Mechanism of inhalation

With the exception of such fibrous materials as asbestos, dust particles must usually be smaller than 5 μ in order to enter the alveoli or inner recesses of the lungs (see illustration of the bronchial tree in Chapter 42, "Ionizing Radiation"). Although a few particles up to 10 μ in size may enter the lungs occasionally, nearly all the larger particles are trapped in the nasal passages, throat, larynx, trachea, and bronchi, from which they are expectorated or swallowed into the digestive tract. When larger particles of certain toxic dusts are trapped in the upper respiratory passages, they can be absorbed by the body fluids in the nasal passages and in the digestive tract before they are eliminated. Hence the final toxic effects of larger dust particles may be delayed. The larger particles of irritant dusts can cause immediate effects in the upper respiratory system.

Ragweed pollen, which varies from 18 to 25 μ in diameter can cause hay fever from its action in the upper respiratory system. This type of dust and other allergenic types, as well as bacterial and irritant dusts, can cause difficulty even in the larger airborne sizes.

When dust-laden air is inhaled, some of

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When dust-laden air is inhaled, some of

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In very rare cases, enough dust has been inhaled to cause mechanical blockage of the air spaces. (Flour dust has been known to cause this condition.) Some dusts may be essentially inert and remain in the lungs indefinitely with no recognizable irritation, and a few (like limestone dust) may be gradually dissolved and eliminated without harm.

Silicosis is the most important lung disease caused by the inhalation of mineral dust. It is well-known in industries where crystalline free silica dust is present, such as foundries, glass manufacturing, granite cutting, mining, and tunneling in quartz rock. It is found throughout the world, and in the past it has had many names, such as miner's asthma, grinder's consumption, miner's phthisis, potter's rot, and stonemason's disease. The same occupational disease, however, is meant by all these names, and it is caused by dust from crystalline free silica, usually quartz.

Silicosis has been defined as "a disease due to breathing air containing silica characterized *anatomically* by generalized fibrous changes and the development of miliary nodulation in both lungs, and *clinically* by shortness of breath, decreased chest expansion, lessened capacity for work, absence of fever, increased susceptibility to tuberculosis (some or all of which symptoms may be present), and by characteristic X-ray findings."*

Silicosis has been known to manifest itself after widely differing periods of exposure to silica dust. Apparently, development of the disease depends upon:

1. The amount and kind of dust inhaled.
2. The percentage of free silica contained in the dust.
3. The form of the silica.
4. The size of the particles inhaled.
5. The duration of the exposure.
6. The powers of resistance of the individual concerned.
7. The presence or absence of a complicating process such as infection.

Many theories have been advanced over the years to explain why crystalline free silica acts as it does in the lungs. It is now believed that the fibrosis produced is caused not by the hardness or sharpness of the particles, but by a combination of slight solubility with a physiochemical effect and an immunological effect—but no one is certain of the exact mechanism of the disease. Experimental work on the reasons for the development of silicosis is still going on in various parts of the world. If the precise mechanism of silicosis could be determined, better medical preventive measures might be developed and possibly a cure could be found.

Amorphous free silica differs from crystalline free silica in physical structure and in physiological effects. In the amorphous state, molecules of silica are randomly oriented and may be naturally crystallized to opal and diatomaceous earth (Kieselguhr) or artificially converted into such forms as silica gel, silica fume, and fused silica or quartz.

If amorphous silica is heated to a high temperature, as in calcining, forms of crystalline free silica called cristobalite and tridymite result, intermediate forms of amorphous silica are known as crypto-crystalline (ultra-microcrystalline). Inhalation of these crystalline forms can readily cause diatomite pneumoconiosis.

When diatomaceous earth is calcined, particularly in the presence of a trace of alkaline flux, appreciable quantities are converted to cristobalite. As a result of studies made by the U.S. Public Health Service, it has been recommended that the threshold limit value for crude or amorphous diatomite be placed at 20 mppcf (million particles per cubic foot), but that the atmospheric concentration for dust containing cristobalite be kept under 5 mppcf.

Various commercial products containing particles of silica under 1 μ in size are available. The physiological effects of these products have not been well defined. Until more experience with human beings is available, these products should be handled with care.

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*American Public Health Association, 1790 Broadway, New York City. "Report (Joint) of the Committee on Pneumoconiosis and the Committee on Standard Practices in Compensation of Occupational Diseases." *Year Book*, 1933.

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Free silica is uncombined silicon dioxide (SiO_2). Silicates contain silicon and oxygen combined with other elements in more complex molecules. The SiO_2 reported in chemical analyses for mineral and geological reports is the *total* of the silicon dioxide present, both the free silica (if present), and the silica combined in the mineral. Such analyses are not reliable indications of the silicosis potential of the material, because it is the uncombined or free silica that is most important in industrial dust exposure. So that an exposure can be properly evaluated, the percentage of uncombined silica must be determined by petrographic analysis using a polarizing microscope or, preferably, by X-ray diffraction analyses and special analytical chemical procedures.

There has been some experimental evidence that some dusts may tend to inhibit the action of silica on the body, but this inhibiting action is so slight and uncertain that it must be discounted in practice. In fact, there is also evidence that the nonsiliceous components of a dust mixture containing free silica may provoke a disabling condition more severe than that caused by the silica acting alone.

With the exception of asbestos and some talcs, the silicate dusts do not ordinarily cause a serious disabling lung condition such as is produced by free silica. Much higher levels of silicate dusts than of free silica dust can be tolerated. In many industries, men have worked with silicate dusts that contained no free silica without development of disability or of nodulation in the lungs. The X-ray may show shadows indicating dust deposits in the lungs, but the pneumoconiosis is essentially harmless. However, partially disabling pneumoconioses have been reported where men have worked for long periods of time in very high concentrations of certain silicate dusts. Disabling pneumoconioses from exposure to abnormally high concentrations of mica, tremolite talc, and kaolin dusts have been described in the literature. The clinical signs are not the same for these silicate dusts as for free silica, but the symptoms can be marked.

Asbestosis. Several minerals having a fibrous character are classed as "asbestos"—hydrated silicates of magnesium with variable amounts of iron, calcium, sodium, potassium, and aluminum present as impurities. The fine airborne fibers of asbes... pass through the upper respiratory tr... the lower parts of the lungs to caus... tion and to form "asbestos bodies" ... the fibers are encapsulated. This ... fibrosis probably begins as a "collar" ... the terminal bronchioles. There is ... that other minerals having a fibrous ch... ter (except glass fiber) can produce a ... tion similar to that of asbestos.

Following a study by the U.S. P... Health Service of the asbestos textile ... try,* it was recommended that the dust ... centration be kept at less than 5 mpp... prevent asbestosis. Evaluation of an ... sure to asbestos dust is based on the ... amount of dust, since the concentrati... injurious fibers will be kept within ... limits if the fine dust is kept below ... suggested threshold limit.

Miscellaneous pneumoconioses. E... though a dust is classified as har... amounts above the TLV can lead to ... by causing a pneumoconiosis, mechan... irritating the walls of the respirator... or interfering with ordinary lung ... Mica dust and kaolin dust are two goo... amples of dusts that ordinarily are ... ered benign but amounts above the TL... cause a troublesome pneumoconiosis. ... pneumoconiosis has been observed in ... ing operations where mica dust, but n... silica was present. There were ... changes in the X-ray pictures of the ... and some disability. The cases occ... where the dust exposures were massiv... many years.

Toxic dusts and fumes

Systemic reactions are caused by ... dusts and fumes of various elements ... their compounds and by certain organ... pounds. All metallic fumes are irritat... pecially when freshly generated. Indu... important metals and their compounds ... can have a toxic effect when the d... fumes are inhaled include arsenic, an... cadmium, chromium, lead, manganese, ... cury, selenium, tellurium, thallium, va... and a few others.

*U.S. Public health Service, Wash... D.C. "A Study of Asbestosis in the A... Textile Industry." Bulletin No. 241. ...

PLAINTIFF'S EXHIBIT

NSC-17

000508

1965

National Safety Congress Transactions

Volume 1

GENERAL SESSIONS

ANNUAL MEETING OF MEMBERS

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We are faced with the need to develop new techniques; new equipment; and new thinking if we are to develop and produce the mineral materials which remain immediately available to us, let alone find new deposits covered by hundreds of feet of overburden.

Contrary to the situation which existed 50 years ago, there is, today, a real dearth of qualified candidates for the jobs available in our industry. There is an acute lack of young people training for technical or supervisory positions. The closing of mining schools, due to a lack of students, is shocking. I cannot help but attribute these conditions to the unfortunate image which has been created.

Our Nation is committed to assist new nations in their efforts to improve living standards and our industry is dedicated to do its part in meeting domestic needs as well. Neither of these objectives can be met unless we make a dramatic change in manpower availability. Competent technical skills will be needed to help the emerging countries develop and produce their resources as well as find ore-bodies not readily apparent from surface manifestations. Similar talents will be urgently needed at home if we are to maintain our own standards of living.

As a result of these almost unprecedented demands, every effort must be made to present to the potential candidate for a natural resource career a true story of the opportunities that exist within our industry.

Conservatives in the mining industry have been slow to recognize that a revolution has hit our industry. Science has been let in the back door with seeming reluctance. The mining engineer is, too often, regarded as a doer rather than as a thinker, and little credit has been given to the development of the mineral sciences.

In modern mining one can see at least three distinct fields of scientific application which are rapidly becoming apparent. The first requires an approach from pure mathematics and physics to rock mechanics and environmental engineering. The second requires an approach from statistical mathematics to valuation, control and economic engineering. The third embraces the social sciences with applied physiology, ergonomics and even psychology invading the field.

All of these revolutionary changes from 50 years ago can do little if we neglect to provide a safe and stable working environment. Where our fathers designed and supported their workings by shrewd instinct and experience, we can today add some qualitative knowledge; and our sons will add growing precision in numerical prediction.

With so many obvious opportunities and challenges facing our industry, the need for talent is at once apparent. We must point out to our sons that these opportunities exist and that they are as fully challenging as any which are publicized in the exotic and sophisticated fields of space or communication. We must emphasize that ultimate tragedy is not the reward for a minerals career and this is attested to by the record we have made. We must point out that our mining communities offer families opportunities to develop under the influence of the best academic, medical, religious, cultural and recreational facilities.

This is not a new problem, but the urgency is more acute than when Agricola, in 1556, reported as follows:

"Many persons hold the opinion that the metals industries are fortuitous and that the occupation is one of the sordid trades and altogether a business requiring not so much skill a labour. But as for myself, when I reflect carefully upon its special points one by one, it appears to be far otherwise. For the miner must have the greatest skill in his work. . ."

Modern nations, like man, do not live by bread alone, but by the evergrowing consumption of metals for tools and their products. Nations desperate for these metals often take ill-conceived measures to acquire them. A hungry world is not a peaceful world—and the world is hungry for tools with which to produce.

We must, therefore, be in a position to assist in the orderly location and development of new ore deposits wherever they may occur in the world. Only a well-trained cadre of skills, available to our neighbors, will allow our industry to make significant contributions to world stability.

The Russians, like the Roman of yesterday, put political prisoners and conquered peoples in their mines. God grant that our Nation will never be faced with such an alternative, but be assured that our national welfare would be seriously jeopardized without our mineral products and survival could well dictate such actions.

Even though Agricola pointed up our problem over 400 years ago, little progress has since been made in appraising the public of our importance to them. Our vote potential is so much less than "other minority groups" that our voice is seldom heard or our problems considered in political circles. Commitments of national minerals significance are too often made without painstaking consultation and analysis which under emergency circumstances can dangerously deplete our existing mineral supplies without feasible plans for replacement.

I cannot help but repeat again and again —we must not let another 400 years go by before effectively appraising the public and its political representatives of our industry's significance to national well-being, its opportunities, its challenges, its security, its true family environmental advantages, and its working conditions.

You men in this accident prevention field, closely cooperating with industrial relations people, have laid a firm foundation and have built a sound structure. You have a marketable product for America and the world.

Our job is now to sell ourselves. Only in this manner can we hope to have men in the mines and minerals available to avert national disaster and meet our world commitments to bring an enduring peace to a mineral-hungry world.

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DUST HAZARDS RELATED TO HEALTH

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The overall problem of dust hazards related to health is only partially solved. Much has been learned in the past and put to use; much remains to be done. The complex problems which remain require combined efforts in the fields of engineering, physics, chemistry, toxicology, physiology, pathology, and medicine.

One link, or relationship, between hazards and their adverse effects on health is the assessment of exposures to predict their biologic effects. Precise and specific means of assessment would permit accurate predictions of effects, and economical and effective control of the hazards. Completely satisfactory methods for the assessment of exposures to dusts are not yet proved or in use.

Precise definition of the cause-and effect relationships in the *pneumoconioses* is especially difficult, because disease may first appear a number of years after initial exposures.

This discussion reviews some of the relationships between dust hazards and health by considering the nature of dust, the way the respiratory system copes with dust particles which are inhaled, some of the aspects of sampling to measure degree of exposure, and some of the effects on health which may result from excessive exposures.

The Nature of Dusts

Dust particles which are hazardous to health when inhaled are invisible to the unaided eye. The smallest particles ordinarily seen without magnifying devices are about 30 or 40 microns in size; those which are hazardous are ordinarily smaller than 5 or 10 microns. (1 micron is approximately 1/25,000 inch.)

Small particles, those in the range of 1-micron diameter, behave in air much differently than do particles which are large enough to be seen. These small particles, once airborne, remain in the air for long periods of time. For example, quartz particles of 1-micron diameter settle only 0.01 foot per minute in still air. In turbulent air, if sedimentation is the only mechanism of removal, half of the 1-micron quartz particles in a 7-foot-high space would still be

airborne 8 hours after generation of dust had stopped. A 1-micron quartz particle projected into still air with an initial velocity of 10,000 feet per minute (about 100 miles per hour) will lose its momentum in a distance of 0.01 inch and will thereafter settle or move with air currents. Particles smaller than about ¼ micron (0.3 micron for quartz, 0.7 micron for coal) in diameter are affected more by forces of diffusion than by the force of gravity. At ordinary temperatures, the Brownian displacement in air of particles of this size is about the same as their Stokes settling velocity, about 1 millimeter per minute. Thus, the dynamic characteristics of small particles are such that once airborne, for all practical purposes, they move with air currents. Sedimentation has a negligible effect upon dust particle concentrations in normal work situations, and the kinetic energy they possess at generation is quickly dissipated.

Particle size is also important in matters involving the composition of dust. Dust produced by drilling or crushing rock does not necessarily have the same composition as a sample of the parent rock. Even in dust which has become airborne the small particles may have composition different from the larger ones. Three kinds of samples, host rock, settled dust, and airborne dust were obtained from each of nine locations in metal mines. Two fractions of the settled dust samples were analyzed; one fraction contained all particles which passed through a 325-mesh screen (—325 mesh fraction), the other contained only particles smaller than about 5-microns diameter (—5 μ fraction). The airborne samples were taken well downstream from the points of generation to permit large particles to settle prior to sampling. These results indicate decreasing free silica content with decreasing particle size.

Data from some coal mines show more ash in airborne dust than in the coal being mined. In the airborne dust from these mines, the sample fractions containing only particles of small size have a lower percentage of free silica than do the fractions with particles of larger size. For example, the fraction containing only particles smaller than 5 microns may contain 2 percent free silica, whereas the gross airborne sample may contain up to 20 percent.

The coal seems to break along seams of high impurity or high ash content, but in the dust generated, the particles of quartz tend to be larger than those of the other minerals. These data illustrate that mechanics and particle dynamics have effects upon the composition of dusts.

Respiratory System

The respiratory surface in the lungs of a normal man ranges from about 300 square feet at rest to about 1000 square feet at deepest inspiration. The membrane separating the alveolar air space from circulating blood may be only one or two cells in thickness. In the course of an 8-hour day of moderate work, a man breathes about 300 cubic feet of air. Contrast the forced ventilation exposure of the large delicate lung surface with the ambient air exposure of the skin, which has some 20 square feet of surface and a thickness measured in millimeters. It is evident that the lungs represent by far the most extensive and intimate contact of the body with the ambient atmosphere.

The respiratory tract of man branches successively from the trachea to some 25 to 100 million ultimate branches. These branches terminate in some 300 million air sacs, or alveoli. The cross section of the trachea is about 2 square centimeters, and the combined cross sections of the alveolar ducts, which handle about the same quantity of air, are about 8,000 square centimeters.

The aerodynamic behavior of particles varies with size, density, and shape. Discussion of dust deposition in the respiratory system is simplified by the concept of "equivalent size" of particles. The equivalent size of a particle is the diameter of a unit density sphere which has the same terminal falling velocity in still air as does the particle.

The respiratory tract, with its successive branches and tortuous passageways, is a highly efficient dust collector. Essentially, all particles greater than 4 or 5 microns equivalent size which enter the respiratory system are deposited in it. About half of those of 1-micron equivalent size appear to be deposited and the other half exhaled. The sites of deposition in the system are different for various sizes.

Some studies indicate that particles greater than 2½ or 3 microns equivalent size are deposited, for the most part, in the upper respiratory system, that is the nasal cavity, the trachea, the bronchial tubes, and other air passages; whereas particles 2 microns in equivalent size are deposited about equally in the upper respiratory system and in the alveolar or pulmonary air spaces. Particles about 1 micron in size are deposited more efficiently in the alveolar spaces than elsewhere; essentially none are collected in the upper respiratory system.

Although the respiratory system is a very efficient dust collector, all of the dust collected is not retained. The system has a highly efficient mechanism for removing the collected dust. For example, during 30 years of work a coal miner may inhale and collect in his respiratory system 10 to 15 pounds of dust, but after this 30 years, his lungs may contain only 0.1 to 0.15 pound of dust. The efficiency of removal is thus in the order of 99 percent.

The primary mechanism of clearance in the upper respiratory system is ciliary action. The respiratory tract, from the epiglottis to the terminal bronchioles, is lined with cells having minute hair-like processes called cilia. The cilia, by continuous whip-like motion, cause a blanket of mucous-like fluid to flow upward on the surfaces of the air passages. This blanket carries dust particles and other foreign material upward and out of the respiratory tract to be swallowed.

Surfaces in the alveolar spaces do not have cilia. The primary clearance mechanism here is phagocytosis. Phagocytes are cells which engulf foreign materials such as dust particles. These cells appear in the lungs, possibly by disengaging from the surface lining, and migrate with their burdens of foreign material either to the pulmonary lymph system or outward to the ciliated air passages, where they are carried away by the ciliary action.

Because the efficiency of lung clearance is so great, a small decrease in it may result in a great increase in the amount of material retained in the lungs. Several observations on interference with lung clearance have been made. The efficiency of lung clearance appears to decrease with increasing lung dust burden. Irritant gases have been shown to decrease or stop ciliary action in animals. Some materials which appear to be toxic to phagocytes reduce their effectiveness in removal of material from the pulmonary spaces. The mechanisms of pulmonary deposition and clearance deserve, and undoubtedly will receive, a great deal more study.

Dust Sampling

Any program for control or reduction of exposures to dust requires a means of assessing exposures. Since the etiologies of some occupational diseases, particularly the pneumoconioses, are not fully known, it is not possible to define all the characteristics that contribute to the toxicities or biologic effects of dust. All of the sampling methods used in different parts of the world for estimating exposures to mineral dusts are empirical. None is an absolute method which will yield data from which the hygienic significance of exposures can be precisely judged.

In the United States, the American Conference of Governmental Industrial Hygienists promulgates Threshold Limit Values for toxic materials for use by industrial hygienists as guides in devising control of occupational exposures. Threshold Limit Values have been developed for a number of toxic dusts. The Threshold Limit Values for dusts with systemic toxicities, lead or cadmium, for example, are ordinarily expressed in mass units, i.e., in milligrams per cubic meter of air.

Sampling for such materials may be by filter or other means which collect all of the airborne material. The Threshold Limit Values for pneumoconiosis-producing mineral dusts, on the other hand, are expressed in terms of particle count; the customary unit of concentration is millions of particles per cubic foot of air (mppcf).

The Threshold Limit Values for mineral dusts can be used to judge only data yielded by a standard procedure of impinger sampling in liquid medium and lightfield microscopic counting of the collected dust. The Threshold Limit Values for mineral dusts cannot be applied to data from other particle count methods of sampling.

The standard method of impinger sampling and counting was presented in 1942 at a meeting of the National Conference of Governmental Industrial Hygienists. Because the method is empirical, it must be followed closely by all its users if data obtained by one person are to be comparable to those

obtained by another. Even then, variables in sampling and counting within the method as it is described may permit two investigators, both applying the method skillfully and conscientiously, to obtain quite different results to represent the same environment.

Sampling may have different purposes, which merit employing different techniques. These generally fall into two major categories: (1) sampling for engineering surveillance, testing, or control and (2) sampling for health research or epidemiologic purposes.

Engineering applications of sampling may include locating sources of contamination, monitoring performance of environmental control systems, or doing research in such problems as collection efficiencies of air cleaners. A sampling program for engineering purposes should be designed to yield the specific information desired. For example, one might need only a single sample before and another after a change in ventilation to determine whether the change has had the desired effect.

Hygienic applications of sampling, on the other hand, may be directed at predicting the health effects of an exposure by comparing sampling results with hygienic guides, determining compliance with health codes or regulations, or research to define as precisely as possible environmental factors for comparison with observed medical effects. In the latter case, sampling may provide the basis for development or refinement of hygienic guides such as Threshold Limit Values.

Sampling for atmospheric particulates presents quite different from those of sampling for gases and vapors. Gases and vapors, when inhaled, can penetrate all portions of the pulmonary system and follow the laws of distribution by diffusion and absorption. The sizes and densities of particles, on the other hand, are major influences in determining the sites at which they will be deposited in the pulmonary system. Since the effects produced by particles trapped in the nasal passages or deposited in the ciliated portions of the pulmonary system may be quite different from those of particles which are deposited deeper in the pulmonary system, size-selective sampling is generating increasing interest among industrial hygienists.

At the Pneumoconiosis Conference held in Johannesburg, South Africa, in 1959, in which experts in pneumoconiosis from all over the world participated, it was concluded that in the light of present available evidence the best single parameter to measure in the case of coal dust, is the mass concentration of respirable dust, and in the case of quartz dust, is the surface area of the respirable dust.[6]

The respirable fraction of a dust cloud was then defined as all particles smaller than 1 micron, half of those of 5 microns, and none of those 7 microns or larger in equivalent diameter. Sampling devices have been developed to sample this respirable fraction. They either reject particles too large to penetrate to the deeper portions of the lung or collect larger particles in a pre-sampler so that the respirable portion can be collected separately for weighing and analysis.[7]

The results of sampling for dusts using such devices, either for gravimetric determinations or for determination of composition, cannot be interpreted by use of our current Threshold Limit Values or similar guides for judging exposures. Such sampling, however, may represent a sensitive method for predicting the disease-producing potential of exposures to mineral dust.

The devices might also be used to distinguish the portion of an exposure to toxic dusts which results from pulmonary absorption and the portion which results from absorption through the gastrointestinal tract. Such samplers are worthy of much greater study and use than they now receive in this country.

Some Effects from Exposure to Dust

The two types of occupational diseases which may result from exposure to dust are the pneumoconioses and chemical intoxications. Pneumoconioses are diseases of the lungs which result from exposure to dust. Chemical intoxications are not limited to the lungs and are characterized by local or systematic effects, which result from reaction to, or absorption of, toxic material.

The most common pneumoconioses are silicosis, coal workers pneumoconiosis, and asbestosis. These diseases are characterized by pulmonary fibrosis, which is detected by chest X-ray examination, and by impairment of pulmonary function as the disease progresses.

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In 1963 the Public Health Service [illegible] available knowledge should be applied toward control, but this is not sufficient to assure that the disease can be economically controlled in all cases. Additional medical and engineering studies are needed to find the most reasonable, economical, and sure means of control.

In 1963 the Public Health Service published a report by the Service and the Bureau of Mines on a study of silicosis in the metal mining industry.[2] In this study some 1,000 workers at some 50 metal mines were examined. X-ray examinations showed a crude prevalence of 3.4 percent silicosis among the study population. The prevalence of silicosis among underground workers was about twice that among surface workers, 4 percent versus 2.2 percent. Underground face workers showed an overall crude prevalence of about 5 percent silicosis.

In a further breakdown of these data the rates for face workers according to years of work were: less than 10 years of work, 0.1 percent silicosis; 10 to 20 years, 2.5 percent; 20 to 30 years, 11 percent; and more than 30 years, 26 percent.

It is reasonable to suspect that older men suffered higher dust exposures in earlier years than are common in the industry now. This matter was examined in some degree by comparing silicosis rates among men who worked in metal mines at some time prior to the year 1935 with rates among men who worked only after that year. The examination showed 8 percent silicosis among men with 10 to 15 years of total work in metal mining, but with some work prior to 1935. Among men with all of their work experience after 1935, 20 to 25 years of work produced a silicosis rate of 7 to 8 percent.

Thus, the earlier exposures seem to have resulted in the 8 percent rate of silicosis with about 10 years less work experience than did the later exposure.

In May of this year, the Division of Occupational Health, Public Health Service, announced the results of a study of coal workers pneumoconiosis among a sample of Appalachian bituminous coal miners. The prevalence of the disease among the active miners examined is about 10 percent; among retired and other inactive miners examined the rate is almost 20 percent. More than 20 percent of active miners in the 55- to 64 age group are affected. The duration of exposure seems to be very significant, the prevalence of cases increase markedly among groups with more than 20 years of underground work.

The problem of pneumoconioses is far from solved. Control of the disease depends upon control of exposure. All presently

Relatively few problems of intoxications from dust arise in actual mining operations, but they are not infrequent in milling and smelting operations. The effects of absorption of toxic dust are extremely variable. Effects may range from muscle and joint pain from antimony compounds to chills and fever from zinc fumes. Some chromium compounds may cause lung cancers and perforation of the nasal septum; manganese may cause staggering, high stepping, and other gait disturbances; and mercury may cause irritability and emotional instability.

In contrast to the pneumoconioses, which do not regress with any known treatment, most chemical intoxications respond favorably to medical treatment and cessation of exposure.

Summary

Human lungs are size-selective dust collectors. Only relatively small particles, generally those less than 5 microns in diameter, reach the alveolar spaces. Such small particles move with the air currents; they settle very slowly in still air, and even when thrown into the air with high velocity they travel through the air only a short distance. The lungs have a very large surface, 300 to 1,000 square feet of very delicate tissue. This surface is exposed to contaminants in the air breathed. The lungs have good defenses against particulates; when unimpaired, these clearance mechanisms remove about 99 percent of the insoluble dust deposited in the lungs.

The control of exposures to dust requires a means of assessing dust concentrations in the air. Methods used for sampling and quantitating mineral dust concentrations are empirical, and results yielded by one method cannot be judged by standards based on another. Even with a single method, for example, the impinger sampling and counting method, differences in application can cause differences in results obtained by two investigators.

Dust sampling may be undertaken for either of two rather distinct purposes, for engineering testing and control or for health studies. The objectives of sampling program should be kept well in mind while it is being planned and carried out.

Because only the relatively fine dust reaches the lungs, size-selective sampling devices intended to simulate the deposition characteristics of the lungs have been developed. The mass concentration or surface area of particles of such size that they penetrate to, and are deposited in, the deeper portions of the lungs may prove to be a sensitive index of hazard from exposures to pneumoconiosis-producing dusts. Although data derived from such sampling cannot be interpreted by standards based on count, size-selective gravimetric sampling may eventually represent a major refinement in assessment methods.

The effects of exposure to pneumoconiosis-producing dusts is similar for the various dusts and are irreversible. Chemical intoxications vary with the toxic material absorbed and ordinarily improve with medical treatment and removal from exposure.

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CAN COST CONTROLS SABOTAGE SAFETY?—FACT OR FANCY

By J. EDWIN J. FAHLGREN.
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To eliminate waste in administration, cost control is absolutely essential. Without it management lacks the foundation for knowing which costs are excessive or unproductive, and the mechanics for keeping them under constant observation. Top Management has no other proper means of controlling and fixing the responsibility for excesses.

A cost control system has as its objective a means by which intelligent management is kept informed. The system of control in itself will not solve problems, and solutions are derived from the system only after enthusiastic administration and intelligent interpretation. If the controls are properly administered, any variations between the actual and estimated costs will become conspicuous in time to be corrected before significant losses develop. Complete cost control is based on certain criteria or standards which are used as a basis for comparison and as measurement units to provide essential information for the modern functions of management.

When a significant variation appears, management is in a position to analyse it and determine where it occurred, why it happened, and who was responsible. The fact that, because of a proper cost system, management can put the finger on the person or a new policy responsible for the variation is one of the greatest factors in efficient operation. It eliminates "guessing" or "passing the buck."

The establishment of cost control within an organization sets in motion cost reduction. They are different entities and should not be confused as being the same thing. Cost control is concerned with the maintenance of costs in accordance with standards that have already been established through cost reduction programs; it is a device to hold the line in accordance with these standards, to consolidate the gains made. Cost reduction, on the other hand, is aggressive, instrument against waste and, in fact, is engaged in a never ending battle to push costs downwards. It challenges all cost standards, and its endeavours are directed to reduce them continually. Cost control is the "established authority," and cost reduction is the "progressive opposition," always seeking to improve the situation. Cost reduction should be promoted as a state of mind. It must be a continuous program without any let-up, as it is never completed. Cost reduction must be a live and vital part of a company's functions. Any product line that is competitive today demands analysis for tomorrow.

In every organization, irrespective of size, attractive opportunities exist for cost reduction. In fact, only those industries and businesses, large or small, who realize their competitive position and the economic situation as a whole; who realize we are now actively engaged in an economic world war; who realize that whatever the changing conditions of the world there is no substitute for cost reduction and efficiency - only those will survive in the battle for markets of the next decade.

It is generally recognized by industry today, that our respective working force is our first and greatest asset. Our success is dependent upon its competence. As we research and analyze operating problems and our manpower resources, we are, in fact, projecting tomorrow's expectancies. Our present period is an era of radical change. While change is the normal condition of life, the rate of change in our world is greater in scope and rapidity than that of any era. Rapid change brings a certain amount of confusion and conflict, as is apparent when we note that youth in general feels uncomprehended. There is uncomprehension between parents and their offspring and between society and youth. It is even greater between that section of society who actually experienced the great depression and today's youth. Science and technology have caused a greater spread between the educated and skilled versus the uneducated and unskilled, similar to that between developed and underdeveloped nations. As we question and probe the problem of trying to understand youth, we finally realize that youth feels frustrated because opportunity is not immediate, and they are ahead of the times. They wish to satisfy all of their longings without having [illegible] learning, work and sacrifice experienced by preceding generations. They wish to live the full life immediately, without comprehending life, and they rebel against rules and any direction which they can interpret as coercion.

This may have little, if any, to do with safety or cost control directly. But indirectly, in the future it can well have profound effect, and the demands on management's resourcefulness to cope with employees of the new society will present many challenges. Today we hasten to place stress on human rights and the welfare state and little on human obligations. The rapidity of change is unprecedented in operating history and we will be working with a different complement of personnel, who are indicating a lack of decorum. I introduce this observation, because it is important that we recognize an undisguised problem that is entering the field of cost. It is a problem we will resolve, but we should be aware of it and be prepared to take steps now and [illegible] to overcome a serious problem that has sprung from our affluent society.

Time and change brought our respective Workmen's Compensation Acts, several decades ago. It is a doctrine which stated that the risk of economic loss through personal injury on the job should be borne by industry, and that economic loss which results from such disablement is to be considered a cost of production and should be incorporated in the price of production in accord with the current price system.

Subsequently industry began to study the "real" cost of personal injury and operational accidents. These costs involved:

(1) The rising premiums on compensation insurance.

(2) The cost of premiums on occupational health (dust diseases).

(3) The cost of wages paid workers for the time lost by workers who were injured.

(4) The cost of light duty work when a man is physically and mentally able to undertake this work.

(5) The cost of damaged equipment.

(6) The overtime made necessary by an accident.

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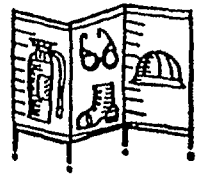
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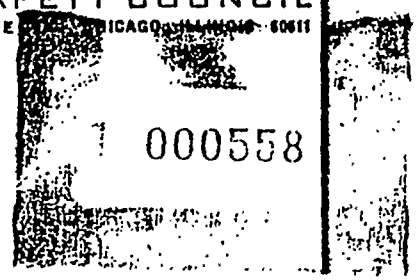
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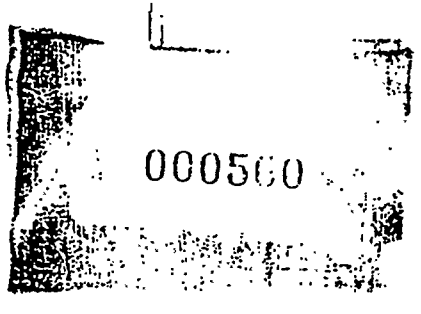
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ANNUAL COUNCIL MEETING

MINUTES OF THE ANNUAL COUNCIL MEETING

The 1966 Annual Council Meeting of the National Safety Council was held in the Grand Ballroom of the Conrad Hilton Hotel, Chicago, on October 24, with Howard Pyle, President, presiding.

Following the singing of the national anthem, the invocation was offered by Reverend William O. Goedert, Assistant Superintendent of Schools, Archdiocese of Chicago.

In opening the meeting, Mr. Pyle read and expressed his and the Council's deep appreciation for a letter received from President Lyndon B. Johnson, as follows:

THE WHITE HOUSE
Washington

October 15, 1966

Mr. Howard Pyle
President
National Safety Council

One of the most cherished goals of our society is to guarantee all our people the highest possible measure of personal safety and economic security.

Yet accidents — on the highways, in our homes, on the job, in every phase of national life — are taking a terrible human toll every day.

Last year 107,000 Americans died in accidents, 49,000 of them in traffic mishaps. More than 10 million suffered disabling injuries.

These accidents cost our people indescribable personal misery. And they cost our nation many billions in ravaged productive energy.

Our common challenge is one that you attending the 1966 National Safety Congress and Exposition live with daily. It is to marshal effective new methods of protecting human life and avoiding economic loss through accident prevention.

Each of you has sought out a heavy responsibility. But each of you has the gratitude of all our citizens.

I extend you every best wish for a Congress that will prove rewarding to you and to the public you so faithfully serve.

Lyndon B. Johnson

Mr. Pyle then introduced the Honorable Abraham A. Ribicoff, United States Senator from Connecticut. Mr. Pyle referred to Senator Ribicoff's previous public service as a Municipal Judge in Hartford, Connecticut, a member of the Connecticut Legislature, a member of the United States House of Representatives, Governor of Connecticut, and Secretary of Health, Education and Welfare.

Senator Ribicoff then delivered his address "Traffic Safety and Public Policy," which is included as a part of these transactions, on following pages.

Following Senator Ribicoff's address, Mr. Pyle expressed the National Safety Council's appreciation for his service to the cause of traffic safety, over a period of many years, and presented him with a testimonial plaque, authorized by the National Safety Council's Executive Committee, describing this service.

Mr. Pyle then proceeded with the business of the meeting by announcing a quorum present, in person or by proxy.

It was voted to dispense with the calling of the roll; also to dispense with the reading of the minutes of the previous annual meeting, as the minutes had been printed and circulated to the membership.

Mr. Pyle called for the report of the Nominating Committee, which consisted of the following members: William H. Lowe, Chairman; Emile F. du Pont; C. Hunter Greer; Donald M. Higgins; W. G. Hotchkiss; Frank E. Laderer; Miss Marion E. Martin.

Mr. Lowe reported in behalf of the Nominating Committee, pointing out that the Constitution authorizes the Committee to name candidates for election to the Board of Directors and to all elective offices, and to place in nomination at the Annual Council Meeting such candidates as wel the

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SAFETY EXPOSITION EXHIBITORS — 1966

[illegible] Protection Equipment Co., 1201 Kalamazoo St., South Haven, Mich. 49090
Industrial gas masks and accessories.

[illegible] and Company, 4915 N. Avers Ave., Chicago, Ill. 60625
Industrial clothing.

[illegible]vance Glove Mfg. Co., 901 W. Lafayette Ave., Detroit, Mich. 48226
Industrial work gloves and clothing.

[illegible]anced Learning Systems, Inc., 25 E. Salem St., Hackensack, N. J. 07601
Programmed instruction on lifting.

[illegible] Life Affiliated Companies, 151 Farmington, Ave., Hartford, Conn. 06115
Safety films and safety pamphlets.

[illegible] Space Devices, Inc., P. O. Box 338, Paramount, Calif. 90723
A safety device for protection from falling when climbing.

[illegible] Brass Co., P. O. Box 86, Wooster, Ohio 44691
Fire fighting equipment and accessories.

[illegible] Wood Steel Co., Conshohocken Road, Conshohocken, Pa. 19428
Abrasive rolled steel floor plate.

[illegible]-Types Rope & Sling Products, 4920 W. Madison St., Chicago, Ill. 60644
Lifting devices.

[illegible]merican Allsafe Co., Inc., 1245 Niagara St., Buffalo, N. Y. 14213
Drybrow sweatbands, nylon fan guards and related products.

[illegible]merican Biltrite Rubber, 22 Willow St., Chelsea, Mass. 02150
A complete line of safety soles and heels.

[illegible]merican Chain and Cable Co., Inc., 929 Connecticut Ave., Bridgeport, Conn. 06602
Sling chains and sling chain assemblies, wire rope slings and assemble-your-own wire rope slings.

[illegible]merican Dryer Div., Utah-American Corp., 1124 Franklin St., Huntington, Ind. 46750
Electric hand dryers and emergency lights.

[illegible]merican Industrial Safety Equipment Co., 3500 Lakeside Ave., Cleveland, Ohio, 44114
Welding and cutting goggles, spectacles, welders' lenses, hard hats, visitors' spectacles, and goggle clips.

[illegible]merican LaFrance, 100 E. LaFrance St., Elmira, N. Y. 14902
Fire apparatus and fire fighting equipment.

[illegible]merican Optical Co., 14 Mechanic St., Southbridge, Mass. 01550
Head, eye, respiratory, protective devices; safety clothing; safety specialt[illegible]oducts

American Society of Safety Engineers, 5 N. Wabash Ave., Chicago, Ill. 60602
Professional society.

Ampco Metal, Inc., 1745 S. 38th St., Milwaukee, Wis. 53201
Hand tools of spark-resistant alloys for use in explosive or flammable condi

Ansul Co., One Stanton St., Marinette, Wis. 54143
Fire protection products.

Antrex Corp., 4355 N. Avers, Chicago, Ill. 60618
Safety Talker Message Repeater, portable public address systems.

Apex Safety Products, Washington and Elm Sts., Cleveland, Ohio 44113
Safety hats and caps.

Atlantic India Rubber Works, 571 W. Polk St., Chicago, Ill. 60607
Hand vacuum lifters.

Atlas Safety Equipment Co., Inc., 175-179 N. 10th St., Brooklyn, N. Y. 11211
Industrial safety belts, harnesses, and straps. Ladder climber's safety device. Genie descent control.

Atlas Underwear Corp., 803 N. Dowling St., Piqua, Ohio 45356
Underwear

Bacharach Ind. Instr. Co., 200 N. Braddock Ave., Pittsburgh, Pa. 15208
Gas analyses instruments Humidity and temperature indicators and record Multi-gas leak detectors. Air flow velocity indicators.

Badger Fire Extinguishers-Powhatan Brass & Iron Works, Ranson, W. Va. 254
Fire fighting equipment and supplies.

W. M. Bashlin Co., 119 W. Pine St., Grove City, Penn. 16127
Linemen's and industrial safety belts, slings, high voltage rubber gloves, slee

Bausch & Lomb Inc., 635 St. Paul St., Rochester, N. Y. 14602
Vision and audio testing equipment.

Bear Manufacturing Company, 2016 5th Avenue, Rock Island, Ill. 61108
Automobile Safety tests.

Bell Glass & Mirror Co., 1328 Flatbush Ave., Brooklyn, N. Y. 11210
Traffic safety mirrors.

Bell & Howell Co., 7100 McCormick Rd., Chicago, Ill. 60645
Motion picture cameras, projectors, an[illegible] projectors.

Best's Safety Publications, A. M. Best C[illegible] 75 Fulton St., New York, N. Y.
Safety publications.

Best Mfg. Corp., Menlo, Ga. 30731
Work Gloves

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Channing L. Bete Co., Box 112, Greenfield, Mass. 01301
Scriptographic Booklets.

Bethlehem Steel Co., 701 E. Third St., Bethlehem, Pa. 18016
Wire rope, sling and boom pendants, beam guard rail, and anchor safety nets

Fire-Gamewell, 209 W. Central St., Natick, Mass. 01760
Fire fighting and safety equipment, portable spotlights, foam liquids and fire fighting chemicals, fire protection systems.

W. L. Bouton Co., Inc., 320 Main St., St. Buzzards Bay, Mass. 02532
Industrial eye protection, goggles, and spectacles.

W. H. Brady Co., 727 W. Glendale Ave., Milwaukee, Wis. 53209
Self-sticking markers and accident prevention signs.

Breath-O-Life Oxygen, Barclay Bldg., Bala Cynwyd, Pa. 19004
Emergency oxygen administration set.

Lester L. Brossard Co., 540 N. Michigan Ave., Chicago, Ill. 60611
Safety mirrors for industrial use. Liquid hand cleaner.

Stewart R. Browne Mfg. Co., 839 Stewart Ave, Garden City, N. Y. 11530
Portable explosionproof inspection lights.

W. H. Buhrke Co., Inc., P. O. Box 311, Fort Smith, Ark. 72901
Occupational safety equipment—safety belts, straps, assemblies, harnesses, and allied products.

W. D. Bullard Co., 2680 Bridgeway, Sausalito, Calif. 94965
Safety hats, caps, and accessories, industrial first aid kits, safety hoist hooks, vehicle alarms, air purifiers, and ear plugs.

CAH Industries, 10245 Pacific Ave., Franklin Park, Ill. 60131
Self-extinguishing waste receptacle.

Cardox Div., Chemetron Corp., 840 N. Michigan Avenue, Chicago, Ill. 60611
Fire fighting equipment and supplies.

Cesco Products Corp., 512 Hancock Ave., Bridgeport, Conn. 06602
Hand-portable pressurized dry chemical fire extinguishers.

Casell Co., Inc., 1785 Tanen St., Napa, California 94558
Emergency lights and barricades.

Cesco Safety Products, 2727 W. Roscoe St., Chicago, Ill. 60618
Safety glasses and lenses, cup goggles, special purpose goggles, welding helmets, face shields, respirators, plastic aprons, and hoods.

A. B. Chance Co., 210 N. Allen St., Centralia, Mo. 65240
Hot line maintenance and line construction tools. Hot line tools.

Charleston Rubber Co., 16 Stark Industrial Park, Charleston, S. C. 29405
Rubber, plastics, and rubber coated gloves, aprons and sleeves.

Chemi-Temp. Corp., 200 Route 17, Lodi, N. J. 07644
Instant ice and heat packs.

Chrysler Corp., 341 Massachusetts Ave., Detroit, Mich. 48231
Safety features in 1964 line of automobiles and trucks.

David Clark Co., Inc., 360 Franklin St., Worcester, Mass. 01604
Muff-type ear protection.

The Coca-Cola Co., P. O. Drawer 1734, Atlanta 30301
Coca-Cola served through the courtesy and cooperation of the Coca-Cola Bo
Company of Chicago.

Columbus McKinnon Chain Div., 160 Fremont St., Tonawanda, N. Y. 14152
Sling chains, hooks, and coupling links.

Conbridge Products Co., 82 Carroll Ave., Bridgeport, Conn. 06607
Safety tools.

Consumer Contact Co., 11039 Manchester Rd., St. Louis, Mo. 63122
Safety incentives and awards.

Converse Rubber Co., 392 Pearl St., Malden, Mass. 02148
Safety toe rubber footwear, industrial rubber footwear, protective clothing of r
and neoprene.

Crown Products Co., 2140 Superior Ave., Cleveland, Ohio 44107
Emergency respirators.

Custom Materials Inc., 279 Billerica Road, Chelmsford, Mass. 01824
Static-free permanently conductive polyolefin.

Davis Emergency Equipment Co., Inc., 55 Halleck St., Newark, N. J. 07104
First aid kits, gas masks and breathing equipment, combustible and toxic gas a
lyzers, and protective hats.

Demp-Nock Co., 21433 Mound Road, Warren, Mich. 48090
Pressure sensitive plastic film lettering kit.

Den-Va Company, 62 Stanhope St., Brooklyn, N. Y. 11221
Nylon safety spectacles.

Detex Corp., 53 Park Place, New York, N. Y. 10007
Watchmen's clocks.

R. E. Dietz Co., 225 Wilkinson St., Syracuse, N. Y.
Lanterns, torches, flashers, barricades, and safety equipment.

Dockson Corp., 3839 Wabash Ave., Detroit, Mich. 48208
Spectacles, goggles, face shields, helmets, hats, and respirators.

Dow Corning Corp., P. O. Box 7038, Greensboro, N. C. 27407
Sight Savers, lens cleaning stations.

Harnischfeger-Norton Co., 100 Pioneer Rd., Box 1719, Charlotte, N. C. 28201
Load chain hoists.

E. I. du Pont de Nemours & Co., Inc., 1007 Market, Welmington, Del. 19898
"Nomex" fabric.

Dymo Products Co., Box 1030, Berkeley, Calif. 94701
Labeling device for use in office or shop.

Eagle Mfg. Co., 24th and Charles Sts., Wellsburg, W. Va. 26070
Safety cans, cigarette-cigar butt cans, drain cans, drip cans, brass oilers.

Economy Engineering Co., 4511 W. Lake St., Chicago, Ill. 60624
Telescoping work platform.

Fairmont-Wilson, 1205 Walnut St., Coshocton, Ohio 43812
Coated and impregnated work gloves.

Electronic Specialties Co., Island Ave., Batavia, Ill. 60510
Warning lights, barricades, and accessories.

Elkhart Brass Mfg. Co., Inc., 1302 W. Beardsley Ave., Elkhart, Ind. 46514
Nozzles and other fire department supplies and fire fighting equipment.

Enraco Engineering Corp., 136 Official Road, Addison, Ill. 60101
Gas vapor alarm systems.

Falcon Alarm Co., Inc., 20 Stern Ave., Springfield, N. J. 07081
Fire alarms, sirens, horns, bells and other signaling devices.

Federal Sign and Signal Corp., 13625 S. Western Ave., Blue Island, Ill. 60406
Sirens, horns, bells, and warning lights for visual and audible signaling.

Fendall Co., 2222 Diversey Pky., Chicago, Ill. 60647
Spectacles, face shields, and cup-type and cover goggles.

Fenwal, Inc., 400 Main Street, Ashland, Mass. 01721
Fire detector units, explosion suppression systems, smoke detectors.

Ferno-Washington, Inc., 6th and Pine Sts., Greenfield, Ohio 45123
Emergency patient handling equipment and accessories for the first aid room.

Fibre-Metal Products Co., 5th and Tilghman Sts., Chester, Pa. 19016
Safety hats and caps, face shields, safety masks, welding helmets, headrest and combination goggles.

Finn Organics, Inc., 205 Main St., Lodi, N. J. 07664
Solvents, carbon removers, emulsion cleaners, polishers, and disinfectants.

Ford Division—Ford Motor Co., Box 658, Dearborn, Mich. 48121
Ford passenger car with safety features.

Franklin Metal Products, 213-215 N. Des Plaines, Chicago, Ill. 60606
Waste cans and drum covers.

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Frommelt Industries, Inc., 465 Huff St., Dubuque, Iowa 52001
Wrap-around portable safety welding shield; portable welding screen.

Fyrepel Products, Inc., 160 S. Williams St., Newark, Ohio 43055
High heat protective clothing and equipment for industry, space-military, and fighting agencies.

The Fyr-Fyter Co., 221 Crane St., Dayton, Ohio 45401
Fire extinguisher, automatic sprinkler systems, electronic alarm systems.

General Fire Extinguisher Corp., 8740 W. Washington Blvd., Culver City, Calif.
Fire Extinguishers.

General Motors Corp., 3094 W. Grand Blvd., Detroit, Mich. 48202
Automotive safety.

Gilbert & Barker Mfg. Co., 7300 Friendly Rd., Greensboro, N. C. 27410
Drum grounding device.

Glendale Optical Co., Inc., 130 Crossways Park Drive, Woodbury, N. Y. 11797
Eye and face protective equipment.

The Globe Div. U. S. Gypsum, 101 S. Wacker Drive, Chicago, Ill. 60606
Safety grating, cable tray, channel and fittings, slotted angles.

Globe Mfg. Co., Pittsfield, N. H. 03263
Fire protective clothing.

Globe Safety Products, 125 Sunrise Place, Dayton, Ohio 45407
Resuscitators.

B. F. Goodrich, Industrial Products Co., 500 S. Main St., Akron, Ohio 44318
Industrial rubber safety footwear, and protective clothing.

The Granet Corp., 25 Loring Drive, Framingham, Mass. 01701
Coated fabric work glove.

A. E. Halperin Co., Inc., 75 Northampton St., E., Boston, Mass. 02118
Stretchers, first aid kits, and accessories.

Haws Drinking Faucet Co., 4th and Page Sts., Berkeley, Calif. 94710
Emergency eyewash and showers.

Hazard Controls, Inc., 8127 Holman Ave., Delair, N. J. 08110
Warning lights, barricades, signs, reflectors, cylinder clamps, lockouts, ladder shoe, can carriers, flags, and barrier rope.

Warren Heim Corp., 222 N. 5th Ave., Mt. Vernon, N. Y. 10553
Canvas buckets, bags, and protective covers.

Karl Heitz, Inc., 979 Third Ave., New York, N. Y. 10022
Eye protection accessories.

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Heller Industries, Inc., 1717 Marive Plaza, Milwaukee, Wis. 53202
Traffic cones.

High Pressure Engineering Co., Inc., 1349 W. Reno, Oklahoma City, Okla. 73109
High pressure pure breathing air compressors.

Hild Floor Machine Co., Inc., 1217 W. Washington Blvd., Chicago, Ill. 60607
Explosionproof vacuum cleaners and floor scrubbing and polishing machines.

Hilti-Fastening Systems, 360 Fairfield Ave., Stamford, Conn. 06904
Power-assisted drive tools that fasten pins and threaded studs into concrete masonry and steel.

Hoffman Electronics Corp., 700 Hoffman Dr., Santa Barbara, Calif. 93105
Highway emergency call box system.

Hopco (Hopfeld Industrial Mfg. Co.), 745 A St., San Rafael, Calif. 94902
Safety ladders, and fiberglass safety diving boards.

Hy-Test Safety Shoes, Div., of International Shoe Co., 1509 Washington Ave., St. Louis, Mo. 63166
Safety shoes and conductive and nonconductive footwear.

Illinois Glove Co., 7301 N. Lawndale Ave., Skokie, Ill. 60078
Industrial work gloves and lineman's gloves.

Industrial Gloves Co., 700 Garfield St., Danville, Ill. 61832
Industrial clothing and accessories.

Industrial Products Co., 2820 N. 4th St., Philadelphia, Pa. 19133
Industrial clothing.

Inland Chemical Corp., 1120 Bush St., Toledo, Ohio 43608
Industrial chemicals.

International Film Bureau, Inc., 332 S. Michigan Ave., Chicago, Ill. 60604
Safety films available on a sales and rental basis.

Interstate Rubber Products Corp., 908 Avila St., Los Angeles, Calif. 90012
Traffic cone system for traffic control.

Iron Age Shoe Co., 1205 Madison Ave., Pittsburgh, Pa. 15212
Work and dress-style safety shoes and safety rubber footwear.

Irving Air Chute Co., Inc., 1020 S. Broadway, Lexington, Ky. 40501
Automobile seat belts, industrial harnesses.

Jackson Products, 5523 E. Nine Mile Rd., Warren, Mich. 48091
Goggles, welding helmets, face shields, safety hats and caps.

Joanna Western Mills Co., 2141 S. Jefferson St., Chicago, Ill. 60616
Luminescent material for safety signs.

Johnson-Williams, Inc., 2300 Leghorn St., Mountain View, Calif. 94041
Portable instruments for detection of toxic combustible gases.

Jomac-North, Inc., 863 Easton Rd., Warrington, Pa. 18976
Chemical and protective vinyl clothing and gloves, and terry cloth glove products.

Jones and Co., 861 Broad St., Providence, R. I. 02907
Full-vision visor goggles and replaceable lenses.

Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh, Pa. 15230
Wire rope and chain slings.

Juhl Mfg. Co., 4110 Lincoln Blvd., Venice, Calif. 90292
Safety harness.

Junkin Safety Appliance Co., Inc., 3121 Millers Lane, Louisville, Ky. 40216
Interlocking barrier gate guard for power presses; safety shields for gri... stretcher cases and stretchers.

Justrite Mfg. Co., 2061 N. Southport Ave., Chicago, Ill. 60614
Safety cans, bench cans, plunger cans. Oily waste cans. Electric lanterns and ... lights for use in hazardous areas.

Karel First Aid Supply Co., 4342 Ogden Ave., Chicago, Ill. 60623
Medical equipment for industrial hospitals and first aid rooms.

Kelmore Inc., 599 Springfield Ave., Newark, N. J. 07103
Explosionproof refrigerators and freezers.

Kennedy-Ingalls, Inc., 3735 N. 35th St., Milwaukee, Wis. 53216
Protective clothing.

Keystone View Co., Market and Center St., Meadville, Pa. 16335
Occupational visual service, driver vision test service, and gas sensing and reco... instruments.

Walter Kidde and Co., Inc., 675 Main St., Belleville, N. J. 07109
Portable fire extinguishers, and accessories. Automatic carbon dioxide fire ... tinguishing system.

Kimsafe, Inc., 4900 Campbell Road, Willoughby, Ohio 44094
Personal protection devices for industry.
Personal protection devices for employees in industrial plants.

Mathias Klein and Sons, Inc., 7200 McCormick Road, Chicago, Ill. 60645
Linemen's and electricians' hand tools, linemen's safety equipment, wire-pull... tools.

Knapp Brothers Shoe Mfg. Corp., 173 Spark St., Brockton, Mass. 02401
Safety shoes.

... Kenz Glove Co., 2141 W. North Ave., Chicago, Ill. 60647
Leather and rubber work gloves.

... by Co., Inc., P. O. Box 88, Branford, Conn. 06405
Fluorescent light tube disposal.

... er G. Legge Co., Inc., 101 Park Ave., New York, N. Y. 10017
Safety floor maintenance materials. Personnel and equipment grounding devices.

... igh Safety Shoe Co., First and Minor Sts., Emmaus, Pa. 18049
Leather and rubber safety footwear including conductive and electrical hazard shoes.

... bey Products, Owens-Illinois, Inc., Box 1035, Toledo, Ohio 43601
Safety incentives.

... erty Protective Leathers, Box 211, Clark Mills, N. Y. 13321
Leather gloves and mittens.

... isville Ladder Co., 1163 Algonquin Pkwy., Louisville, Ky. 40208
Fiberglass and aluminum steps, platforms, extension trestles, aluminum planks and stages, steel warehouse ladders.

... Company, 2501 Hudson Rd., St., Paul 55119
Abrasive flooring material, filter masks.

... om McAn Shoe Co., 67 Millbrook St., Worcester, Mass. 01606
Safety shoes.

... an A. McDermott Corp., 1639 Stephen St., Ridgewood, Brooklyn, N. Y. 11227
Warning and safety lighting for municipal industrial and utility use.

... hinery Center, Inc., 1201 S. 6th West, Box 964, Salt Lake City, Utah 84110
Sala Safety Block.

... ck Products Co., 1324 Hird Ave., Cleveland, Ohio 44107
Welders goggles.

... gid Glove Mfg. Co., Inc., 2201 W. Wabansia Ave., Chicago, Ill. 60647
Industrial gloves.

... r-Lin Safety Devices, 222 W. Ontario, Chicago, Ill. 60610
Seat belt warning device.

... rathon Rubber Products Co., Box 448, Wausau, Wis. 54401
Industrial and municipal protective clothing.

... rbon Chemical Div., P. O. Box 68, Washington, W. Va. 25181
Portable highway safety signs.

... rco Advertising, Box 1220, Medford, Oregon 97501
Safety incentives.

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A. J. Masuen Co., Le Mars, Iowa 51031
Industrial first aid kits and supplies.

Martindale Electric Co., 1375 Hird Ave., Cleveland, Ohio 44107
Protective masks and refills, protective eyeshields, and electrical testing instrum

Martin Decker Corp., 3431 Cherry Ave., Long Beach, Calif. 90807
Cane scales and indicators.

Medical Supply Co., 1027 W. State St., Rockford, Ill. 61101
First aid kits and accessories. Resuscitation training aids, stretchers.

Meyer Machine Inc., Box 114, Red Wing, Minn. 44066
Safety products for the protection of person while climbing.

Henry L. Michael & Co., Inc., 550 Fifth Ave., New York, N. Y. 10036
Steel bandcutting machine.

Midwest Resilient Floor Co., 7777 W. Lake St., River Forest, Ill. 60305
Floor products.

Milburn Co., 3246 E. Woodbridge, Detroit, Mich. 48207
Protective hand creams and related products.

Miller Allied Corp., 1418 Park Ave., Alameda, Calif. 94501
Material handling slings and adjustable lifting safety beams.

Miller Equipment Co., Inc., 13th and New Sts., Franklin, Pa. 16323
Linemen's safety equipment and accessories.

Millers Falls Co., 57 Wells St., Greenfield, Mass. 01301
Shockproof power tools.

Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh, Pa. 15208
Complete line of safety equipment for industry and mining.

Morton Mfg. Co., 5125 W. Lake St., Chicago, Ill. 60644
Safety grating.

Mott Corp., 500 Shawmut Ave., LaGrange, Ill. 60526
Safety mowers.

M-P Corp., 6466 Chene St., Detroit, Mich. 48211
Safety blade for rotary lawn mowers.

National Chemsearch Corp., Box 10087, Dallas, Texas 75207
Safety solvent; cleaners; degreasers, disinfectants; weed killers detergents; ins
cides; and water treatments for industry.

National Fire Protection Assn., 60 Batterymarch St., Boston, Mass. 02110
Fire safety.

000572

National Marker Corp., 2314 Pawtucket Ave., East Providence, R. I. 02914
Fire extinguisher and alarm markers.

National Safety Products Co., 424 New Road, Avon, Conn. 06001
Porcelain on aluminum safety signs.

Nelson Mfg. Co., Inc., 3636 Main St., Kansas City, Mo. 64111
Wire rope fittings, miniature slings, and a miniature crane demonstrating various fits.

Northern Signal Co., 350 Tower Rd., Saukville, Wis. 53080
Flashers and barricades.

Occupational Hazards, 812 Huron Road, Cleveland, Ohio 44115
Occupational Hazards Magazine.

O and J Resuscitators—Ohio Chemical and Surgical Equipment Co., 1400 E. Washing-
Ave., Madison, Wis. 53701
Resuscitation and oxygen breathing apparatus.

Ohio Turnpike Commission, 682 Prospect St., Berea, Ohio 44017
Information folders on safe turnpike driving.

Onox, Inc., 121 Second St., San Francisco, Calif. 94105
Skin-toughener solution for the treatment of athlete's foot.

Organized Labor Safety, 1200 Fifteenth St., N. W. Washington, D. C. 20005
Safety Literature.

Osborn Mfg. Co., 960 N. Lake St., Warsaw, Ind. 46580
Safety pliers, lockout devices, mufflers and stretcher cases.

Oxygen Equipment and Service Co., 8335 S. Halsted St., Chicago, Ill. 60620
Resuscitator, inhalator, and aspirator.

Pac-Kit Safety Equipment Co., 1 Seneca Place, Greenwich, Conn. 06831
First aid kits and supplies.

Packwood Mfg. Co., Div. of Calgon Corp., 1545 Tower Grove Ave., St. Louis,
63110
Hand cleaners, waterless cleaners, germidical cleaners, sanitizing compounds, and maintenance cleaners.

Panasonic Chicago, 4615 N. Clifton Ave., Chicago, Ill. 60640
Closed-circuit T.V.

Paraflex Equipment Co., 105 Industrial Road, Hammond, Ind. 46320
Flashing lights, barricades, traffic cones, vests, flags, trouble lights, signs.

Patent Scaffolding Co., Inc., 38-21 Twelfth St., Long Island City, N. Y. 11101
Wood and light metal ladders and stages, steel and aluminum scaffolds.

Pedley-Knowles & Co., 533 Second St., San Francisco, Calif. 94107
Safety and work nets of manila rope and plastic.

Pem-All Mfg. Co., 39A Myrtle St., Cranford, N. J. 07016
Fire extinguishers.

The Pioneer Rubber Co., 1939 Tiffin Road, Willard, Ohio 44890
Industrial gloves.

Pitman Mfg. Co., P. O. Box 605, Grandview, Mo. 64030
Hydraulic digger, derrick, and aerial devices.

Porto-Clinic Instruments, Inc., 405 Lexington Ave., New York, N. Y. 10017
Complete portable driver testing and training unit.

The Positive Safety Mfg. Co., 1052 E. 134th St., Cleveland, Ohio 44110
Power press safety devices.

Power-Pak Products, 83 Clyde Ave., Buffalo, N. Y. 14215
Fire extinguishers.

Prairie State Products Co., 3822 W. Lawrence Ave., Chicago, Ill. 60625
Industrial safety signs.

Protectoseal Co., 1920 S. Western Ave., Chicago, Ill. 60608
Safety containers for the handling, storing and dispensing of flammable liquids.

Protexall Co., P. O. Box 307, Green Lake, Wis. 54941
Clothing.

Pulmosan Safety Equipment Corp., 30-48 Linden Pl., Flushing, N. Y. 11354
Respirators, eye protection, helmets, protective clothing, asbestos and leather gloves, safety glasses, first aid kits, and face shields.

Puritan Compressed Gas Corp., 13th & Oak Sts., Kansas City, Mo. 64106
Oxygen breathing and respiration equipment.

Pyrotronics, Div. Baker Industries, 2343 Morris Ave., Union, N. J. 07083
Fire and smoke detection and alarm systems.

Racine Glove Co., Inc., Box 368, Rio, Wis. 53960
Safety gloves and apparel for industry and fire protection, safety specialty products.

Radiator Specialty Co., 1400 W. Independence Blvd., Charlotte, N. C. 28201
Traffic guides; cones, lights, flags.

Rainfair, Inc., 1501 Albert St., Racine, Wis. 53401
Wet weather and safety clothing.

Ramset Fastening System, 289 Winchester Ave., New Haven, Conn. 06504
Low-velocity piston tool.

000573

Record Industrial Co., 3301 Arch St., Philadelphia, Pa. 19104
Industrial safety shoes, work clothing and work gloves.

Red Wing Shoe Co., 119 Main St., Red Wing, Minn. 55066
Safety workshoes, oxfords, and boots.

R. C. Renfroe and Sons, Inc., 1926 Spearing St., Jacksonville, Fla. 32206
Safety clamps for lifting steel.

Revere Plastics, Inc., 16 Industrial Ave., Little Ferry, N. J. 07643
Traffic flags.

Reynolds Televator Corp., 1104 Sixth St., Muskegon, Mich. 49440
Telescoping, electronically operated scaffold.

Rio Hardware Mfg. Co., 540 W. Chevy Chase Drive, Glendale, Calif. 91209
Air-conditioned helmet systems.

The Robbins Co., Brook & Maple Sts., Attleboro, Mass. 02703
Safety incentives.

Rockford I. C. Webb, Inc., 301 N. Madison St., Rockford, Ill. 61110
Noise resistant ear protectors.

Roll-Ezy Mfg. Co., 7032 N. Tahoma Ave., Chicago, Ill. 60646
Fluorescent light tube breaker.

Ross Mfg. Co., 2700 W. Barberry Pl., Denver, Colo. 80204
Automotive seat belts. Industrial safety belts, lanyards, net, and ladder safety devices.

The Rucker Co., 747 Bancroft Way, Berkeley, Calif. 94710
Electrical shock safety device.

Safe-Cut, Inc., Div. Verkau Corp., 973 Market St., San Francisco, Calif. 94103
Steel band cutter.

Safety Appliance Corp., P. O. Box 689, Tyler, Texas 75701
Protective foot coverings.

Safety & Industrial Net Co., 23 Edgerton St., East Hampton, Conn. 06424
Safety Nets.

Safety Box Toe Co., 812 Statler Office Bldg., Boston, Mass. 02116
Steel toes for dress, semi-dress, and work shoes.

Safety Clothing and Equipment Co., 1990 E. 69th St., Cleveland, Ohio 44103
Safety clothing and equipment for industrial workers.

Safety First Products Corp., 175 Saw Mill Road, Elmsford, N. Y. 10523
Portable stored pressure dry chemical fire extinguishers.

Safety First Shoes, Inc., 8th and Greenleaf Sts., Allentown, Pa. 18105
Safety shoes for industry, railroad, and military use.

The Safety Journal, Anderson, S. C. 29621
Safety publication.

Safety-Sight, Inc., 1640 Gorsuch Ave., Baltimore, Md. 21218
Radiator water level gauge.

Salescaster Displays Corp., 1010 E. Elizabeth Ave., Linden, N. J. 07036
Illuminated moving message signs.

W. H. Salisbury and Co., 401 N. Morgan St., Chicago, Ill. 60622
Linemen's rubber protective devices.

Sawyer-Tower Products, Inc., 76 Stanley Ave., Watertown, Mass. 02172
Industrial protective, and safety clothing.

Schuberth Corp., 1205 Champlain St., Toledo, Ohio 43604
Safety hats and caps, face shields, accessories.
Helmets, safety hats and caps, safety goggles, and wrap-around protective goggles.

Scott Aviation Corp., 225 Erie St., Lancaster, N. Y. 14086
Respirators, inhalators, and environmental protection equipment.

Seiberling Latex Products, 215 Plum St., New Bremen, Ohio 45869
Industrial rubber gloves.

Sellstrom Mfg. Co., Highway 53 at U. S. 14, Palatine, Ill. 60067
Eye and face protective equipment.

The Servus Rubber Co., 1136 Second St., Rock Island, Ill. 61201
Rubber footwear of all types.

Fred Silver & Co., 145 Sussex Ave., Newark, N. J. 07103
Traffic Safety Mirrors.

Singer Safety Products, 450 N. Lake Shore Dr., Chicago, Ill. 60611
Gloves, portable welding screens.

Snyder Mfg. Co., Inc., 1458 Fifth St., New Philadelphia, Ohio 44663
Air suits, hoods, splash and dust suits, shoe covers, safety vests, flags, fabric and film laminations, and fiberglass containment closures.

Sonoscope, Inc., P. O. Box 155, Lansing, Mich. 48901
Combination tape recorder and automatic slide projector.

Speakman Co., 301 E. 30th St., Wilmington, Del. 19899
Emergency eyewash and showers.

Sta-Put Enterprises, Inc., 201 Willow St., Massapequa Park, N. Y. 11762
Wheel chocks.

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Standard Industrial Products Co. of Ill., 3527 Farmington Rd., Peoria, Ill. 61601
Drinking station smoking receptacles.

Standard Safety Equipment Co., 431 N. Quentin Rd., Palatine, Ill. 60067
Acid and chemically-resistant clothing.

Standard Signs Inc., 3190 E. 65th St., Cleveland, Ohio 44127
Industrial accident prevention signs and road work area protection equipment.

Stephenson Corp., Box 1000, Red Bank, N. J. 07701
Radar speed control, breath test for intoxication, resuscitator.

Stephen-William Co., 216 W. Ontario, Chicago, Ill. 60610
Safety signs and posters.

Stonehouse Signs, Inc., 842 Larimer St., Denver, Colo. 80204
Accident prevention signs and tags.

Stop-Fire, Inc., U. S. 1 at Black Horse Lane, New Brunswick, N. J. 08902
Fire extinguishers.

Surety Rubber Co., North High St., Box 97, Carrollton, Ohio 44615
Safety apparel, gloves, sleeves, aprons, and specialized protective equipment.

Surety Mfg. Co., 4139 W. Kinzie St., Chicago, Ill. 60624
Press guards.

Survivair, Division of U. S. Divers Co., 3323 W. Warner Ave., Santa Ana, Cal. 92702
Self-contained breathing equipment. Wet pick-up vacuum unit. Voice amplifiers.

S. G. Taylor Chain Co., Inc., 3-141st Box 508, Hammond, Ind., 46325
Alloy steel chain and fittings.

Thomas Optical Co., Inc., 1015 Commerce St., Petersburg, Va. 23804
Safety frames, safety lenses and vision tester.

Trans Continental Electronics Corp., 56 Thomas St., New York, N. Y. 10013
Safety shower — eyebath combination.

21st Century Sign Co., 5242 Irving Park Road, Chicago, Ill. 60641
Safety signs.

Tri-Trix, Inc., 6411 N. Mequon Rd., Mequon, Wis. 53092
Safety cones traffic posts.

U-C-Lite Mfg. Co., 290 Prairie St., Crystal Lake, Ill. 60014
Battery-operated electric hand lanterns, flashers and emergency lights.

United States Rubber Co., 1230 Sixth Ave., New York, N. Y. 10020
Safety footwear.

United States Safety Service Co., 1535 Walnut St., Kansas City, Mo. 64108
Industrial eyewear and hearing protection.

Vinyl Plastics, Inc., 1825 Erie Ave., Sheboygan, Wis. 53081
Conductive flooring.

Wagner Sign Service, Inc., 3100 Hirsch St., Melrose Park, Ill. 60160
Changeable copy displays for employee relations and safety programs.

Watchemocket Optical Co., Inc., 232 W. Exchange St., Providence, R.I. 02903
Safety goggles, respirators, face shields and safety signs.

Welsh Mfg. Co., 9 Magnolia St., Providence, R. I. 02909
Respirators, safety spectacles, goggles, safety hats, faceshields, and welding helmets.

Wheeler Protective Apparel, Inc., 224 W. Huron St., Chicago, Ill. 60610
Industrial safety apparel.

Whelen Engineering Co., Inc., 3 Winter St., Deep River, Conn. 06417
Emergency and warning lights, flashers, and beacons.

Wilkie Optical Co., Inc., Schreve Ave. & N. J. Turnpike, Barrington, N. J. 08007
Safety eyewear.

Williams Jewelry and Mfg. Co., 4544 N. Western Ave., Chicago, Ill. 60625
Safety plaques, trophies, awards, emblems, badges, and incentives.

Willson Products Div., Electric Storage Battery Co., 2nd and Washington St., Reading, Pa. 19603
Personal protective equipment for industry.

Edmont-Wilson, 1200 Garfield Ave. S. W., Canton, Ohio 44706
Rubber, neoprene, and plastic gloves.

Wire Rope Corp. of America, Inc., 609 N. 2nd St., St. Joseph, Mo. 64502
Wire rope slings.

Worklon, Inc., 64 New York Ave., Huntington, N. Y. 11744
Special purpose clothing—acid-resistant, lint-free, static free and fire retardant.

D. W. Zimmerman Mfg. Inc., 146 S. Westwood Ave, Toledo, Ohio 43607
Lifting equipment.

American Industrial Hygiene Association, 14125 Prevost, Detroit, Mich. 48227
Information about associations activities.

American Medical Association, Council on Occupational Health, 535 N. Dearborn St., Chicago, Ill. 60610
Occupational Health literature.

Chicago Fire Department
Information on the work of the Fire Prevention Bureau.

Chicago Police Dept., Traffic Div.
Traffic safety.

Inter-American Safety Council, 140 Cedar St., New York, N. Y. 10006
Safety publications, visual aids, and films, in Spanish for industrial, highway, and home.

National Ski Patrol System, Inc., 828 Seventeenth St., Denver, Colo. 80202
Ski safety.

Outdoor Power Equipment Institute, 734-15th St., Washington, D. C. 20005
Power lawn mower safety.

Prevention of Blindness Inc., National Society for the, 16 E. 40th St., New York, N. Y. 10016
Literature and information on industrial and vocational school eye health and safety programs.

President's Committee on Employment of the Handicapped, Washington, D. C. 20210
Information on Hire-the-Handicapped Program.

U.S. Coast Guard, Washington, D. C. 20226
Boating safety.

Underwriter's Laboratories, Inc., 207 E. Ohio St., Chicago, Ill. 60611
Product testing.

University of Southern Calif., Los Angeles, Calif. 90007
Safety research.

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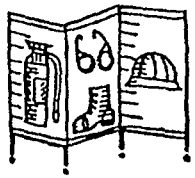
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1967 1968 1969 1970 1971

NATIONAL SAFETY CONGRESS

OCTOBER 23-26, 1967 / CONRAD HILTON HOTEL, CHICAGO

The Congress is always a big week, a worthwhile week for the 13,000 safety people who attend.

At the '67 Congress you can meet other safety people, with the same problems and responsibilities as yourself. You can exchange views and ideas on accident prevention, health, hygiene, and fire prevention . . . on safety in industry, traffic, school, at home and on the farm.

You can see the largest of all safety equipment exhibits at the Congress . . . an opportunity for you to make well-informed buying decisions for your company.

This four-day educational program, planned and presented by the National Safety Council, can be your most thought-provoking, most worthwhile safety experience in 1967.

Make plans early to attend the 1967 Congress and bring the other people in your organization who have safety responsibilities.

FUTURE CONGRESS DATES
1967 October 23-26
1968 October 28-31
1969 October 27-30
1970 October 26-29
1971 October 25-28

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pure oxygen rushing through a small orifice of the regulator nozzle generate heat?

Would you have the three legs of the combustion triangle inside this regulator? (Fuel, oxygen, and heat).

What would happen? This? (Show the blown up regulator.)

How Can We Guard Against This?

1. Disconnect the oxygen regulator and connect the SAF-T-PAK regulator.
2. Show how the safety check valve on the SAF-T-PAK regulator stops the reverse flow of gas.
3. Insert Smith's SC219 with Flo-Trol and demonstrate the built in check.

Burning Rate of Steel.

Experiment XII

1. Take a milk bottle, into which you have previously inserted a piece of asbestos paper saturated with water. (This should be lying flat on the bottom of the bottle.) Fill the bottle with pure oxygen from the torch.
2. Light a small piece of steel wool with a match to show that the match will raise the steel to its kindling point.
3. Drop the piece of steel wool into the milk bottle filled with oxygen and call attention to how rapidly it burns in the oxygen atmosphere.
4. Indicate that this experiment ties in with Safety Rule No. 9 and caution the audience about what could happen if the oxygen should come in contact with grease on clothing or if a person lights a cigarette when his clothing is saturated with pure oxygen.

Review each safety rule to determine if the objective has been accomplished. The audience now compares their understanding of the reasons for these rules to how they felt about them through the first run through the rules.

Grand Finale of Safety Meeting.

1. Fill green balloon with oxygen only. Ask audience, "What will happen when you touch the balloon with flame?"
2. Fill red balloon with acetylene only. Ask the audience if there is sufficient oxygen in the surrounding air to burn all of the carbon of the acetylene.
3. Fill a small yellow balloon about four inches in diameter with equal amounts of oxygen and acetylene. Ask "How much pressure, *psig*, is there in this balloon?"
4. Set off the oxygen balloon with torch flame. Note the disappointing "pooff".
5. Set off the acetylene balloon. Note the heavy black carbon residue.

Attention: Before setting off the (yellow) oxy-acetylene mixture balloon, ask audience to cover their ears and remove *their hearing aids.*

6. Set off the yellow balloon, but be sure your own ears are protected.

After explosion, compare the mixture which was low in pressure in the yellow balloon and the 2,200 *psig* in the oxygen regulator when it is attached to a full cylinder. Is there any question how this could have happened? (Again show the blown up regulator.)

In closing, let us be mindful that, in calculating the effect of an accident, you will come out with this answer:

ACCIDENT: (—) Subtracts from your pleasures.
(+) Adds to your miseries.
(:) Divides your income.
(x) Multiplies your worries.

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2. Give recognition for good individual records of safety.

3. Keep good records, provide a follow-up and take some kind of disciplinary action on those who will not act in a safe manner.

The Oklahoma Department of Highways started a safety program a few years ago, and as you will probably agree, maintaining public employee interest in a safety program is unusually difficult due to the nature of public employment. However, the training program did stimulate enough interest and added knowledge so that there was a marked reduction in accidents on the job. As proof of this, the Department was able to turn as much as $46,009 back to the workmen's compensation fund in one year.

Prior to the last two years, the accident rate for our Oklahoma Highway patrol cars had been relatively high, until we started a defensive driving course and relied on accident records to lead us to change the color of the flashing warning lights on the back of the cars from red to amber. We learned that the amber light gives our troopers and their cars better protection. Apparently this is true since red has become so commonplace.

Training is essential, but let us never forget that practically all human endeavor, from the cradle to the grave, is based on awards. The baby learns to walk by striving to get something that is held out of his reach by his parents. When he walks he gets the reward.

A student in school is recognized for excellence in scholarship. An athlete strives harder when he knows he will receive the cheers from the crowd. The military gives medals, ribbons, badges for outstanding services. Awards are given for church activities that are above the routine.

Give recognition its due place in your program because if you don't, others will pass you in their safety efforts as they use this lever.

Because there are many people who will not, or do not have enough reason to, [illegible] safely, there must be an effective follow-up and, if necessary, disciplinary action, even though it may be distasteful for you to administer.

In the Highway Patrol, we found that the Accident Review and Screening Board which places the blame for unsafe acts made a strong impression on many of the men who did not react in the desired manner when we used a milder approach. When the Board starts talking about actions which effect the pocketbook and job security, we gain a renewed interest in the program.

Again I refer to this as a control situation which you have to a very high degree in industry and in public employee groups. It appears that you must take advantage of this situation through necessity because of the great amount of injury, death and time lost in your organization.

By nature, most people are gamblers who like the thrill of taking a chance. Many of them seem to thrive on the game of chance. Speed provides the stimulant of thrill and tingling spine. They take short cuts to save time so they can go to the races, the circus where they see the dare devils, and to the T.V. programs that are tense with danger.

All of this seems to be a necessary ingredient in their daily working, recreational and home lives.

We know this and it is my belief that we must accept it if we are to deal effectively with this mass problem in our society. You should take advantage of the control situation in your department and:

1. Be sure that you have taught the employee to act safely.

2. Give recognition for good individual records of safety.

3. Keep good records, provide a follow-up and take disciplinary action if warranted.

We must do the best job that we can with the knowledge at hand. Let us not be too hopeful that someone else will come up with a magic formula. Let's create our own formula through dedication and determination.

Administrators must not overlook the opportunity or responsibility to provide an effective safety program for their employees.

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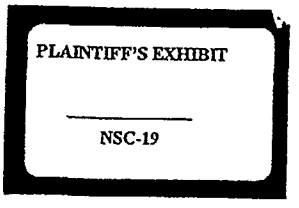
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VOLUME 1 OF THE TRANSACTIONS

55th NATIONAL SAFETY CONGRESS

(October 23-26, 1967, Chicago)

Papers Delivered in the

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(With List of Exhibitors and General Index)

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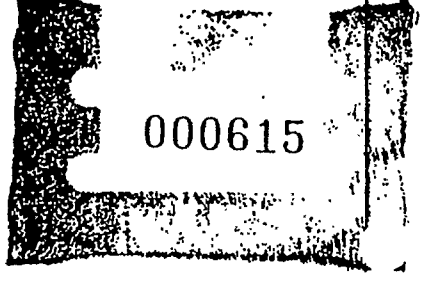
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problems. Invite them, seek them, get them to come to you. Be approachable.

9. Have a trial period, followed by a careful reexamination by all people concerned.

Helpful Hints for the Successful Supervisor.

The five most important words of a supervisor are, "I am proud of you."

The four most important words of a supervisor are, "What is your opinion?"

The three most important words of a supervisor are, "If you please."

The two most successful words are, "Thank you."

The one most important word is, "Your."

The least important word is, "I."

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minimum injury to employees; to promote maximum efficiency; and to effect savings by preventing injury and by reducing interruptions caused by occupational accidents."

The objective was followed by an outline of methods of obtaining the objective: "The effectiveness of the Accident Prevention Plan will depend upon the participation and cooperation of supervisors and employees of all contractors and sub-contractors engaged on this project, and the coordination of their efforts in carrying out the following basic procedures:

1. Planning all work to protect against personal injury, property damage, and loss of productive time.
2. Maintaining a system of prompt detection and correction of unsafe practices and conditions.
3. Making available and enforcing the use of personal protective equipment and mechanical guards.
4. Establishing an effective system of tool and equipment inspection and maintenance.
5. Establishing an educational program to insure the interest and cooperation of all employees through:
   A. Personal example and safety contacts.
   B. Instruction in safety requirements and insistence on compliance with such requirements.
   C. Safety meetings.
   D. Effective use of bulletins, posters, or other safety literature.
   E. Investigation of all accidents to determine their cause and promptly taking the corrective action to prevent their recurrence.
6. Each contractor's and sub-contractor's principal supervisors shall obtain a copy of and shall comply with the Indiana Safety Code for the Construction Industry, and rules and regulations applicable to the work performed by each employer on this project."

Following the outline of six methods to gain the objectives, the responsibilities of the chief project engineer; the safety coordinator; the contractors and sub-contractors; and the job foremen are outlined.

The chief project engineer is responsible for the entire plan as I have outlined it to this point and, in addition, must appoint a safety coordinator, authorizing him to enforce safety measures and to recommend corrective action when sub-standard practices and conditions are observed.

The responsibility of the safety coordinator is to follow all phases of the plan as they have been outlined and in addition maintain adequate records.

The responsibilities of the contractor and sub-contractor are:

1. Comply with all provisions of the Accident Prevention Plan, including attendance at and participation in safety meetings.
2. Appoint a qualified representative with full authority to act on all matters relating to the Accident Prevention Plan.
3. Plan work to protect against personal injury, property damage, and loss of productive time.
4. Cooperate with the project safety coordinator.
5. Comply with the requirements of the Indiana State Code and all other codes relating to his operations.
6. Provide to employees and visitors all personal protective equipment required by the exposure and enforce the use of such equipment.
7. Insure that prompt first aid is administered to an injured employee and transport him to the project clinic or as otherwise directed by the clinic.
8. Comply with all required accident reporting procedures.

The outline of the job foreman's responsibilities include:

1. Setting a good example for the men.
2. Instructing in safe work practices and work methods.
3. Use of proper protective equipment and proper tools.
4. Checking for unsafe conditions and practices.
5. Completely investigating accidents to determine causes and taking all necessary corrective action.
6. Promptly completing required Accident Reports.
7. Holding meetings with men.

The Burns Harbor construction supervision and safety personnel are continually in the construction areas and insist on strict compliance with the Accident Prevention Plan and the "General Safety Rules for Contractors". The fact that the Bethlehem Steel Corporation provides workmen's compensation and general liability insurance to cover approved contractors on the project greatly enhances enforcement of the safety program by Bethlehem and compliance with the program by the contractors.

Weekly safety meetings a[illegible] held by the craft union stewards, [illegible] committees from these meeti[illegible] with plant protection and sa[illegible] personnel of the Burns Har[illegible] to further assist in the compliance by all contractors toward the desired goal of maximum safe working conditions.

Periodically, the business agents for the crafts make safety tours of the construction areas with members of the construction and safety departments pointing out various constructive improvements to further improve the program.

Considerable time is spent working with the A.F.L. craft union safety representative to insure a mutual understanding that, for a safety program to be effective, requires the cooperation of both management and labor. Without the complete sincere support of the unions toward a [illegible] safety [illegible] frequently only [illegible] lip service [illegible] action is taken.

Compliance and cooperation on this project has been excellent. Only infrequently have actions, other than firm reminders, been required to bring the safety procedures into line. The aid of the punch [illegible] ment is enlisted when the most [illegible] rective actions have been necessary. This procedure has been most effective.

Our program is not unlike other [illegible] in the construction industry, having the common denominator of planning, inspection, communication, and follow through accompanied with dedicated hard work on the part of each individual on the site. We attempt to implement our program with enthusiasm, a directness of purpose eliminating "Paper Service" and the attitude "we will [illegible] problem later".

OCCUPATIONAL HEALTH IN THE CONSTRUCTION INDUSTRY

By FRED OTTOBONI

Senior Industrial Hygiene Engr., Bureau of Occupational Health, California State Dept. of Public Health, Berkeley, Calif.

Occupational health in the construction industry is a subject that has not yet received any real interest or attention in the United States. Articles appear from time to time in the American literature on a specific health hazard, such as lung cancer in asbestos insulators, or lead poisoning in painters. Other than a few papers originating in California, where a start has been made on the heat, noise, and dust problems of heavy equipment operators, almost nothing seems to have been written on the present health status of the individual crafts or on the overall health problems or needs of the industry.

This lack of interest and work is significant. Either there are no problems in the industry worthy of mention, or there is an appalling lack of some vital ingredient which is necessary for stimulating the growth of a systematic interest in the health of more than four million American workers.

First, let's define "occupational health". The term has been so loosely used over the last few years that intelligent discussion of the subject has been difficult. Some people interpret it to mean everything from a cut finger to the social well-being of the worker's family. For our purposes here, however, occupational health means the prevention of work-caused disease and disability by control of the work environment, especially where both labor and management have a clear responsibility for observation, supervision, and hazard control. This definition requires particular meaning when one recalls that the majority of occupational diseases are not curable; they are only preventable.

Five conclusions have emerged from our studies of occupational health problems in the construction industry. We feel these are fundamental, if progress is to be made. They are the result of nearly five years of observations in California. They are: (1) that the lack of interest, the lack of [illegible] the lack of action that [illegible] is recognized that the [illegible]

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pressing safety problems in the industry may, in part, be responsible for submerging any concerted interest in health problems. While no attempt is made here to detract from the important responsibility for accident prevention in the industry, it is time that programs in work-induced disease prevention begin to receive the attention they deserve. High accident frequencies cannot, by any stretch of the imagination, justify a lack of interest in healthy working conditions.

Our first conclusion--there is a basic need to recognize that construction workers are now suffering job-induced diseases and that new diseases will emerge with advancing technology.

To the casual observer or even a member of the industry itself, it is reasonable to believe that occupationally-induced diseases in construction work are not a problem. The crafts have long histories of working outdoors in the fresh air with hammers, shovels, and other tools which have in the past traditionally presented safety problems, but not health problems.

A look at the Federal or State health statistics appear to support this concept: not because there is a lack of problems, but because neither the Federal government nor the states—with the possible exception of California—keep any statistics on the subject. When no disease is reported, it is natural to conclude that none exists. However, what appears as no problem is, in reality, no information on the problem.

Experience in California supports this conclusion. In recent years, physician's reports of occupational diseases among construction workers have been coming into the State Health Department at approximately twice the average rate for all California workers. Since 1949, when recording began in California, this rate has been continuously among the three highest of all the major industries. The diseases involve the skin, the lungs, systemic poisonings, hearing loss—essentially the whole range of illnesses normally believed to lie in the exclusive province of factory workers.

Field investigations suggest that more is to come. For example, an estimate based on hearing tests conducted at construction sites by fully-qualified audiologists indicates that some 20,000 heavy equipment operators now working in the state have permanent noise-induced hearing loss. The trend toward larger, faster, and more powerful equipment, designed without consideration for the long-term health of the operator, is expected to intensify this hearing loss problem. It also is expected to introduce silicosis for the first time as a disease of the operators of dozers, power shovels, and front-end loaders.

The equipment operator is not alone in facing these health hazards. The recent replacement of the plasterer's conventional trowel with a spray nozzle has introduced serious hearing loss problems insofar as the plaster guns that we have measured are concerned. Further, the gun application of asbestos-containing fireproof coatings continues without control and without concern. Yet, data coming in regularly from studies of men working around asbestos dust leave very little doubt that the gun operator and other craftsmen in the area are being subjected to the risk of asbestosis and lung cancer.

There are many more examples. Plastic adhesive and surfacing materials have made life an itchy nightmare for the tile setter and the cement mason. It is important to realize that much of this skin disease is accompanied by a permanent allergy to the epoxy resin hardener used in the process. The slightest further exposure to the hardener brings on a repeat case of the itch and the man is permanently disabled for any further work with the plastic.

Another example involves today's welder. There was a time when very little except ordinary steel was found on a construction job. An unprotected welder could work with very little hazard from fumes. Alloys are changing this. For instance, inhalation of the fumes from manganese steel will produce an illness which closely resembles Parkinson's disease. Consider also that nickel, cadmium, vanadium, and some other metals are toxic by inhalation.

It is clear that the pick and shovel are gone, and along with them went the fresh air and the iron man. The construction industry has entered the era of machines and chemicals, and it should recognize this.

A second conclusion—it must be recognized that the methods which have been developed for the protection of the factory worker may not be feasible on a construction job.

Most of the occupational health literature and practically all of the preventive methods in use were developed with the factory worker in mind. The factories [illegible] for research in the [illegible] critical industrial health pro[illegible] of the late 19th and early 20th centuries [illegible] where the interest, the research, and the money has been invested. The emphasis today, although comparatively small, is still on the factory. As a result, the standard control methods available in all the textbooks, *ventilation, isolation, enclosure, substitution,* and personal protection, are organized to make practical and economical sense in a factory setting.

The factory hand works for the most part in a fixed location. Exposure is repetitive and predictable over a long period of time. Utilities are available and control methods can be designed, tested, and finally built-in as part of the company's long-term capital investment. It is not unusual to see a $20,000 ventilation system built into a plant to protect 10 or 15 welders.

But look at the welders on the construction job. In a lifetime, each will have done about as much work and generated as many fumes as a factory welder. However, the control system here is non-existent, because the control methods in the textbooks do not make practical or economic sense on a construction job.

Factory spray painting is done in a ventilated booth, according to the books. Since a booth would cost too much on a construction job, we scratch our heads and spray paint anyway.

Dust, noise, heat, and almost any health problem is controlled by cookbook methods in the factory. The cook book doesn't work for construction, so we live with the problems and hope they will go away.

It is now critically necessary that we accept the fact that a construction job is not the same as a factory job, and that the factory hazard-control cookbook—although free—is not applicable.

A third conclusion—we must begin to develop our own occupational health standards.

The golden era of occupational health in the United States ended in the mid-1950's. The movement which began in the 1930's and provided wide knowledge of industrial diseases and excellent textbooks is slowly dying. The Federal program is small and without legal authority. State programs not only have been declining in manpower, but show little interest in the construction industry. The traditional standard-setting agency [illegible] Industrial Conference of [illegible] Industrial Hygienists, is dependent on [illegible] dues-paying members for support. [illegible] $13,000 yearly total budget will not [illegible] more than a fraction of the country's problems, and that fraction will be factory oriented.

On this basis, it is unlikely that the widely subsidized work that went into helping the industrialist to understand his problems and to custom-tailor his environmental control will be available to the construction industry. The facts are that the responsibility for providing a reasonably healthy place to work lies directly with construction labor, and construction management.

The need for environmental standards is growing with each day. Noise offers a fine example: Heavy equipment, trucks, compressors, chain saws, jackhammers, and a wide variety of power hand tools are producing hearing loss that is reaching scandalous proportions. There are choices. The individual contractor can hire an acoustics expert and modify these tools at his own expense. As another choice, he can attempt to stuff cotton plugs in his men, a method that will be of no practical value on a construction job, and one that will probably reduce productivity. A popular alternative is to do nothing and let the insurance companies worry about it.

The sensible solution is to collectively write a set of performance standards for power equipment. These can be written right now, from knowledge at hand, and would specify maximum allowable noise intensities at an appropriate given distance from the equipment. The tool manufacturers may have difficulties at first. But their engineering and research departments are available and in the best position to control hearing loss at the lowest possible cost.

Adequate labelling also must be considered. Very few of the materials capable of causing eye, skin, or lung problems such as plastics, paints, welding rods, fluxes, solvents, lubricants, etc., have useful warning labels when they reach the construction site. This has two negative effects, in addition to the potential for injury. First, even the interested men cannot find out how to protect themselves. And second, if the material does cause a problem, the men have no clear information that might be useful in selecting a less harmful product for the next job.

This is particularly dramatized by the experience of the cement masons, where labels are often so vague as to make it impossible for them to determine whether the surfacing material they are expected to apply on a particular job is a dermatitis-causing epoxy, a bronchospasm-causing urethane, or a relatively safe polyester.

The noise and label problems are straightforward. They follow the textbook closely. Others may not be so simple because of the mobile nature of construction work. Solutions to these will require imagination and money. Ideas from the space program are sure to be useful and we expect to see exploitation of the controlled individual environment in the form of air-supplied suits for plasterers, cement masons, and welders; and air-conditioned, noise-and dust-tight capsules for heavy equipment operators. Standards, once set, can make these easily accessible at mass-produced costs.

The logical approach is to accept the responsibility and begin to develop some standards that can be put into contracts and equipment purchase orders; otherwise the industry faces attrition of skilled manpower, higher compensation costs, hazard pay, and if the problem gets bad enough, the inevitable application of the ill-fitting industrial cookbook to these construction jobs.

A fourth conclusion—records and statistics must be kept.

I repeat, health information on working men is scarce. This is particularly so in the construction industry because even the information that is obvious in a factory is clouded by the nature of construction work.

A factory is a relatively permanent environment. Jobs acquire reputations: they smell; old timers get lung disease; this or that chemical will make you sick if you inhale it. This is epidemiology in its most primitive form, done without the help of the professionals or the government. Nevertheless, it is very effective in discovering diseases and developing control methods.

Contrast this with a construction job. The office is often a house trailer and a single craft is not likely to be on a given job for more than a year. Who now is going to do the epidemiology? Work-induced health damage suffered by a craft during the course of a single project very easily passes without notice. It is not until a series of such projects —and years—have passed that disability is marked enough to prevent further employment. At this point, cause-effect relationships are obscure. No single event can be held responsible, and the work force has a few less craftsmen. If by some chance the illness is recognized as work-induced, the last employer may be held responsible for the entire cost of compensation. This is no solution.

For example, earth mover operators have long suspected that somehow spinal problems are connected with their jobs. This may or may not be so; there are no statistics. It is hardly possible that all equipment operators are born with bad backs. It is most likely, however, that the vibration and bouncing on some types of seats on some types of equipment are causing spinal damage. Unless it is known, first, whether or not operators are truly suffering spinal problems and second, exactly which machines and what conditions are responsible for the problems, prevention of "back trouble" will be impossible.

With computers now available, it is feasible to record the pertinent details of every job, every illness, and every death for every man working in the construction industry. This should be done by every craft union, with the cost shared by the employer. Routine computer output will then tell us whether painters die young, or equipment operators get silicosis, or plasterers get emphysema, and whether the lung cancer that has been found in asbestos insulators is being controlled or not controlled.

A fifth conclusion—uniform, reasonable regulation must be insisted on.

Competition is very real in construction. In fact, it appears to be so fierce that it often is cited as the justification for poor health and bad safety practices. For instance, the question as to why water is not being used to control dust on a given haul road very often will bring the reply that this is highly commendable; however, "it was not included in the job estimate because the competition never includes such things, and in order to bid the job successfully it was necessary to dispense with the water wagons".

This is a standard answer for many problems. Its effect is to penalize the legitimate contractors and to make the natural growth of healthy working conditions next to impossible. This fanatic interest in cost-reduction seems to be eroding the few existing health standards accepted by the industry.

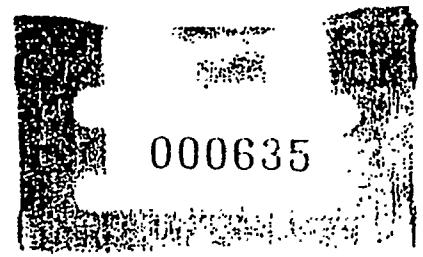
For example, everyone knows that a sandblaster should wear an airsupplied helmet. This has been accepted without question for decades. Yet during the last year the writer has seen five construction jobs where sandblasters were working. They all religiously wore the proper helmets—but not one had an air-supply hose connected to the helmet! Apparently the air supply isn't being figured into the bids anymore, even though it is still in the law.

Diesel engines in underground construction are an example of long-term, legal erosion. Diesels were allowed underground only after long study and, finally, the setting of rigorous standards by the Bureau of Mines. These included specially designed engines, matching exhaust scrubbers, and ventilation rates based on numbers which accompanied the vehicle from the manufacturer. Competitive progress over the last 20 years has led to the erosion of standards and the acceptance of any diesel vehicle with a home-made scrubber, and ventilation rates based on air sampling methods that have not been proved reliable. The engineered and tested standards and safety factors prepared by the Bureau of Mines are being forgotten. Although a few contractors still use Bureau of Mines equipment, continuous pressure from the industry has eroded the minimum standard. One thing is certain: eroded standards, no matter how legal, neither increase [illegible] make diesel exhaust better to smell or [illegible] to inhale.

The competitive inducement to [illegible] money by shaving health and safety [illegible] need not continue. Good applied [illegible] ards, as they are developed under [illegible] conclusion noted above, can be made a part of all construction contracts and all labor management contracts. In this way, healthy working conditions will be officially recognized as a legitimate cost of doing [illegible], and the toll will be paid in dollars by the buyer of services rather than in the health and longevity of the craftsmen who provide them.

The construction industry has a host of hidden and pressing occupational health problems, with more to come. For the short term future, government rescue does not seem possible and a serious and planned effort by management and labor is badly needed.

The construction industry has enjoyed and become addicted to the privilege of hard work and fresh air. Change is always difficult. But one way or another, like it or not, the technology that we are using to change the face of the earth will, in the long run, change us also.



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°Past General Chairman

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PLAINTIFF'S EXHIBIT
NSC-52

OCTOBER 1967

SAFETY NEWS

A NATIONAL SAFETY COUNCIL PUBLICATION

National Safety Congress and Exposition

Chicago, October 23-26

safetybrief



A breath of life — Mouth-to-mouth resuscitation was applied to power-line worker by a co-worker. The victim brushed against a live wire during routine line-work, and was knocked unconscious. He had stopped breathing. Quick thinking by co-worker was credited to saving a life. Seconds after photo was taken, the shout, "He's breathing," reassured on-lookers. Besides an unforgettable experience, the only ill effects suffered by the victim were minor burns on the hand and arm. (Photo: Courtesy United Press International.)

Have a heart — Heart and circulation diseases are listed as the third highest handicapping illness in the U.S.A. Yes, it is true. Heart disease scares the victim, but in some cases, it frightens the boss even more! If you are wondering just how much of a problem it is to hire a heart case, a new booklet will be of interest— *Workmen's Compensation and the Cardiac.* It shows how labor, management, and the medical profession cooperate to employ and rehabilitate cardiac patients. It is available from Chicago Heart Association, 22 W. Madison, Chicago, 60602.

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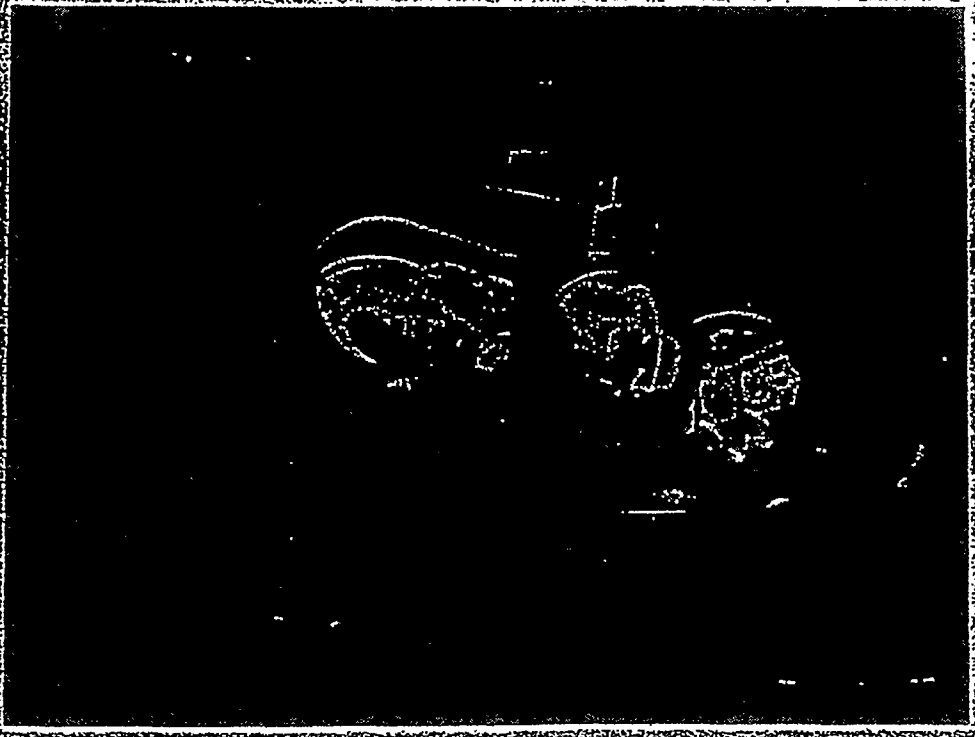
Asbestos dust and cigarets pose cancer risk — According to a recent study by three New York medical researchers (and reported in the June 6 issue of the *Wall Street Journal*) asbestos workers who smoke cigarets have a ninetyfold greater risk of dying from lung cancer than persons who neither smoke nor work around asbestos.

The researchers noted that microscopic asbestos fibers, once inhaled, remain permanently in the lung tissues. Asbestos workers who don't smoke cigarets should never begin. Those who do, should stop now.

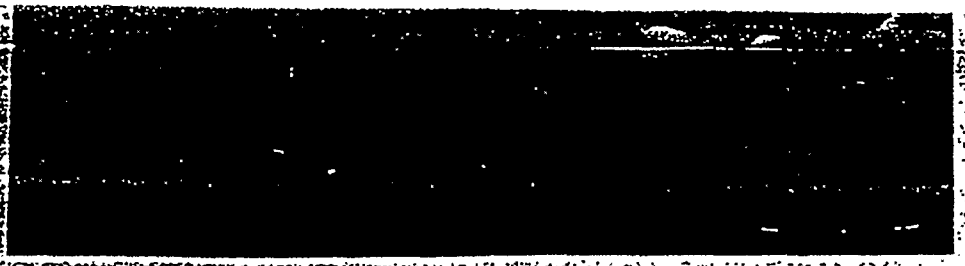
Comprehensive airport plan — The Federal Aviation Agency has introduced a new national airport plan to accommodate massive U. S. airport needs. If our airports are to be capable of safely handling the impending all-jet and supersonic fleets of the next decade, aviation interests and progressive communities must make known to their senators and representatives the need for adequate federal funds to augment local financing. The current plan includes recommendations for constructing new landing facilities at existing airports.

National Safety News, October 1967

Challenging inner space — An artist's concept shows a phantom, cut-away view of Lockheed Missiles & Space Company's research submarine Deep Quest with a diver support module. Lockheed studies show that such a support system could help move divers and equipment safely from the surface to underwater sites. The support module would enable man to increase the amount of useful work he can perform at depths of 600 feet, and it might eventually help him surpass the 1,000 feet diving record.



As a result of the intense interest in oceanographic exploration, the American Bureau of Shipping is in the process of formulating guidelines for the certification of deep submergence vehicles and other submersibles. These guidelines, when promulgated, will aid insurers who must currently determine seaworthiness of vessels (such as the Deep Quest) on the basis of their own engineering studies. Marine Office of America is the insurer of the Deep Quest.



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Seat belt enforcer — An inexpensive electronic system has been developed to insure and enforce occupants of motor vehicles to comply with keeping their seat belts fastened at all times. The system works through the ignition and starter solenoid of the vehicle.

Offshore drilling safeguards — An inter-industry agreement on a comprehensive pattern of shipping fairways and anchorage areas throughout the oil fields in U.S. coastal waters from Florida to the Rio Grande provides a major step toward safeguarding life and property in the offshore oil drilling area of the Gulf of Mexico. The objective, according to the American Merchant Marine Institute, Inc., is to eliminate interference among operations and to reduce the hazard of collision between ships and fixed drilling structures. — **End.**

Threshold Limit Values For 1967

Threshold Limit Value is a phrase that is often used in industrial health and equally as often misunderstood or misinterpreted. The recommended and intended values, adopted at the 29th Annual Meeting of the American Conference of Governmental Industrial Hygienists, Chicago, May 1-2, 1967, are reprinted here as a guide for the safety engineer.

The Threshold Limit Values refer to air-borne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day, without adverse effect. Because of wide variation in individual susceptibility, exposure of an occasional individual at or even below the threshold limit may not prevent discomfort, aggravation of a pre-existing condition, or occupational illness.

Clinical tests are becoming available that permit detection of those individuals who will hyperreact upon exposure to certain industrial substances. Being predictive in character, they may be applied as screening tests in the preplacement job examination. Requests for further details of these tests should be directed to the Chairman of the Committee.

Threshold limits should be used as guides in the control of health hazards and should not be regarded as fine lines between safe and dangerous concentrations. Exceptions are the substances given in Appendix A and certain of the substances given a "C" listing. The values not given a "C" listing refer to time-weighted average concentrations for a conventional 7 or 8 hour workday.

Time-weighted average concentrations permit excursions above the limit, provided they are compensated by equivalent excursions below the limit during the work day. The degree of permissible excursion is pegged to the threshold limit value of the particular substance as given in table in Appendix C under "Test TLV Factor." Hence, it is not considered appropriate to interpret air concentration values as exceeding time-weighted average limits, if such values lie within the permissible excursions. (See section on Legislative Code.)

The amount by which these concentrations may be exceeded for short periods without injury to health depends upon a number of factors such as the nature of the contaminant, whether very high concentrations even for short periods produce acute poisoning, whether the effects are cumulative, the frequency with which high concentrations occur, and the duration of such periods. All must be taken into consideration in arriving at a decision as to whether a hazardous situation exists. Enlightened industrial hygiene practice inclines toward controlling exposures below the limit rather than maintenance at the limit.

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Threshold limits are based on the best available information from industrial experience, from experimental human and animal studies, and when possible, from a combination of the three. The basis on which the values are established may differ from substance to substance; protection against impairment of health may be the guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance or other forms of stress may dominate the basis for others. The Committee holds to the opinion that limits based on physical irritation should be considered no less binding than those based on physical impairment; growing bodies of evidence indicate that physical irritation may promote and accelerate physical impairment.

These limits are intended for use in the field of industrial hygiene and should be interpreted and applied only by persons trained in this field. They are not intended for use, or for modification for use, 1) as a relative index of toxicity, by making a ratio of two limits, 2) in the evaluation or control of community air pollution or air pollution nuisances, 3) in estimating the toxic potential of continuous uninterrupted exposures, 4) as proof or disproof of an existing di-

to page 52

from page 48

sease or physical condition, or 5) for adoption by countries whose working conditions differ from those in the United States of America and where substances and processes differ.

Documentation of Threshold Limit Values. A separate companion piece to the TLVs is issued by ACGIH under this title. This publication gives the pertinent scientific information and data with reference to literature sources that were used to base each limit. Each documentation also contains a statement defining the type of response against which the limit is safeguarding the worker. For a better understanding of the TLVs it is essential that the Documentation be consulted when the TLVs are being used.

Ceiling vs Time-Weighted Average Limits. Although the time-weighted average concentration provides the most satisfactory, practical way of monitoring air-borne agents for compliance with the limits, there are certain substances for which it is inappropriate. In the latter group are substances which are predominantly fast acting and whose threshold limit is more appropriately based on this particular response. Substances with this type of response are best controlled by a ceiling "C" limit that should not be exceeded. It is implicit in these definitions that the manner of sampling to determine compliance with the limits for each group must differ, a single brief sample, that is applicable to a "C" limit, is not appropriate to the time-weighted limit; here, a sufficient number of samples are needed to permit a time-weighted average concentration throughout a complete cycle of operations or throughout the work shift.

Whereas the ceiling limit places a definite boundary which concentrations

Mixtures. Special consideration should be given also to the application of these values in assessing the health haza which may be associated with exposure to mixtures of two or more substances. A brief discussion of basic considerations involved in developing threshold limit values for mixtures, and methods for their development, amplified by specific examples are given in Appendix B.

"Inert" or Nuisance Particulates. A number of dusts or particulates that occur in the working environment ordinarily produce no specific effects upon prolonged inhalation. Some insoluble substances are classed as inert (e.g., iron and steel dusts, cement, silicon carbide, titanium dioxide, cellulose); others may be soluble (starch, soluble oils, calcium carbonate) but are of such a low order of activity that in concentrations ordinarily encountered do not cause physiologic impairment; still others may be rapi eliminated or destroyed by the bo (vegetable oils, glycerine, sucrose). In the case of the insoluble substances, there may be some accumulation in the respiratory passages. In the case of the soluble substances, this accumulation will ordinarily be temporary but may interfere to some extent with respiratory processes. Hence, it is desirable to control the concentrations of such particulates in the air breathed by any individual, in keeping with good industrial hygiene practice.

A threshold limit of 15mg/m^3, or 50 mppcf, whichever is less, is recommended for substances in these categories and for which no specific threshold limits have been assigned. This limit, for a normal work day, does not apply to brief exposures at higher concentrati Neither does it apply to those substances which may cause physiologic impairment at lower concentrations but for which a threshold limit has not yet been adopted. Some "inert" particulates are given in

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Whereas the ceiling limit places a definite boundary which concentrations should not be permitted to exceed, the time-weighted average limit requires an explicit limit to the excursions that are permissible above the listed values. The magnitude of these excursions may be pegged to the magnitude of the threshold limit by an appropriate factor shown in Appendix C. It should be noted that the same factors are used by the Committee in making a judgment whether to include or exclude a substance for a "C" listing.

"Skin" Notation. Listed substances followed by the designation "Skin" refer to the potential contribution to the overall exposure by the cutaneous route including mucous membranes and eye, either by air-borne, or more particularly, by direct contact with the substance. Vehicles can alter skin absorption. This attention-calling designation is intended to suggest appropriate measures for the prevention of cutaneous absorption so that the threshold limit is not invalidated.

These values are reviewed annually by the Committee on Threshold Limits for revision or additions, as further information becomes available.

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Simple Asphyxiants—"Inert" Gases or Vapors: A number of gases and vapors, when present in high concentrations in air, act primarily as simple asphyxiants without other significant physiologic effects. A TLV may not be recommended for each simple asphyxiant because the limiting factor is the available oxygen. The minimal oxygen content should be 18 per cent by volume under normal atmospheric pressure (equivalent to a partial pressure, pO_2 of 135 mm Hg). Atmospheres deficient in O_2 do not provide adequate warning and most simple asphyxiants are odorless. Several asphyxiants are listed in Appendix E. Some asphyxiants present an explosion hazard. Account should be taken of this factor in limiting the concentration of the asphyxiant.

Physical Factors. It is recognized that such physical factors as heat, ultraviolet and ionizing radiation, humidity, abnormal pressure and the like may pl added stress on the body so that the effects from exposure at a threshold

limit may be altered: Most of these stresses act adversely to increase the toxic response of a substance. Although most threshold limits have built-in safety factors to guard against adverse effects of moderate deviations from normal environments, the safety factors of most substances are not of such a magnitude as to take care of gross deviations. For example, continuous work at temperatures above 90F or over-time, extending the work-week more than 50 per cent, might be considered gross deviations. In such instances judgment must be exercised in the proper adjustments of the threshold limit values.

"Notice of Intent." At the beginning of each year, proposed actions of the Committee for the forthcoming year are issued in the form of a "Notice of Intent." This Notice provides not only an opportunity for comment, but solicits suggestions of substances to be added to the list. The suggestions should be accompanied by substantiating evidence.

As Legislative Code. The Conference does not consider the Threshold Limit Values appropriate matter for adoption in legislative codes and regulations and recommends against such use. If, however, the list is so used, the intent of the concepts contained in the Preface should be maintained and provisions should be made to keep the list current.

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The TLV Committee includes the following industrial hygienists: Herbert E. Stokinger, Ph.D., chairman; E. J. Baier, H. B. Elkins, Ph. D.; W. W. Fredrick, Ph. D.; B. Grabois, P.E.; P. Gross, M.D.; W. J. Hayes, Jr., M.D.; F. T. McDermott; E. Mastromatteo, M.D.; W. W. Melvin, M.D.; R. G. Smith, Ph.D.; M. R. Zavon, M.D., and H. N. MacFarland, Ph.D., who acted as a consultant.

Copies and price schedule may be obtained by writing to Mr. A. D. Hosey, Secretary - treasurer, ACGIH, 1014 Broadway, Cincinnati, Ohio 45202.

The second edition of the *Documentation of Threshold Limit Values*, rewritten and greatly enlarged to include the approximately 400 substances in the list, is available and may be purchased from ACGIH. Cost: $4.50.

Related publications, also available from ACGIH are: *Air Pollution Control Process Flow Sheets; Air Sampling Instruments Manual;* and *Analytical Methods Manual.*

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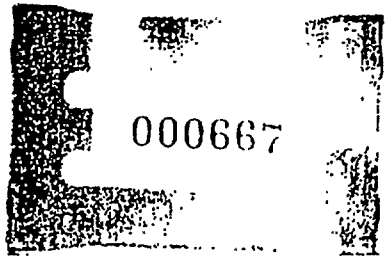
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mittee is to make management aware of the benefits of safety efforts and to educate workers. Joint safety seminars are held at scheduled intervals from four to seven months. Films are shown, panel discussions held, demonstrations given, and particular subjects are discussed, such as "X-ray and effects of radiation on the human body." Company representatives are also invited.

A campaign emphasizing the importance of defensive driving was launched the first week of June involving a questionnaire, visual aids such as posters, and newspaper and radio coverage. They are enlarging the scope of their off-the-job safety activities and cooperating with local safety council organizations and community officials.

Award of Honor to

UNITED STEELWORKERS LOCAL 6500

Sudbury, Ont., Canada

This local is receiving recognition for the third time. They received an Award of Merit for 1965 and the Award of Honor for 1966. They have now qualified for another Award of Honor for activities conducted during 1967. Their efforts have assured the continuity that is so important in keeping a good safety program going and growing.

They continue to give extensive publicity to safety through local television, plant bulletins, and their own paper. Safety training is a vital part of their program for union members.

They have accelerated their activities and improved present ones, so that the Awards committee judges agreed they deserved to receive the top award again.

Award of Honor to

INTERNATIONAL LONGSHOREMEN'S ASSOCIATION

New York City

This international union received an Award of Merit for the year 1964, and now they have qualified for the top award — the Award of Honor — for 1967.

The International has consistently promoted safety in its publications. They have expanded their activities from the Port of New York and vicinity to the entire Atlantic coast and Gulf area and the Great Lakes. Safety training receives top priority. An example is the 12-hour training course on "Handling Dangerous Cargoes" given in Milwaukee. They participate in committees of the USA Standards Institute. They have assisted in waterfront fire prevention month which included safety demonstrations. Correspondence and testimony on behalf of the Occupational Safety and Health Act of 1967 has taken hours of their staff time.

The judges noted the significant acceleration of safety efforts and agree that the International Longshoremen's Association truly deserves the Award of Honor.

Award of Honor to

OIL, CHEMICAL AND ATOMIC WORKERS LOCAL NO. 4-447

Destrehan, La.

This makes the fourth time that this local has received recognition for safety activities. They were granted the Award of Merit for the years 1964-65-66.

This local has significantly accelerated their accident prevention work over the previous years. A major activity was a "Poison Prevention Week;" the National Drivers Test was again extensively promoted among their members; they conducted the annual Christmas holiday safety campaign; and also the annual Labor Day safety campaign. They are active in the entire metropolitan New Orleans area. The local is made up of 11 groups, each group employed by a different company. Each group leader is also safety chairman. All groups elect an overall safety director to coordinate and promote union safety activities.

The judges commend this local for increasing its safety efforts and agree they deserve the highest possible recognition.

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Citation for Distinguished Service to Safety to

JULIUS N. JACOBSEN, Safety Chairman,
Oil, Chemical, and Atomic Workers Local 4-447, Destrehan, La.

The judges were impressed with Brother Jacobsen's tenacious efforts on behalf of safety in his local union. The documented material vividly revealed the many extensive activities he promoted and participated in. It also showed the amount of time and energy he unselfishly put forth to promote safety.

The judges noted the many areas of activity in which he is engaged, including safety training, and the fact he was not deterred in achieving noteworthy goals. The Awards committee of the Labor Conference warmly commends him for his solid achievements.

OCCUPATIONAL HAZARDS—MAKING THE INVISIBLE VISIBLE

By RALPH NADER
Attorney, Author, Safety Critic, New York, N. Y.

The chief forms of domestic violence affecting American working men and women are motor vehicle crashes and occupational dangers and diseases. Taken together or singly, their toll in death and injury utterly dwarfs the violence incurred through street crimes. While the nation is properly concerned about street crime, it virtually ignores the far greater death, injury, and wage losses on farms, in mines, factories and open work areas such as construction sites. Consider one comparison out of many that could be detailed: all the riots in this country during the past three years in our cities have led to about 260 dead; each working day brings death to 55 workers, disabling injury to 8,500 workers and lesser injuries to 27,200 other laborers. Every year, 14,000 to 15,000 workers die, over half a million are disabled by occupational diseases, over two million are disabled by occupational accidents, and over seven million are injured. The toll is even greater than indicated by the above data because death through toxic exposure over time to chemicals or particulate matter is rarely recorded. The half million plus workers disabled from the effects of asbestos, beryllium, carbon monoxide, coal dust, cotton dust, cancer-causing chemicals, dyes, pesticides, radiation etc. must be taking terminal doses over time from some of these exposures. There is another reason why the above data must be considered understated—a reason which leads to the first of six realities which should be recognized publicly before significant progress can be made to reduce worker injury and disease:

1. Under-reporting by industrial firms of actual injuries and disease experienced by laborers has long been an endemic managerial disease. First, the definition of what constitutes an injury is decided by an industry-dominated body called the United States Standards Institute of America—a group of industries and industry technical societies. Second, companies go to considerable length to avoid reporting a lost time injury—not only to keep their insurance rates down but to preserve their place in safety competitions. For example, a worker in a Jones & Laughlin steel plant received a groin injury; he was taken off his usual job and placed in a chair where he sat doing nothing for two weeks. Any blue-collar man knows that such a practice is not unusual in numerous industries.

2. Plant physicians surrender to or are constrained by corporate dictates as to the exercise of their medical judgment and right to publication of cases in the medical literature. A recent case in point involved a Dr. John Zalinsky, a physician at the Brush Beryllium plant outside Cleveland, who had cases of workers suffering from beryllium poisoning and wanted to publish them in a

medical journal (without mentioning their names, of course). He was told if he did he would have to look for another job. The doctor had a bad heart and was concerned about looking for other employment. Before he could do anything, he died of a second heart attack.

Dr. Lorin E. Kerr of the United Mine Workers Welfare and Retirement Fund, an authority on coal workers' pneumoconiosis (or, as the coal dust disease is popularly called, "black lung"), has sharply denounced "the attitude and influence of employer-oriented physicians who avoid facing known facts about the ravages of coal dust in human lungs because to do otherwise would cost money. The impact of physician knowledge and attitudes is apparent in inaccurate or incomplete death certificates. These documents are essential for determining the existence of a dangerous dust requiring governmental action for control or eradication. Too often, no records mean no action. Physician denial or avoidance of known facts can also determine the publication of information. In 1956, the concern of some physicians about management attitudes effectively blocked the publication of a paper of mine on coal workers pneumoconiosis in the most widely circulated medical journal in the United States. One can only wonder how many times other medical information vital for the protection of the health of workers has not been published for the same reason. Physician attitudes also influence other groups such as company lawyers, state legislators, and officials who, all-told, are remarkably resistant to the elimination or control of coal dust because it would cost money."

Coal workers' black lung or pneumoconiosis affects at least 150,000 active and retired miners in advanced stages of lung destruction. Two thousand men die from this disease in Pennsylvania every year. What Dr. Kerr was referring to was a critical rupture in the recording and communicating of data by members of the medical profession.

3. State safety laws and regulations are weak, inspection is poor, and penalties rarely imposed. The states spend an average of 40 cents per worker per year on industrial safety. Some states such as Texas and Oklahoma have taken this down to two cents per worker per year. Of the 1,524 state inspectors, 697 inspect boilers, elevators and mines, leaving only 827 inspectors for general safety inspection, construction, safety promotion and education, health, and industrial hygiene, according to the Bureau of Labor Statistics. (There are almost twice as many fish and game wardens — about 3,000 — employed by the states to look out for wildlife.) Four states have no safety inspection staff in any area and 17 other states have 10 or less on their safety inspection staffs. More shocking is the fact that only three states have staffs specializing in the area of occupational health and industrial hygiene.

4. By and large, union leaders have been far too pliable when confronted by management's inaction or decisions regarding worker health and safety. Too often, health and safety conditions are treated as trade-offs for more tangible union gains in wages at the collective bargaining table. This has been the case, for example, with the United Mine Workers leadership, which finally is becoming slightly aroused over the plight of their workers but little dedicated to overturning coal management's modus operandi that treats coal miners as being less expensive than coal. Union leaders simply do not give health and safety a first rank priority; their lack of aggressive lobbying for the proposed Occupational Safety and Health Act of 1968 in Congress cannot be covered up by resolutions and resonant statements for the records. Labor leaders are wanted on the ramparts, not just on the record.

5. The Federal government has abdicated its responsibility to devote funds toward effective research programs and training programs for occupational health and safety. The Department of Health, Education, and Welfare (HEW) has had no sense of the importance of this problem, the need to develop preventive systems and competent medical and engineering personnel. HEW's advocacy has been weak and, if anything, the occupational health activity in the Department has been downgraded recently. The one area where HEW has received some consistent funding—$5 million since 1953—for research on the causes and prevention of coal workers' pneumoconiosis has had little to show for it, apart from a prevalence study completed three years ago. It is dismaying to note that not only does Western Europe spend twenty times the level on research in the coal dust disease area, but

control measures are years ahead of those in this country, which does not even have coal dust standards in force.

6. The workmen's compensation system in this country—its coverage, benefits, and deterrence—is creaking with obsolescence. A thorough inquiry is needed and serious thought should be given to uniformity. Not only are there irrational or politically inspired differences between states but some states are still mired in a value system of a bygone age. For example, coal miners' black lung disease is not considered work-related by the compensation laws of all states, except Pennsylvania (1965), Virginia (1968), and Alabama. Such human derelicts, spitting up coal dust, struggling for breath, afflicted with emphysema, massive fibrosis, or enlarged heart, are denied workmen's compensation in such states as West Virginia, Kentucky, Ohio, and Illinois. In Kentucky, according to the state's Department of Labor, about 1,400 out of 2,000 mines licensed to do business do not comply with the workmen's compensation law for other mine injuries apart from black lung. Yet, the present governor and his predecessor have not considered law and order to be applicable to coal operators.

Where does this leave the National Safety Council? Certainly, it does no service to truth and candor to hide the fact that the Council's industrial members and constituency take a strong interest in how far the Council goes in the occupational health and safety area. That interest, to use a mild word, resulted in the Council's being placed in a difficult position regarding the Occupational Safety and Health Act of 1968. Some observers believed that the Council retracted from a relatively positive position on the bill in February to a statement more in consonance with industry's preferences a few months later. For the Council, it is the same old dilemma of "to be or not to be" that has plagued its potential independence in other safety areas. If the Council is to be true to its potential in occupational health and safety, it cannot ignore at least some of the above-noted problems obstructing progress toward more humane working conditions.

LASER BEAM PRECAUTIONS

By WILLIAM McCULLOUGH
Collective Agreement & Grievance Officer, Canadian Union of Public Employees, Ontario Hydro Employees Local 1000, CLC, Toronto, Ont.

Before we consider the hazards and precautions for the safe use of the laser beam, we should understand what it is. The name laser is an acronym for light amplification by stimulated emission of radiation. The original concept was invented by Dr. Townes in 1955. In 1958 Dr. Townes and Dr. Arthur Schawlou gave a paper on how to construct an optical maser. The name maser is an acronym for micro-wave amplification by stimulated emission of radiation. An optical maser is a laser.

In 1960 Dr. Theodore Maiman, a scientist then working with the Hughes Aircraft Company, gave the world's first demonstration of a laser beam. In 1964 Dr. Townes won the Nobel prize for his work on the theory of lasers.

The light that comes from a conventional light source radiates in all directions in waves of varying lengths that reinforce or cancel each other. Because it is non-directional and of varying wavelengths, it is said to be incoherent. Light from a laser beam travels in only one direction and is all at the same wavelength, so that it reinforces itself and is known as coherent light. Because it travels in one direction in straight lines, it is a very narrow beam.

To obtain a directional beam from an incoherent conventional source of light it must be focused, and even then it soon spreads it's beam again. Ordinary light sources are usually heat units such as incandescent lamps, arc lights, etc. In a neon tube the glass walls remain cool but the electrons activate the neon atoms within the glass tube and accelerate them to levels normally found at high temperatures. The atoms of the source material are brought to a continuous excited state and they fall back to normal by losing energy through heat and visible light.

Division of Bethlehem Mines Corporation—an iron ore mine—also won the same Sentinels of Safety Award for 1967 and 1968. Our Foam Slag Plant at Sparrows Point has a record of an accident-free string of 1,440,073 man-hours. No. 58 Coal Mine of the Ellsworth Division of the Bethlehem Mines Corporation, Marianna, Pennsylvania, established a world record of 2,206,643 man-hours without a disabling injury. These accomplishments show that a real and burning desire for safety, good safety tools, and good organization can get results. Bethlehem certainly has.

One final point: no program is self-perpetuating. Therefore, you must work continually to keep your safety program effective. We realized, a few years ago, that our accident rate was not dropping as steadily as we felt it should—perhaps something was wrong. The company decided to conduct safety audits. The audits, we hoped would point out to local management the weaknesses and strengths of their programs and also provide corporate management with an overall picture of its safety program. Four areas are audited in our safety program: accident investigation, job safety analysis, job safety training, and safety observation. The audit team, composed of men from similar operations and the home office, reviews the complete safety program at an operation and reports its findings in writing to the local operating head. The audit points out for the superintendent where his program needs more emphasis, needs changes, needs modification if he is to reduce the accidents and approach a zero disabling injury rate.

That's where Bethlehem wants to be. We know that a good organization is an important step in our path to zero.

COMMUNITY STABILITY

By RALPH E. HUHTALA
Mgr., Personnel & Public Relations, Lake Shore Inc., Iron Mountain, Mich.

I could say that every citizen of a mining community assumes his responsibility for promoting effective mine safety; but to do so would be unrealistic, because the man on the street—the city official, the retailer, the school teacher—has his own problems and is content to leave the matter of accident prevention and industrial safety to the safety director, the National Safety Council or to others who have assumed that specific responsibility. But when an accident does happen which results in a disabling injury or—heaven forbid—a fatality, then the previously disinterested bystander becomes concerned, because he now has something at stake.

Generally speaking, mines are located in small communities, and we in management are often unmindful of the widespread effect that even a single disabling injury has on a small town. The grocer has to decide whether he should extend credit at a time of reduced income. The local governing body becomes concerned as to whether hospital and rehabilitation facilities are adequate, and maybe the city-subsidized ambulance doesn't have the support it needs to be ready for every emergency. The clergy and welfare agencies are often called upon for counselling. Even the school teacher's efforts may become less effective because of absenteeism that may occur when the family bread-winner is disabled. Multiply this by five, 10, or 20 and the job of the safety director or engineer takes on increasing importance—he, then, has a stake in community stability.

To further illustrate the strong interrelation between the accident prevention specialist, the mine manager, and the community, let us review a major mine disaster which happened just over 40 years ago in the community in which I lived, and see vividly how one community's stability was very badly shaken.

It was an underground iron mine with three levels—at 600, 800, and 1200 feet. The mine employed 150 men on two shifts. On a November morning, after a summer of unusually heavy rain, a section of swamp 300 feet square caved in, dropping quicksand and water into the 600 foot level and then down the shaft to the other two levels, trapping 52 men. It was then described as the worst mining disaster in U.S. history to my knowledge, it is still so regarded.

Briefly, here are some of the facts: of the 52 killed, 34 lived within the limits of one small city. Forty were married. Three pairs of brothers and three father and son teams were among the victims. The oldest victim was 66; the youngest, 18. Survivors included 107 children under the age of 16—three men left seven children each. One man survived, climbing 800 feet in 10 minutes.

The elected county mine inspector was in the mine at the time and was one of the casualties. Only 10 bodies were recovered. The maximum workmen's compensation benefit at that time was $14 per week payable for a maximum of 300 weeks.

The operating company was generally regarded as one of the pioneers in mine safety. The state mining engineer said, "The mine had not been under suspicion as dangerous." The state geologist described mine conditions as excellent and said, "Every possible precaution had been taken."

All of the community's limited resources were mustered to alleviate the hardships—

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[illegible] and clergymen banded together to [illegible] the survivors, and pro[illegible] with donations of food and clothing. The company was insured for workmen's compensation — voluntarily included the survivors of the mine inspector, who was not an employee, on their compensation payroll. The Red Cross withdrew from the scene, saying the situation was so well handled that anything they might do would be a duplication of effort.

The company was cleared of any negligence, and the U.S. Bureau of Mines report said, "From inspection and study, it is our judgment that the mine was operated according to the best mining practices and that all care possible was taken by the mining company to safeguard their employees and that the accident was due to causes that could not have been foreseen."

I am confident that in the intervening 40 years those of you who are experts in the field have developed new techniques that would make a recurrence of such a disaster highly unlikely, and that you will continue to dedicate yourselves to the prevention of accidents, thereby assuring continued "community stability."

A SUMMARY OF OCCUPATIONAL HEALTH ASPECTS IN MINING OPERATIONS

By ERNEST MASTROMATTEO, M.D., D.P.H., D.I.H.
Chief, Occupational Health Service,
Environmental Health Branch, Ontario Department of Health, Toronto, Ont., Canada

Mining is one of man's most ancient occupations. It began when man first began to dig for rocks and metals to make tools and weapons. About 20,000 years ago man began to sink shafts and drive tunnels for flint used to make knives, axes, and arrow heads. The Egyptians used copper for metal utensils, weapons, and ornaments over 15,000 years ago. By 4,000 B.C., copper was in general use throughout Europe. North American Indians had learned to hammer copper utensils, but they did not learn how [illegible] copper. Copper and tin occur togeth[illegible] Cornwall, England; they were sm[illegible]ether to produce bronze for the [illegible]ime about 2,000 B.C. Bronze daggers a[illegible] dating from this period have been recovered from ancient tombs.

Prehistoric man showed the effects of his occupational exposure to flint. He undoubtedly developed silicosis from flint-knapping—one of the oldest of industries. Egyptian mummies have been found with anthracosis and pleural adhesions. The stone cutters for the pyramids must have suffered from severe exposure to silica.

Mining has already been regarded as a hazardous occupation. Living and social conditions described by the early historians were appalling. The ancient miners were almost always slaves, condemned criminals, prisoners

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of war, or forced labor. The coal mines in Britain were developed in the twelfth century. Many lives were lost from accidents, black damp, fires, and explosion. In the 16th and 17th centuries the coal mines were greatly expanded with the industrial revolution. The industrial revolution brought rapid changes and was followed by awakened social concern about working conditions. Women and young children were employed in mines.

One of the earliest writers on the health aspects of mining was Georgius Agricola, who published his *De Re Metallica* in 1556. Agricola discussed in detail the mining, smelting, and refining of gold and silver. He recommended ventilation with fresh air for mine workings. He also recommended the use of masks to protect against mine dusts.

Mining operations, because of their diversity, present a wide variety of occupational exposures, some of which can result in ill health and disability. I hope in this presentation to touch on many of these exposures, with more particular reference to the mining industry in Ontario.

To some degree, underground work is similar to work done within confined spaces. For this reason, greater attention must be paid to toxic substances encountered underground. The air in mines is more likely to be contaminated than the air in factories. With abnormal conditions, e.g., fires, severe conditions are imposed. Adequate ventilation and control of air is most important in mines.

Pneumoconiosis-Producing Dusts

The pneumoconioses still constitute what is perhaps the most difficult as well as the most severe and costly of the occupational health problems which the mining industry has to face.

Coal Miners' Pneumoconiosis. Coal dust itself has always been considered to be a basically inert dust. In coal mining operations, however, it may be inhaled in large amount. The amount of free silica present in the airborne dust is usually quite small. Two main types of pneumoconiosis are described: simple pneumoconiosis and progressive massive fibrosis (PMF). The former is frequently associated with focal emphysema, whereas in PMF large solid masses of scar tissue are found in the lung. Tuberculosis is implicated in the majority of cases.

Ontario has no coal mining and I have no first hand experience on this subject. A superficial look, however, at the prevalence of coal miners' pneumoconiosis indicates the magnitude of the problem around the world wherever coal is mined. In the United States, a survey of 2,549 Appalachian bituminous coal miners covering the period 1963-1965 disclosed 9.8 per cent with definite x-ray evidence of pneumoconiosis. These miners had spent an average of 29.7 years underground. Considerable publicity has been given to compensation for coal miners' disability in Pennsylvania.

The prevalence of pneumoconiosis in coal miners from different countries is demonstrated in an I.L.O. report. I have adapted information from this publication in the Table below.

TABLE I

Prevalence of Coal Miners' Pneumoconiosis

Country	*Year*	*Number of Coal Miners'*	*Per Cent Miners with Pneumoconiosis*
Australia, N.S.W.	1948	—	12.5
	1960–63	11,526	3.5
Austria	1962	3,487	(8)*
Czechoslovakia	1960	150,000	13.3
France	1962	196,099	12.4
Germany	1961	317,707**	(2,668)*
India	1960	—	18.8
United Kingdom	1962	440,900**	(1,656)*

*New cases reported that year

**Underground miners only

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Silicosis. The inhalation [illegible] consequently no definition excessive amounts of fr[illegible] maximum concentration which is not quartz) gives rise to nod[illegible] to be exceeded has any significance unless fibrous tissue in the lungs. This fibrosis the type of equipment, the method of sampincreases and impairs the function of the ling, and the nature of the dust are prelung. Silicotics have increased susceptibility cisely known.

to tuberculosis, and this is responsible for In mine dust, determination of the free the major disability. silica (quartz) content of the airborne dust

In Ontario gold mines, the quartz content is important. With coal dust, it is customary runs up to 40 per cent, and in uranium to incinerate the sample to determine the mines up to 70 per cent. In nickel mines, amount of ash and also the quartz content the quartz content is quite low. In all, there of the ash.

are about 17,000 underground miners in On- The development of pneumoconiosis in a tario. The number of clinically disabled miner depends first and foremost on the cases of silicosis among these runs from five cumulative effect of dust exposure. As the to ten each year. About 400 actively em- exposure increases the incidence increases, ployed miners show x-ray evidence of sili- and the disease becomes more severe. In cosis without any disability—a prevalence of some cases, it is apparent that the total about 2.3 per cent. mass of coal dust (or other inert dust) is

Of 14,076 actively employed metal miners more important than its content of ash. in the United States examined between 1958- In order to standardize methods for as-1961, 3.3 per cent showed definite evidence sessing the pneumoconiosis risk, a method of pneumoconiosis. of gravimetric sampling of the respirable dust,

Asbestosis. Asbestos is a fibrous silicate. with analysis of the collected dust, seems This form of pneumoconiosis is manifested indispensable. There is much movement in by a diffuse interstitial fibrosis. Gas diffu- this general direction. The threshold limit sion through the alveolar wall is impaired. value for quartz, for example, is now shown Asbestos is mined extensively in Quebec; on a gravimetric basis in the *1968 Notice of* very little is found in Ontario. Cases of *Intended Changes* published by the American asbestosis in Ontario have resulted from its Conference of Governmental Industrial Hyuse; e.g., insulators. (Some talc is mined in gienists. Ontario, and a few cases of talcosis have A standard for respirable coal dust is been reported from this exposure.) needed. The earlier British recommendation

Dust Measurement. Maximum retention of for "approved conditions" is noted below: dust particles in the alveoli of the lung oc-

Location	*Dust Particles per c.c.*
Anthracite collieries	Less than 650 between 1 and 5 microns
Other collieries	Less than 850 between 1 and 5 microns
Stone drifts and hard facings in all collieries	Less than 450 between ½ and 5 microns

curs with particles of one to two microns in particle size. There is little retention of particles less than 0.02 micron or over five microns in size. The limit of the resolving power of a very good optical microscope is about 0.2 microns—more generally, the lower limit is fixed at 0.5 to 1.0 micron. There is general agreement that particles in the range of 0.5 to 5.0 microns are important from the point of view of inhalation into and retention in the lung.

In Ontario, dust sampling in mines is done with the konimeter, in most of the United States it is done with the impinger, and in Britain the thermal precipitator is mainly used. In Ontario, konimeter counts of less than 300 particles per c.c. are considered good; counts of 300 to 500 are fair, and counts greater than 500 are considered bad; all mines are sampled twice yearly. As matters stand at present, no evaluation or comparison of the dust-measuring methods

Further studies have taken place in Britain with gravimetric size selective sampling, and the results of this study will be of interest.

The USSR maximum permissible concentration for coal dust of less than five micron particle size are also shown.

Coal Dust	*Maximum Permissible Concentration mg/m³*
Coal, more than 10% quartz	2
Coal, less than 10% quartz	4
Coal, no quartz	10

Toxic Dusts

Miners exposed to mercury, manganese, or soluble lead dusts may develop systemic poisoning. Lead sulphide ores present no real hazard in mining—only in smelting. Miners exposed to manganese dust in both Chile and Cuba have been reported to develop central nervous system effects similar to Parkinsonism. No mercury, manganese, or lead mines are found in Ontario. It is perhaps worthwhile to mention that manganese steel is commonly used underground in jaw crushers. A welder in Ontario using an oxy-acetylene torch to cut manganese steel underground developed kidney damage which was attributed to the manganese fumes. Ventilation in the work area was inadequate.

Much of the free world's nickel is mined in Ontario. Dust in nickel mines has not produced occupational health problems apart from occasional cases of dermatitis. Increased risk of nasal sinus cancer and lung cancer has been reported in workers involved in sintering and calcining nickel sulfides. This has not occurred in the mining operations.

Increased risk of lung cancer has also been demonstrated in the refining of a cobalt ore containing arsenic. These workers also showed increased incidence of chronic pulmonary fibrotic disease. This exposure is still under study. Arsenical dermatitis is common in handling this material and a few cases involving perforation of the nasal septum from arsenic have occurred.

Noxious Gases

The word noxious comes from the Latin word injurious. To the industrial hygienist, a noxious substance is one which produces adverse effects on the worker from annoyance or discomfort to illness or death.

Oxygen Lack. Oxygen is the most important constituent for human life. Man can live only a few minutes without oxygen—his reserve of stored oxygen in the lungs, blood and tissues is sufficient to last for only four to five minutes once he is deprived of oxygen.

Oxygen lack can occur in mines in different ways—by dilution with simple asphyxiants seeping out of rock strata, by absorption of oxygen into rock strata (this occurs mostly in coal mines), or by consumption in chemical or biological reaction. Oxygen lack can be very insidious in its effects, because it causes impairment of judgment. Therefore, persons in an oxygen-deficient atmosphere may be aware of some difficulty, but they are unable to take the appropriate safe action.

The concentration of oxygen in mine air should be maintained above 18 per cent. When the concentration falls below 16 per cent, symptoms of oxygen lack begin to appear. At levels of six per cent or less, collapse can occur very quickly.

Nitrogen, helium, argon, and hydrogen act as simple asphyxiants by excluding oxygen. Some other gases may be broadly considered to be in this category even though they have other physiological actions. These include carbon dioxide, methane, and ethane. The older term "black damp" refers to a mixture of carbon dioxide and nitrogen.

Carbon Dioxide. This gas acts as a respiratory stimulant. Air normally contains about 300 *ppm*. Workers would not be likely to notice any effect on breathing until the concentration exceeds two per cent in air. Since it causes deeper and faster breathing, it may enhance the effect of any toxic gas present with it, for example, carbon monoxide.

Methane. This gas occurs most commonly in coal mines. It is occasionally encountered in other mines—iron ore, salt, etc. It is primarily a fire and explosion hazard rather than a health hazard, but can act as an asphyxiant.

Carbon Monoxide. Carbon monoxide is not a normal constituent of the air. It is produced by combustion sources—fire, explosion, or the internal combustion engine. It is produced by blasting agents. Concentrations of 400 to 500 ppm in air may be tolerated for a short time; exposures of 1,500 to 2,000 ppm are dangerous in a short time. I do not feel there is sufficient evidence to accept the concept of chronic carbon monoxide poisoning from repeated exposures underground.

Ammonia. Ammonia is occasionally encountered underground. It provides adequate warning of its presence, because of its irritating action.

Sulfur Dioxide. This is produced by the reduction of sulfide ores. Blasting in some types of sulfide ores may produce temporary high concentrations. It acts primarily as an irritant of the upper respiratory tract,

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but severe exposure may result [illegible] result in two to [illegible] days in these severe [illegible] Chronic [illegible] from arsine exposure may also occur.

It has been suggested that continued exposure to low concentrations of sulfur dioxide could result in chronic respiratory disease; e.g., chronic bronchitis with or without emphysema. At the present time, a study is underway in a group of smelter workers exposed to sulfur dioxide in Ontario. Their respiratory illness experience will be compared to other groups in the same company not exposed to this gas.

Oxides of Nitrogen (Nitrous Fumes). Of these, nitrogen dioxide (NO_2) is of special importance. It is produced in diesel exhaust and from blasting agents used underground. The ventilation requirement for diesel engines used underground is determined by the nitrogen dioxide produced (and the disagreeable odor of aldehyde).

This is one of the most insidious of all gases. It may be inhaled in lethal concentrations without marked discomfort at the time of exposure. Later, it produces a delayed pulmonary edema.

Air sampling after blasting underground shows peak concentrations occur two to six minutes after the blast, and significant concentrations may remain for about 15 minutes after the blast. Commonly, levels of 200 ppm are produced, but values up to 800 ppm have been reported after blasting.

Adequate ventilation must be provided to remove nitrogen dioxide and other gases produced by underground blasting. After blasting, there is nearly always mixed exposure to carbon monoxide and oxides of nitrogen. For this reason, any worker affected by blasting fumes with headache, dizziness, or collapse should always be considered to have suffered a significant exposure to oxides of nitrogen as well. Restriction of activities for 24 hours is most important in these cases.

It has been recommended that 75 cfm per horsepower be provided for the control of diesels used underground.

Arsine. Arsine is formed when nascent hydrogen is produced in the presence of arsenic. Acid treatment of arsenical ores may give rise to arsine production. Exposure to arsine results in destruction of red blood cells with anemia. This anemia may develop within a few hours in acute exposures, and in severe cases the anemia is extreme; death

Hydrogen Sulfide. Hydrogen sulfide is produced chiefly from the decomposition of organic matter. It may occur in mines where sulfide ores are found. It is soluble in water or oil and it may flow for some distance from its place of origin to escape at some unexpected place. Hydrogen sulfide has a characteristic odor at low concentrations. Its odor cannot be relied upon, however, to give adequate warning of its presence, because in lethal concentrations this gas rapidly paralyzes the sense of smell. Such concentrations also affect the respiratory center in the brain resulting in failure of respiration.

Radioactivity

Radium, a naturally occurring radioactive isotope, is distributed in small amounts in the earth's crust. The radioactive disintegration of radium results in radon-222 and radon daughters. The air in underground workings contains some radon from seepage of the gas into mine workings. In most non-uranium mines, the concentration of radon does not present any significant exposure; one notable exception is the fluorspar mine in St. Lawrence, Newfoundland.

In uranium mines the radon concentration in the mine air is much higher than in other mines. Studies of uranium miners in the United States have revealed a significant increase in the incidence of lung cancer. The increased incidence is related to the concentration of radon and its short-lived daughters and to the length of time of exposure. It has been estimated that 30 to 50 per cent of deaths in Schneeburg and Joachimsthal miners was from lung cancer as a result of radon exposure.

The hazard from radon daughters is measured in Working Levels (WL). One WL is defined as that combination of radon daughters in one liter of air that will result in an ultimate emission of 1.3×10^5 *MeV* of potential alpha-energy.

In unventilated underground mines, the concentration of radon daughters may vary from a fraction of a WL to several thousand WL. Presumably, some degree of risk exists at all working levels but the maximum increase of lung cancer occurs when the cumulative exposure exceeds 1,000 working level months (1,000 WLM), *and* when the miners

are moderate to heavy smokers, *and* when they have worked in the mines 10 years or more

The simplest control measure is to ventilate the mine with fresh outside air. Another method of control is to limit the miner's time in areas high in radon and daughter products. In all areas where radon is being emanated, the ventilation rate should provide one complete air change every four minutes unless radon daughters have been shown to be low. (This rate of ventilation is very high for a mining operation and I do not think it would be feasible for large scale uranium operations.) Each pair of men mining in the ore should be provided with 1,000 cfm of fresh air discharged from an outlet not more than 30 feet from the working face. On drifts, the airflow needed should be calculated to provide a velocity of 30 ft./min. These recommendations on ventilation are all taken from *Public Health Service Publication No. 494.*

Exposure to thoron and thoron daughters has also been raised in connection with uranium mining. This is currently under study in Ontario.

Noise

Noise in mining operations deserves special comment in its own right. Drilling and underground crushing almost always create excessive noise levels requiring a good hearing conservation program, involving preemployment and periodic audiograms plus the wearing of hearing protection for all workers in high noise areas.

Heat

As mines go deeper, the rock temperature increases by about ½° to 1°F for each 100 feet. When the area is opened up, the heat radiates into the air space. At 8,000 feet, Northern Ontario mines reach a temperature of about 90° to 100°F, with high humidity. Control of humidity at these temperatures presents problems.

In relatively shallow mines, from 300 to 600 feet down, cold can present a problem in Northern Ontario. Heating of fresh mine air is done to take care of these upper levels.

Lighting

Because of the long distances involved and the large unused area underground in hard rock mines, lighting is not extensively used in mines. Miners often work in semi-dark locations. Such levels of illumination likely contribute to accidents underground. No reports of nystagmus, common in British coal miners in Wales, have appeared in Ontario. Miner's nystagmus is related to poor levels of illumination, but there appears to be an emotional overlay.

Vibration

In Ontario, Raynaud's phenomenon of occupational origin (white hand) has occurred in large numbers of aluminum foundry chippers using pneumatic guns. Occasionally, cases are encountered in steel chipping and auto assembly work, but these are quite uncommon. I am not aware of any cases occurring in Ontario hard rock miners using pneumatic drills. It was my impression that the vibration frequency and the amplitude was not in the same range as that of the aluminum chipping guns. It is of interest, however, to note that cases have been reported in uranium miners in Saskatchewan who used a smaller "jack-leg" drill. An important factor in these cases is the cold ambient temperature in the area where the men worked.

Explosives

Some occupational health aspects involving explosives have been touched on in discussing the various gases which might be encountered in mining. Careless handling and storage of dynamite containing nitroglycerin may result in headaches (powder headaches) and cardiovascular stress. Nitroglycerin enters the body by inhalation or skin contact. It dilates capillary blood vessels, resulting in low blood pressure. Two workers employed in the manufacture of explosives died of cardiovascular stress while away from the job.

More recently, mixtures of ammonium nitrate and diesel fuel (AN/FO) have come into use in underground blasting. Trouble has been experienced in Ontario with improper mixing of this material in the past. This has been controlled. Occasionally, there are isolated cases of dermatitis. From time to time, questions are raised concerning oil mist exposure, particularly in filling overhead holes.

From the occupational health point of view, AN/FO mixture does not present any greater hazard than the use of conventional explosives.

In Ontario, a number of deaths have occurred in workers entering blast areas too soon after the explosion. In some cases, the workers died of acute carbon monoxide poisoning; in others, mild carbon monoxide effects were noted, followed by a fatal pulmonary edema from inhalation of oxides of nitrogen.

Synthetic Resins

Various synthetic resins have been introduced into mining applications for special purposes; e.g., grouting and sealing, and rock bolting.

Epoxy and polyester resins are used in rock bolting. The use of epoxy resins may result in cases of respiratory irritation and dermatitis from the hardeners used. Dermatitis is occasionally encountered with the polyester used.

Polyurethane has been used in mines as a seal. These contain isocyanates (MDI or TDI). Of these, MDI is less volatile and less likely to give trouble. Both of these isocyanates, however, may give rise to bronchial irritation or allergic bronchitis with asthmatic-like symptoms. Workers applying polyuretnane foam and those in the general area should wear adequate respiratory protection. An air line respirator is recommended. Workers 150 feet away or more do not require respiratory protection, provided the air flow from the area of spraying is not too excessive.

Acrylamide has been used for grouting. Acrylamide is quite toxic, and cases of dermatitis and peripheral neuritis have been reported with this material.

Conclusions

A wide variety of substances and other agents may be encountered in mining operations. It is important that supervisors and the workers be familiar with the possible adverse health effects of their occupational exposures. To help eliminate or minimize these health effects, the following preventive and other measures are especially required:

1. Education and supervision of the worker.
2. Handling methods to minimize dust
3. Ventilation. Local ventilation should be used where possible at the point where contaminants are generated. General ventilation with provision of fresh air to maintain the concentration of contaminants below their threshold limit values. Ventilation doors and fans must not be interfered with.
4. Rescue and First Aid Training.
5. Regular Monitoring. Periodic dust sampling should be carried out. The threshold limit values should be used as guides to arrive at reasonable control measures. Radioactivity levels should be carried out regularly, not only for uranium mines, but others as well.
6. Medical Supervision
   (a) Dust Exposure. Pre-employment and periodic examination, including chest x-rays, should be done on all miners.
   (b) Noise Exposure. An adequate audiometric testing program should be done.
   (c) Toxic Dusts (e.g., lead). A regular program of examination and biological monitoring should be carried out.
   (d) Radiation Exposure

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munication to the operators of the unit and other personnel working in the unit, who may not otherwise be aware of the type of work being performed in their area of operation. This can prevent them from possibly taking a sample or draining a line, which would affect the area where the work is being performed.

After the repair work has been completed, the maintenance supervisor checks the work site and determines to his satisfaction that all work is completed. He then designates on the permit that the job is completed and returns the permit to the operations supervisor.

The operating supervisor checks the work area and determines to his satisfaction that the conditions are such that the equipment can be returned to normal service. This would include determining that the connecting lines have had their blanks removed, all lines are connected, all lockouts have been removed and the vessel closed up and ready for service. This should complete the permit.

In summary, a work permit is nothing but a check-list that formalizes a communication between people requiring a job to be done and people performing the job in order to obtain the desired result. This is effective communication. It is of no more value than the effort expended in completing it. It provides a means for the elimination of assumption. When we assume, we have made our first step towards trouble.

RESPIRATORY PROTECTION

By HOWARD H. FAWCETT
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Assisted By: W. Burgess, School of Public Health, Harvard University, R. J. Fuerst, Naval Ordnance Systems Command, E. Hyatt, Los Alamos Scientific Laboratory, G. MacLeod, Rite Hardware Manufacturing Co., W. H. Revoir, Chairman, Respirator Committee, Joint A.I.H.A., A.C.G.I.H., R. H. Schultz, U. S. Dept. of the Interior, Bureau of Mines, Mary E. Seaver, R. N., Mobil Oil Co., and J. T. Sienlecki, American Medical Assn.

This presentation on respiratory protection is a report on a few of many impressions gleaned from representing the National Safety Council since 1963 on the A.S.A. (then U.S.A.S.I., now American National Standards Institute) Z88 Code on Respiratory Protection.

There are two views of standards. Some maintain that standards are the answer to the world's problems. Others dispute this, arguing that standards are only legal outs, which operate only to encourage compromise and easily-achieved performance, and that they serve no useful purpose to the common man who is not a fool. The answer as to the real value of standards is probably somewhere between these two extreme viewpoints. Standards are certainly not a panacea; they are no better than the paper on which they are printed if people do not understand their background and intelligently and honestly apply them.

The hazards of chemicals are best understood when chemicals are seen as part of a system. The system in this case consists of three parts: (1) a human being; (2) the environment; and (3) control by appropriate means such as ventilation, engineering changes, or protective devices (respirators, masks, hoods, or breathing apparatus.)

Some chemicals will fume when mixed (e.g., a mixture of glycerine with HTH); some will ignite or erupt (model fuel = 25 percent nitromethane in methanol with HTH) and other chemicals will explode when mixed with air and ignited by a spark (e.g., the two drops of carbon disulfide with air in an explosion gallery with a spark plug).

A philosopher once observed it is better to light a candle than to curse the darkness. Darkness is so widespread on this subject that I am lighting three candles, using as my illumination source chromium trioxide with a drop of acetone. One candle is dedicated to the user of respiratory protective devices. The second candle is dedicated to the regulatory authorities, especially to the U.S. Department of the Interior, Bureau of Mines. The third candle is respectfully dedicated to the manufacturers, in the hope they will communicate a little more effectively, and inform us more adequately, as to the limitations, as well as advantages, of their products.

As a result of all this light — three candle power — perhaps we will begin to understand more completely the complex problem of respiratory protection.

The American Chemical Society estimates 3½ million chemicals are known today, a million of which are referenced in chemical abstracts. In 1965, 3.28 billion people inhabited planet Earth, at least a third of whom were classified as illiterate (according to one United Nations study). Hence, even the best standards in the world on any subject will not be read by a third of the people. There are real barriers to knowledge, but we must find ways to use it more effectively if we and our descendants are to survive.

All is not hopeless, however. We do have at least some information on the potential hazards of several hundred, or at most a thousand or so chemicals. The National Safety Council currently has 60 or 70 chemical data sheets (and active work is underway by the Chemical Section on dozens more); the Manufacturing Chemists' Association has developed approximately a hundred chemical data sheets; the American Industrial Hygiene Association has prepared 150 hygienic guides. The National Fire Protection Association lists some data on perhaps 2,000 substances or combinations at most in 491M. and 704M. Many substances — in fact, most — are still inadequately known insofar as safety aspects are concerned. Misleading references and incompleteness confuse even the knowledge which is available.

Several thousand chemicals are in everyday use or commerce. The system I mentioned previously deserves repeating for emphasis: man; environment; control. Man (or woman) alone contains thousands of variables about which we really know little. For example, a recently published paper shows that a group of several hundred per-

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[illegible] every a thousand [illegible] in their abi[illegible], natural gas [illegible]nt. Yet [illegible] fitting [illegible] pieces for tightness against leakage, and [illegible] is still the criteria used to determine when an industrial-type canister or chemical respirator has been expended in ability to absorb.

The environment is complex too, and full of unknowns. We really know little about the effects of environments on man. Even the A.C.G.I.H. tabulation of threshold limit values, which in the 1969 edition gives criteria for about 250 substances, admits in the preamble it should not be considered foolproof for prevention of injury to all workers, and must be used with intelligence by competent personnel. For short term exposure to higher concentrations, the Commonwealth of Pennsylvania and the National Academy of Sciences-National Research Council Committee on Toxicology have each attempted to establish short term exposure limits for several substances.

Beyond that, little real data or judgment is available. For example, no public limits have been established useful to someone who must evacuate an area in case of an accidental release, an emergency condition which is occurring with increasing frequency. The National Air Pollution Control Administration is understood to be considering the issuance of air quality criteria for short term exposures of the public to atmospheric contaminants under the authority of the Clean Air Act.

Changes in processes, materials, or other measures should be considered first when one begins to study environments. No standard is any better than the understanding and application of how it fits into the system, for it is intended to be a part of a whole, not an isolated piece of literature.

We next consider respiratory protection. We must know what is involved and in what concentration. We must select the correct device, we must train wearers in its use and carefully explain why. We must continually insure it is being properly maintained and cleaned and defective parts replaced. Finally, we must medically monitor the wearer to insure the device is, in fact, preventing the injurious substance from contact with the body — the real test of the success or failure of the system.

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All this costs money, real money, and unless we are willing to make this investment completely and properly, we should not attempt to protect at all, for only futility will result. You buy protection and human health — not a respiratory device.

Respiratory protection was not just invented. Some devices on display in the Dresden, Germany, Fire Museum are dated from 1875 to 1887. Even then, carbon adsorbents were used. For ammonia, a sponge soaked with vinegar was incorporated in a face piece, the ancestor of the chemical respirator. Ask about various devices — there is more background information than you might expect, and it is available if you insist on completeness.

In June 1969, students at a major university appeared in an academic procession wearing World War II surplus gas masks. This is a very serious matter; such masks are being sold in surplus stores all over the country, and they are essentially worthless. The same mistake occurred after World War I — thousands were sold or given away, and loss of life resulted from their misuse. If you come across such old equipment, destroy it at once before it kills.

Not all mask face pieces fit everyone properly. This is poorly appreciated, since we have a tendency to accept something offered without question. About 95 per cent of the adult population can be accommodated by the average full face piece if properly worn and adjusted. The various sizes and shapes of faces are well known; the Army and the Bureau of Mines are well aware of the problem of human variations, but most people who buy and wear masks are not.

Another confusing situation develops when the medical and nursing professions use the word "respirator" to indicate a device for inducing or modifying breathing. Two of these were recently condemned as unsafe by the Food and Drug Administration and ordered removed or recalled from the market. (Devices were manual bellows or bag-type blowers for introducing air into patients through a half-mask piece.)

Respirators are of many types, and the face pieces may not fit properly unless carefully adjusted. It should be noted that the recent revival of beards, sideburns, and other surplus hair on the face is definitely contra-indicated, since all Bureau of Mines tests show that a clean-shaven face is essential for a proper respiratory face piece fit, and this is mentioned in the Z88.2 Code.

There are also specialized respirators, such as the ones for radioactive materials and unusually toxic substances such as beryllium. Even more care than usual is required if they are to perform their intended purpose.

Several chemicals are now definitely known as carcinogenic. A list of a few noted by the A.C.G.I.H. in the 1969 revision include: 2-acetylaminofluorene; 4-aminodiphenyl; benzidine and its salts; dichlorobenzidine; 4-dimethylaminoazobenzene; beta-naphthylamine; 4-nitrodiphenyl; n-nitrosomethylamine; beta-propiolactone; and p-toluidine. These chemicals must be placed in a super-hazard classification, and leave no margin for error.

Another unresolved and very practical problem is the mechanism for wearing corrective lenses inside full face pieces by persons who are virtually helpless without the lenses. All internally-mounted lenses are subject to improper optical alignment when a mask is donned in haste; all external-mounted glasses, even with flat temples, permit or encourage leakage. Only an air-supplied hood accommodates glasses without sacrifice of safety due to leakage.

There appears to have been a serious lack of imagination and initiative over the years in the development and research into respiratory protection in this country. As noted previously, gas masks, respirators, and even self-contained breathing apparatus (including the oxygen self-generating devices) were in a considerably advanced state of development in Germany and England prior to the beginning of World War II when the United States first began to look at the problem. In some ways, the tremendous potential for application of technology and engineering know-how seems to have largely escaped the respiratory protection field. Very few significant advances in respiratory devices during the last fifty years have originated in the United States. (Baralime, the mixture of metal oxides with calcite, the mixture of metal oxides which under favorably dry conditions, [illegible] carbon monoxide to carbon dioxide [illegible] appear as one outstanding American contribution, along with potassium superoxide and refinements in chemical oxygen sources). A number of impregnated actuated carbons have been developed for certain vapors and gases.

A recent advance of the British seems very significant. "Schliere" is the German word for "streak" or "shadow". When one has the proper light source, lenses, and mirrors, it is possible to see as well as photograph shadows representing different densities of air or vapors. In one case, a man was introduced into the Schlieren system and very clear pictures were made of the air movements during inhalation and exhalation, as well as the normal upward air flow of the body. This technique could be useful in studying respiration and respiratory devices. Already, it has suggested why we can expect dust and bacteria from clothing, such as coveralls or nurse's uniforms, to be transferred to the breathing zone due to the upward movement of air close to the body. There is much need for more creative initiative in the field of respiratory protection.

If we want a supply of oxygen in a self-contained device of some type, an interesting question arises as to the most effective and light-weight source. Here is an interesting comparison between the three possible oxygen sources — gaseous, liquid or solid:

Oxygen Sources

	Volume of Free Stored O_2	Weight Unit + Cont.	Space cu. in.
Gas	126	445	2,160
Solid	630	28	460
Liquid	860	19	1,355

Ref: Miller

All three have application; it should be obvious which offers the greatest potential for the future development of light-weight, long-life, self-contained breathing apparatus or hoods of some type if certain technical problems can be resolved.

As one practical illustration, a photo taken in Toronto a few years ago shows 72 forty-cubic-feet air or oxygen cylinders, part of the supply emptied by firemen in their attempts to control a fire. Large numbers of cylinders are needed, and few fire departments or plants have instant refill capability. This is certainly a serious limitation of the cylinder-supplied air or oxygen mask; chemical-oxygen self-generating masks have a similar limitation which is all too often overlooked. There are many instances of fires where many dozens of cylinders or canisters were expended. To illustrate the importance of this problem of masks as it affects the real world, here are some figures recently received from a state fire coordinator relating to the volunteer firemen in that state.

Active Firefighters 2,966

	No. of Devices	Mask/ Man	Time Mask	Man Hrs.	Add. Hrs.	Tot. Hrs.
Type N Masks	233	1-15	1 hr?	233	50?	283
Self-Gen. O_2 B. A.	123	1-30	1 hr?	123	246?	369
Demand-Air-O_2	351	1-12	½ hr	175	241	416
Spares	483					1068

Men — 20 hrs. — alarm

Two-thirds time at actual exposure = 14 hrs. and "working time", for 2,966 men.

From this, the very real limits of operations of the firemen imposed by breathing apparatus and spare cylinders and canisters, become apparent.

There are certain fundamental limitations to any breathing equipment. These have not been widely appreciated.

1. Some substances highly toxic by skin absorption require skin, as well as breathing protection. Examples are: liquid HCN, aniline, other nitro and amino aromatic compounds, phenol, ethyleneimine, and certain organo-phosphates. There are others.

2. Maintenance. There is no excuse for poor or inadequate maintenance of breathing apparatus, masks, or respirators, but in fact,

unless they are properly cleaned, adjusted, expendable parts replaced, canisters discarded after shelf-time is up, and all other recommendations (usually in small print in the instruction manual) taken, protection is an illusion, not a reality.

3. Training. The more complex the mask, starting with the self-rescuer and the dust mask to the self-contained breathing apparatus, the more the need for training. Unfortunately, the U. S. Bureau of Mines does not specify a real training course for wearers of self contained breathing apparatus other than mine-rescue devices. But train you must, in dark, smoke, wetness, cold, and heat, if you are to really acquire the degree of familiarity which will give you assurance about a mask or breathing apparatus when the chips are down and the emergency is real. The extreme importance of this statement is emphasized by numerous fatal cases, which, while beyond the scope of this presentation, are sobering and should some day be published by an impartial scientific organization.

To emphasize again, we must consider respiratory protection as part of the system — man, environment, control. Each part of the system, with all variations, must be carefully evaluated, weighed, and understood before any successful protection either by control measures or by protective devices can be effective. It is far more complicated than buying devices from a salesman who himself may not have all the necessary information or whose zeal for essential details may be less than enthusiastic.

If one wishes to succeed in using respiratory protective devices, we would recommend he look at it as part of a system — man, environment, and control. To ignore an in-depth analysis of any one of the three is essentially to negate any value from a device, no matter how high its rating or how costly its price.

Human life demands our best, and nothing is more vital or urgent to life than our next breath. As our three candles die out, so will life, but hopefully we have encouraged you to look deeply at breathing systems.

To emphasize that my concern for the inadequate state of respiratory protection is not unique, but is shared by others, I have invited a panel to sit with me, to attempt to answer questions.

MacLeod: We are advocates of the positive-pressure approach, with an air-supplied hood. This overcomes many objections of the usual devices or masks. We feel the positive-pressure approach is the device of the future, and it is gradually being recognized as such.

Siedlecki: Representing the medical end of the problem, I would emphasize the necessity for team work by the industrial physician, the nurse, the industrial hygienist, and the safety engineer in a complete evaluation and monitoring of the system. Employees with certain functional impairments or mental or emotional problems should not work in areas where there is potentially hazardous exposure to toxic substances requiring the use of respiratory protective equipment. Employees protected by respirators should have the same medical supervision as those protected by ventilation or other control measures.

Mrs. Seaver: The industrial nurse has a very real part in the education of workers in the need for and proper use of protective equipment, including respiratory. There is a great need in the nursing profession for more information about the system you mentioned. While we concentrate on the man, the environment and control components must be of concern to us as part of the health and safety team. We are anxious to help in this activity.

Hyatt: Even though respirators are the oldest known control measure for protection of the respiratory passages, health and safety men know less about selection and use of respirators than any other aspect of health and safety. I would stress one phase—in working with radioactive materials we knew we had to have a very high degree of protection. Looking at all the respirators made in the United States and other countries to see if they would fit, the one thing that we have learned that many health and safety men do not realize is that the half-mask face piece fits well only three out of four men, and not nearly that high a percentage of women.

Revoir: The use of respirators requires a complete program: knowing the hazard, selecting the proper device, training the user, supervising the use, maintenance, and medical surveillance. I feel that the greatest problem involving the use of respirators is poor

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maintenance. Even the best respirators, if poorly maintained, offer little protection. While in Florida to [illegible] pesticide respirators in the field and in pesticide formulating plants, we found in most cases they were very poorly maintained. They did not give any protection.

Schutz: About ten years ago I heard you say that the respirator business was going to pot, and the Bureau of Mines was leading the way. In view of the new meaning of the word "pot," the old statement has a most interesting new twist, and we categorically deny the accusation is true.

Firenze: Our concern is for those people working in contaminated atmospheres where the nature and extent of the hazard are unknown or are difficult to determine. Firefighters cannot take the time nor do they have the facility to sample the environment to which they are subjected; consequently they often expose themselves to concentrations of contaminants outside the protective limits of their respiratory equipment. For this reason, equipment of this type should be carefully chosen to assure protection against high concentrations of gas, particulate matter, or a lack of oxygen in the atmosphere. Having the right man to select breathing equipment for the organization is crucial. In many instances, such people are lacking sufficient technical ability and information required for the task, thus making faulty decisions. Some of these faulty decisions have caused deaths. In one case, where 14,000 firemen were involved, the officer responsible for the purchase of respiratory equipment selected canister-type apparatus. After an unfortunate fatality occurred, his decision was reversed and self-contained equipment was purchased.

At this time there is a need for better self-contained breathing equipment. Innovations combining lightness and durability with greater capacity would make this type of apparatus more efficient. There is a major short-coming in today's self-contained equipment. In the event the wearer becomes pinned or unconscious there is no provision designed into his breathing equipment to automatically vent to the atmosphere when the air supply is exhausted. Some type of an emergency venting system is needed. Respiratory equipment manufacturers should consider this problem in the design of newer devices.

Question: With all your comments about air pollution compounds damaging respiratory systems, I am surprised you did not condemn the tobacco industry.

Answer: As Manager of Health and Safety and not far from the Roswell Park Cancer Research Center, we have read much scientific information that our number one killer is cigarette smoking. Probably five to six times as many people are killed by cigarettes as by automobiles, yet you know the slaughter on the roads. I will admit I am at a loss to know why we do so little about this source of deliberate air pollution. Perhaps it ties in with something I read about six years ago: the author said the strongest force in the world is not the nuclear bomb but human inertia; meaning it is difficult to change any of us from what we are doing at a particular moment.

Question: Does the National Academy of Sciences sponsor research on respiratory protection devices?

Answer: No, the NAS does not. The National Academy of Engineering recently completed a study for the U. S. Bureau of Mines involving both rescue and survival equipment and techniques.

Question: What is the best satisfactory method of combining prescription safety glasses with a full face mask, or full chin respiratory protection?

Answer: With a hood covering the whole area, any glasses can be worn. If needed in a full face piece, we suggest they be mounted completely inside the face piece.

Question: What is the status of the approval of agricultural respirators?"

Answer: For the past two years (since the Department of Agriculture discontinued the testing of respirators), there has been none. The Bureau of Mines in Washington has the problem under study, and should render

a decision shortly on whether the Bureau will undertake this additional responsibility. For the past two years, including today, there has been no monitoring of agricultural respirators in the United States.

Question: Are panel members advocates of (1) strong government laws and rules for industrial uses of respiratory protection, or (2) of voluntary use of respirators in industry?

Answer: The panel was polled, and five of the nine voted for option (1) four for option (2).

Question: Is the new respirator designed for protection against asbestos fibers a success?

Answer: The respirator developed by Johns-Manville is presently under field evaluation. One cannot answer your question at this time. However, the unit is light-weight and expendable. I understand that the present evaluation study will consider acceptance and level of protection afforded under field conditions.

Question: What will be the actual effect of the new Z88.2 code on the use of respirators?

Answer: It will be mandatory for users of respiratory protective devices to carry out a comprehensive program, including determination of the hazard, selection of the proper device, training the wearer, maintaining the device, and carrying out medical surveillance, since standard becomes, in fact, a part of Federal health and safety regulations. Voluntary consensus standards such as this are considered to be part of new industrial health and safety regulations being issued by Federal agencies such as the U. S. Department of Labor.

SAFETY ASPECTS OF NUCLEAR GAUGES

By J. R. COLEMAN
Radiological Protection Officer, National Lead Co., South Amboy, N.J.

Nuclear gauges using radioactive isotopes were introduced in the early 1950's. These instruments are designed to provide continuous on-line information regarding process material thickness, composition, level, or density.

Prior to 1962, the industrial usage of such gauges was controlled by the United States Atomic Energy Commission. During 1962, a program was initiated to transfer this control to the individual states. At the present time 19 states have assumed this responsibility and are known as Agreement States. Licensing by one of these agencies is a prerequisite to the possession of a nuclear gauge.

In 1964, the Titanium Pigment Division of National Lead Company instituted a program to evaluate the process control capabilities of nuclear level and density gauges. This study has resulted in the installation of numerous nuclear measurement and control systems. Further, this study has established that the radioactive materials associated with these systems represent no health hazard when they are used in conjunction with appropriate safety procedures.

The Atomic Energy Commission and the Agreement State Boards of Health place the responsibility for the formulation and implementation of such procedures in the hands of the user and evaluate the results of safety programs via periodic inspection.

The radiation safety program developed by the Titanium Pigment Division of National Lead Company is the subject of this report. This program has been favorably received by the United States Atomic Energy Commission, the Canadian Atomic Energy Control Board, the Atomic Energy Technical Committee of the AFL-CIO and has been cited by the Prentice-Hall Publishing Company in their monthly *Personnel Management Report*.

As is the case with any potentially hazardous material, the characteristics of the material must be understood before effective safety measures can be formulated. The initial portion of this report will deal with the characteristics of nuclear radiation and the basic principles of nuclear gauges. The

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DUST, MIST, AND FUME RESPIRATORS & UNITED STATES BUREAU OF MINES SCHEDULE NO. 21B

By R. H. MOULTON
Respirator Product Mgr., American Optical Co., Southbridge, Mass.

In 24 years of working with the mechanics of respirators, it seems that those people in safety who know and understand respirators best are those who know and understand the United States Bureau of Mines test and approval schedules best. And so it is that we take a look at the very latest Schedule No. 21B covering Dust, Mist, and Fume Respirators.

First, though, what is a respirator? My favorite definition is "A respirator is a device designed to make inhaled air respirable." And when you think about it, that statement covers a multitude of products in the respirator field. There are three major classes of respirators: atmosphere - supplying respirators; air-purifying respirators; and combination atmosphere-supplying and air-purifying respirators. These break down into six basic types of respirators:

1. Mechanical filter type for dusts, mists and fumes. (BM 21B)
2. Chemical cartridge type for vapors and gases. (BM 23B)
3. Gas masks. (BM 14F)
4. Airline respirators (BM 19B)
5. Self contained demand type. (BM 13E)
6. Self-generating oxygen breathing type. (BM 13E)

Along with these six, we now find appearing on the market a new filter-blower battery powered respirator that may soon appear in quantity. If the filter-blower respirator is submitted to the Bureau of Mines, it would be eligible for testing and approval under Schedule 21B, and maybe under other schedules, too, in the future.

The U. S. Bureau of Mines test and approval schedules originated on the following dates: Schedule No. 13 — March 5, 1919; Schedule No. 14 — May 22, 1919; Schedule No. 19 — April 28, 1927; Schedule No. 21 — August 20, 1934; Schedule No. 23 — November 13, 1944. The Bureau is part of the Department of Interior, and their work on equipment to protect miners is well known in the safety field. The test and approval schedules they have developed covering equipment for miners and others have resulted in extremely high quality merchandise and equipment being available for mining operations. Their fine work has overlapped into industry to such an extent that today it is only natural for those who are responsible for the health and safety of industrial workers to call upon this equipment that has been approved by the Bureau of Mines under their many schedules.

Today, the seal of the United States Bureau of Mines on respirator approval labels is one of the most respected throughout the many industries of America. Without Bureau of Mines approvals, a respirator manufacturer simply isn't in the respirator business. To design, develop, test, and manufacture respirators with the aim of obtaining Bureau of Mines approval takes a lot of time, people of special skills, and a lot of time in laboratory equipment. A tremendous amount of research goes into the development of respiratory equipment in order to get approved units on the market for the consumer.

What is the customer looking for besides the Bureau of Mines approval? Protection of course; that's why the respirators are made. Comfort is a must, if the mask is to be worn. For economy, today all or most manufacturers promote the use of air-purifying respirators which employ one basic mask, with a choice of many filters or cartridges to help the safety man hold his budget down and to keep the plant economist happy.

However, the toughest nut to crack is what we call worker acceptance — comfort. Is it easy to breathe through that respirator? This matter of breathing resistance is often not well understood. How many times have you failed in your effort to blow up a small rubber balloon simply because you do not have the strength to expel air into

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the balloon with enough pressure to make it expand? Yet, you may take a small piece of that very same rubber balloon, stretch it across your mouth and inhale the rubber into the mouth to create a small "bomb" for your child or grandchild to squeeze until it blows up with a bang. What this means, you see, is that we expel air from our lungs by relaxing our rib cage muscles and our diaphragm. We inhale by muscular expansion of the rib cage and lowering of the diaphragm. To state it very simply, we are weaklings at exhaling and quite strong at inhaling. The Bureau of Mines takes this into account in establishing maximum values for both inhalation and exhalation resistance of respirators. In the new Bureau of Mines Schedule No. 21B, there are several new resistance requirements for respirators, and these will be reviewed in this paper.

But now, let's look at some of the approvals that are available under this new Schedule No. 21B. There are, as I see it, at least 13 approvals available under Schedule No. 21B should any or all manufacturers desire to obtain these either in single filter or twin filter respirators that are prevalent on the market at this time:

1. For dusts having a TLV not less than 0.1 milligram per cubic meter; (a) single-use filter; (b) reusable filter. A few of the old-timers in the respirator area might not recognize this one as the Type "T" approval for toxic dusts of many years ago. Later on, it became the approval for toxic dusts not significantly more toxic than lead. You will note that today we no longer talk about MAC, or maximum allowable concentrations, but work now with TLV, which stands for threshold limit value. So, today, your Bureau of Mines approval will be given on "toxic dusts having a TLV not less than 0.1 milligram per cubic meter." It is still possible to get this approval on single-use filters commonly known as the throw-away type, and the approval is still available on a reuseable filter, or, in other words, a filter that may be used and, after it has become plugged with particulate, may be cleaned by compressed air or other means and used again and again. It is first tested, cleaned, tested, cleaned a second time, and then tested for the third time. Today, we find the single use filter or the disposal throw-away type outnumbering the reuseable filters by a huge margin.

2. For dusts having a TLV not less than 2.4 million particles per cubic foot: (a) single-use filter; (b) reusable filter. This approval you might recognize as the old Type "A" approval for dusts such as silica. It is also referred to as the pneumoconiosis-producing dusts plus nuisance dusts approval. Today, the Bureau of Mines approval label will list pneumoconiosis-producing dusts as well as dusts having a TLV not less than 2.4 million particles per cubic foot and, again, we have the approvals for the single use filter and the reusable filters.

3. For dusts having a TLV not less than 0.1 milligram per cubic meter or 2.4 million particles per cubic foot; (a) single-use filter; (b) reusable filter. Many years ago, this was called the "AD" or all dust approval for silica and lead type dusts. Later on it became an approval for dusts and still later it became approval for dusts not significantly more toxic than lead. Today, the approval label reads, "For dusts and also for dusts having a TLV not less than 0.1 milligram per cubic meter or 2.4 million particles per cubic foot," with approvals available on either the single use or reusable filters.

4. Fumes of various metals having a TLV not less than 0.1 milligram per cubic meter. Originally, this metal fume approval was for fumes consisting of solid dispersoids or particulate matter formed by the condensation of vapors such as those of heated metal and other substances. Later, the words "not significantly more toxic than lead" were added. Today, the approval label lists "fumes of various metals having a TLV not less than 0.1 milligram per cubic meter."

5. Dusts having a TLV not less than 0.1 milligram per cubic meter or 2.4 million particles per cubic foot, and fumes of various metals having a TLV not less than 0.1 milligram per cubic meter. This type of approval covers dusts such as lead, dusts such as silica, and metal fumes such as lead.

6. Mists of materials having a TLV not less than 0.1 milligram per cubic meter. This approval you should recognize as the approval for chromic acid mist respirators.

7. Mists of materials having a TLV not less than 2.4 million particles per cubic foot. This approval covers the pneumoconiosis-producing mists such as silica mist.

8. Mists of materials having a TLV not less than 0.1 milligram per cubic meter or 2.4 million particles per cubic foot. This type of approval would cover both chromic acid mist respirators and silica type mists respirators.

9. Dusts and mists of materials having a TLV not less than 0.1 milligram per cubic meter or 2.4 million particles per cubic foot. This is the most common type of respirator approval and is commonly referred to as "the dust and mist approval." It actually is four approvals in one, since it covers lead type dusts, silica type dusts, chromic acid mist, and silica type mists.

10. Dusts and mists of materials having a TLV not less than 0.1 milligram per cubic meter or 2.4 million particles per cubic foot, and fumes of metals having a TLV not less than 0.1 milligram per cubic meter. This is another common approval covering respirators for lead type dusts, silica type dusts, chromic acid mist, silica type mist, and metal fumes such as lead fume. Most metal fume respirators are also approved for dusts and mists and, therefore, are in this tenth category.

11. Dusts, fumes and mists, having a TLV less than 0.1 milligram per cubic meter, or for radio-nuclides. This type of approval first appeared in March of 1965. It covers highly toxic dusts, fumes, and mists plus radioactive particulate in the form of dust, fume, or mist.

12. Radon daughters and radon daughters attached to dusts, fumes, and mists. This is a brand new approval covering radon daughters and these radon daughters when attached to particulate such as dusts, fumes, and mists. It is expected that approved units will soon appear on the market for use in such places as uranium mines. Uranium and other heavy metals such as thorium and radium, which are radioactive, disintegrate, and one of the products of disintegration is a radioactive gas called radon. Radon gas disintegrates into radioactive metal atoms which in turn disintegrate into other radioactive metal atoms until finally a non-radioactive stable lead atom is formed. All of these disintegration products are called radon daughters. Some radon daughters will remain suspended in the air as individual radioactive atoms while most will attach themselves to inert dust, mist, or fume particles in the air.

13. All dusts, fumes, and mists. This approval really covers the waterfront. It applies to: silica type dusts, lead type dusts, silica type mists, chromic acid mist, metal fumes such as lead, highly toxic dusts, mists and fumes including radioactive dusts, mists and fumes. With these 13 previously listed potential approvals, it is important to make note of the fact that there is provision in Schedule 21B for testing very complicated units, extending approvals of previous approved respirators, or other testing that might be requested of the Bureau of Mines. This keeps the door open for approvals of devices that may yet be invented and that would not be covered in the previous 13 categories.

Before discussing the actual tests in Schedule 21B, we should review the materials used and the size of the particulate involved. A yardstick is needed to give us an idea of just what we are working with in the respirator laboratories.

Particle Size

1 meter = 39.37 inches

1 micron = $\frac{1}{1{,}000{,}000}$ of a meter

Silica dust = 0.6 micron

Lead dust = 0.6 micron

Lead fume = 0.3 micron

Silica mist = 1 to 5 microns

Chromic acid mist = 3 to 10 microns

DOP = 0.3 micron

Fitting Tests

Coal dust — 1.2 microns

Isoamyl-acetate vapor - 100 ppm; 1,000 ppm

Generally, with normal vision, the smallest particle that can be seen with the naked eye is somewhere between 10 and 20 microns in size. When you look at the particle size of silica dust (0.4 to 0.6) which we round off at 0.6 micron in diameter, you will realize that this dust is about 20 times smaller than can be seen with the naked eye. Likewise, lead dust is about 20 times smaller than can be seen with the naked eye, and the lead fume generated for use in testing respirators is approximately 30 times smaller than can be seen with the naked eye. The silica mist used in the silica mist test is from two to 10 times smaller than could be seen with

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the naked eye, and the chromic acid mist particle size ranges from the particles that might be seen with normal vision down to those that are about three times smaller than could be seen without the aid of an optical instrument. In the DOP or dioctyl phthalate smoke used in testing filters for radioactive particulate, the particle size of the DOP smoke is about 30 times smaller than could be seen with the naked eye.

In the new respirator fitting test involving coal dust, the coal dust is about 10 times smaller than can be seen with the naked eye. Isoamyl-acetate vapors are used for fitting tests on certain respirators.

The materials for testing are placed in test chambers for efficiency tests, with many pieces of equipment such as air pumps, precipitators, and monitoring equipment being used during the actual conducting of the test.

A review of the 21B test requirements will point out to you several new changes in the breathing resistance requirements since there are now limitations on the initial resistance to inhalation at 85 liters per minute and several adjustments have been made in the allowable exhalation resistance at 85 liters per minute. All of these new requirements will result in respirators being developed that are very comfortable to the worker as far as ease of breathing is concerned.

There are, however, new tests involved for respirators, and some of them could become controversial since it appears that it might be necessary for manufacturers of respirators to make face masks much larger than those that workers are familiar with, and there is a tendency for workers not to accept face masks that are rather large in design. Perhaps modern day technology will allow respirators to be constructed that will meet all of these new requirements and still meet the very important worker acceptance requirements. Following are some of the special tests required of various dust, mist and fume respirators:

1. Dust, Mist and Fume Respirator Facepiece Pressure-Tightness Test. Fifteen to 20 people — variety of faces. Respirator fitted — exhalation valve held closed — exhale gently into facepiece — positive pressure created in mask — no leakage — respirator fits. This test is the simplest one of all and is a test that is standard operating procedure for most respirator wearers to make sure that they have the mask properly seated on their face before entering a contaminated area. Other tests, however, are not so simple as this one, as we shall see as we look at the following test.

2. Coal-Dust Tightness Test for Dusts, Mists, Fumes and Radon Daughters Respirators. Three people — six respirators — two respirators per person. One person can perform only one test per day. Coal dust concentration: 75 ± 25 MG/M³. A probe is placed inside the respirator facepiece. Two lpm of air drawn from mask for 30 minutes. The test subject will spend: Three minutes walking and turning and nodding head; 1½ minutes smiling; 1½ minutes frowning; three minutes reciting alphabet; three minutes talking; three minutes shallow and deep breathing. Then the test subject will repeat the above 15-minute schedule. During 30-minute test period, air is continually sampled with second probe located near mask in breathing zone. After test is over, leakage into facepiece must not have exceeded the following:

Respirator	*Max. per cent of Ambient Conc.*
Dusts and Mists	10
Fumes	5
Radon Daughters	5

This is a new fitting test that is appearing for the first time in the Bureau of Mines Test Schedule 21B. The mask is called upon to withstand such things as smiling, reciting the alphabet and talking, with repeat performances and with maximum allowable leakages into the facepiece held to such a low level that it appears certain that many respirators that are presently on the market with old Schedule 21 approvals could not possibly stand up to the requirements of these new fitting tests against coal-dust. Thus, it would seem that truly "bigger and better" respirators will soon be appearing on the market.

3. Isoamyl-Acetate-Tightness Test for Fume Respirators That Protect Against Fumes of Metals Having a TLV Not Less Than 0.1 Milligram per cubic Meter. Adapt mask to organic vapor cartridge(s) or canister. Fifteen to 20 people must wear respirator for two minutes in test chamber containing 100 parts by volume of isoamyl-acetate vapor per million parts of air. Odor of isoamyl-acetate shall not be detected by test subjects. The above is another fitting test designed especially for metal fume respirators and its description is quite self-explanatory.

4. Isoamyl-Acetate-Tightness Test for Respirators Designed to Protect Against Dusts, Fumes and Mists Having a TLV Less Than 0.1 Milligram per Cubic Meter, or Against Radionuclides. Adapt mask to organic vapor cartridge(s) or canister with similar size and resistance.

a. Test for respirators where the contaminant concentration is known not to exceed 10 times the TLV or 10 times the concentration limits for the radionuclides involved. Twenty persons wear mask five minutes each; 100 ppm isoamyl-acetate vapor in air. Two minutes walking, nodding, shaking head in normal movements. Three minutes exercising and running in place. Isoamyl-acetate odor must not be detected by anyone.

b. Test for respirators where the contaminant concentration is known not to exceed 100 or 1,000 times the TLV or 100 or 1,000 times the concentration limits for the radionuclides involved. The canister or cartridge(s) will be used in place of the filter unit. Twenty people will wear respirator five minutes each in test chamber containing 1,000 ppm of isoamyl-acetate vapor. Two minutes walking, talking, nodding and shaking head in normal movements. Three minutes exercising and running in place. Odor of isoamyl-acetate must not be detected by test subjects.

5. Special tests for respirators designed for respiratory protection against dusts, fumes, and mists having a TLV less than 0.1 milligram per cubic meter or against radionuclides.

DOP Man Tests and Chamber Tests. Take three complete respirators with sampling probe in mask. Six people each wear all three masks (total 18 wearings); 100 micrograms of DOP per liter of air in test chamber — eight liters of air per minute drawn from probe in mask. Two minutes facial movements*; one minute talking*; two minutes running in place.

The one respirator with the highest DOP penetration will be worn by three people for two hours each while performing following tests in chamber concentration of 100 micrograms of DOP per liter of air:

0-15 minutes: test subject seated in chamber. Eight lpm drawn from mask probe. If excessive leakage detected, subject will leave chamber and a stream of DOP will be directed at respirator to determine the source(s) of leakage into respirator.

15-60 minutes: leave chamber and carry on normal activities without adjusting facepiece.

60-75 minutes: return to chamber containing DOP. Eight lpm drawn from mask probe. Test subject will cough**, turn head from side to side, smile**, frown**, recite the alphabet loudly**, talk**, breath hallowly and deeply.

75-105 minutes: leave chamber and engage in normal activities.

105-120 minutes: enter chamber and repeat the 60-75 minute routine.

Performance Requirements

Where the contaminant concentration does not exceed the TLV or concentration limits for the radionuclides involved by a factor of:	Maximum allowable penetration for the respirator—percentage of ambient concentration	Maximum allowable penetration for average of all tests percentage of ambient concentration
10	1	0.5
100	1	0.5
1,000	0.1	0.05

*For respirators used in contaminant concentrations up to 10 times the TLV or 10 times the concentration limits for radionuclides substitute turning head from side to side for facial movements and substitute shallow and deep breathing for talking.

**For respirators used in contaminant concentrations up to 10 times the TLV, or 10 times the concentration limits for radionuclides, the test subject will not engage in activities marked with double asterisk.

You will note the tests required for respirators to protect against very toxic dusts, fumes, and mists, or radionuclides are very severe. It is interesting to note that there are respirators on the market that have been approved for protection against radio-nuclides where the concentration does not exceed the threshold limit value or concentration limits by more than 10 and more than 100 times. However, no mask, at the time of writing this article, has been approved by the United States Bureau of Mines for protecting against radionuclides in a concentration from 100 to 1,000 times the TLV.

Although the Uranine Chamber Test is in Schedule 21B, it is no longer used by the Bureau of Mines or most manufacturers since uranine contaminates the laboratory and the equipment, making it almost impossible to get accurate test results.

A review of all of the previously described test procedures and requirements will give you an idea of the tremendous amount of laboratory work that lies behind an approved respirator. You can see that, if you pass all the necessary tests as we have reviewed them and you have a Bureau of Mines approved respirator, then, as a manufacturer of respirators, you need a little bit more. To the approved respirator you must have added suitable packaging to meet Bureau of Mines standards, proper advertising, suitable literature or catalogs for the users to use as reference, proper quality control for all components during manufacturing, a sales and distribution setup, and you are set to do business.

It is important to note that the United States Bureau of Mines does not condone anything that is improper in any category involving an approved respirator, and this is as it should be.

A look into the laboratory of a well-equipped manufacturer of respirators would provide you with a view of a dust chamber or metal fume chamber that duplicates those of the United States Bureau of Mines in Pittsburgh, Pennsylvania. You would see amazing instrumentation for use in conducting various tests and monitoring them. You would also see in the laboratory a special mist chamber or chambers, instruments for chemical analysis, microbalances for weighing, DOP smoke testers, chambers for conducting man tests and coal dust tests, plus hundreds of other items so vital to the design, development and production of respirators capable of meeting the requirements of Bureau of Mines Testing Schedule No. 21B for dust, mist, and fume respirators.

So, if you need respiratory protection determine just exactly what that protection should be and get that protection from a reputable source. Above all, make sure that it has the United States Bureau of Mines approval.

INDUSTRIAL SAFETY IN METALS INDUSTRY

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The seeds of safety are sown with care; let us all cultivate the plant! G.M. has the seven basic principles of safety: provide active top management support; maintain adequate safety personnel; develop safety instructions for every job; instruct each new employe; operate through supervision; make every employe safety-minded, and extend efforts beyond the plant. At the 25th anniversary G.M. Safety Conference, we of Harrison Radiator were afforded the opportunity to propose the six senses of safety: use common sense; see clearly; hear acutely; respond promptly; standardize consistently; and learn constantly. We offer now the seven safety systems: "Partners in Safety System;" "The Defensive System;" "The Technical System;" "The Suggestion System;" "The Maintenance System;" "The Statistical System;" and "The Quality System."

Let us expand these systems, thus further developing safety standards for us also, in this review, recognize and stipulate the effect preventive maintenance and defensive safety modern equipment can have on our *power equipment operators should be trained* systems control.

First, the "safety for others" system. What do we mean by this expression? Frankly, we mean just that! Wherever there is work to be done, especially dangerous work (and all work can be dangerous), promote the concern for the other guy's safety—in short, any two people or organizations should feel *responsible for* each other's safety simply because they want to protect their fellow man. This is the first true application of "partners in safety."

Now, let us take the second step. Management has always required the supervisor to look out for his men; so, why not the reverse? Not that we think the supervisor will trip and fall if his employees do no watch out for him, but rather that all employees, with management, promote all types of safety for their mutual benefit.

Third, let us eliminate the causes for complaint and create a standard communication for use between the manufacturer and the user. You in manufacturing should not be so quick to defend your product that you overlook some constructive safety features buried in an accident. And users should not always be ready to sell any dealer down the river because they have a safety problem. Rather, let us pool our efforts and be "partners in safety"—buddy problem solvers, if you will—but always working together!

Let us accept the challenge to promote and encourage the defensive driving system, the same philosophy that helps to save lives on the highway. We, too, can save lives and reduce accidents in our plants by driving defensively.

The Defensive System. We speak of a defensive system, and immediately everyone says to himself, "Oh, sure!" The fork truck operator must drive defensively, undoubtedly so, but why stop there? Is not the pedestrian also responsible for his actions? Of course he is! Yes, *all must be instilled with the* desire to make their operation safe for the other fellow as well as for himself.

How about sign knowledge—are they clear? Are they placed so they can be seen? Are they standardized? Are they obeyed before the last second? Are the violation corrections enforced?

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operators should be trained to thoroughly understand the vehicle they are controlling. They should be educated to the extent that they can apply general defensive safety, be alert, and react to danger signs—for example: decrease in normal speed; lack of power; apparent lack of lubrication; worn or damaged tires; poor brakes; missing parts; excessive wear; oil leaks; difficult steering; unusual noises; overheating of motors and controls; erratic operation; failure of safety or warning devices; or poor acceleration. These are not only cost prevention items, but in reality are the forerunners to accidents.

The skillful operator lets the other fellow know what he is doing and what his intentions are. Timing is of great importance and is a result of planning ahead and executing as planned; on time, in time. This also means controlled time and controlled action and reaction. This is known as communications.

The Technical System of safety control has two major divisions, what has been done; and what potential controls, or safety devices, can be applied to future industrial trucking safety. We suggest that computer systems will play only 50 per cent of the future major role in material handling control. We further suggest that sensors will play the other 50 per cent. However, these systems in no way eliminate the decision and attention of the human mind! Safety minded engineers and designers will undoubtedly call upon the simple and sophisticated sensors for safety control long before the computerized program goes into effect.

The technical system is personified by the sensors. The safety of present and future material handling systems is and will be dependent upon sensors. There are just four basic types of mechanical sensors: limit switches; pressure sensors; tilt switches, rotating paddles. There are three prime magnetic sensors, namely: magnetic; radio frequency; and capacitance.

The Suggestion System evolves around more than people vying for an award, or occasionally not liking some part of their job and as a consequence coming up with a safety suggestion. The real meat of this system is getting all personnel actively en-

endeavor. Another problem often to be encountered when any new system is introduced into an organization is one arising from political controversies. These controversies may result from jealousies, rivalries, etc., between the safety system and other organizational subsystems. This problem is not uncommon and results primarily because of fears that this new system will detract from the effectiveness of existing systems. The safety administrator must allay this fear by clearly indicating how the safety system will enable other subsystems to maximize their effectiveness and contribute more to the overall organizational goal. After solving these initial problems, the safety administrator must work out a transitional plan for moving the new system into operation He must consider when the system will be placed into operation and should determine if it is practical to place the entire system into existence at once, or if segments of the system should be phased into the picture at predetermined intervals. Another consideration concerns developing a plan for patterning the activity of the safety system's smaller subsystems The administrator must be certain that the system's goals, objectives, strategies, rules for operation, work flow procedures, etc., are understood by each member of his system.

Once the system is implemented, it must be managed. The administrator must rely on basic management practices (e.g., planning, executing, and control) to be effective. He must be able to survive the demands of the future as well as the present. He will do well to consider alternative ways to accomplish his long range goals and objectives and weigh these against available resources. Projections of this kind will foster operational efficiency and effectiveness.

Ultimate Responsibilities of Safety System

Once designed and made operational, the safety system will make efforts to:

(a) gain and maintain management support;
(b) motivate, educate and train organizational personnel;
(c) develop and maintain an accurate record system;
(d) establish the duties and responsibilities of supervisory and employee personnel
(e) institute a system of accident investigation and reporting;
(f) establish safe work practices;
(g) provide controls over purchase, use, and maintenance of personal protective equipment;
(h) develop and maintain an accurate record system;
(i) provide a program of inspection for equipment, vehicles and buildings;
(j) provide a system of preventive maintenance for vehicles;
(k) maintain close liaison with medical units, legal units, and communication units;
(l) provide an employee suggestion program. A system must be promulgated by which to draw opinions and suggestions regarding safety from the rank and file.

In Conclusion

Only fundamental concepts of safety system design have been discussed here. Deeper consideration is required before these ideas can be made to satisfy individual organizational requirements. However, if the administrator treats the suggestions as a frame of reference from which he can further develop his system and add his own pertinent inputs, these ideas could lead to effective safety system development.

As a final note, we must be convinced that for a safety program to be effective, it must permeate all operations within an organization. Operational effectiveness and safe work practices should be made synonymous.

We must also consider that the people in the organization can make or break the safety effort. It is therefore the responsibility of the safety administrator to sell the organization on the purpose and benefits of the program, and solicit its support.

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RESPIRATORS—SELECTION AND TRAINING

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Although respiratory protective devices are probably the oldest method of controlling occupational diseases, health and safety men are generally less informed about the selection, applications, and limitations of these devices than about any other particular field in health and safety. It is emphasized that in the control of occupational diseases caused by airborne contaminants, primary consideration should always be given to preventing the air from becoming contaminated.

There are many situations in which respiratory protective devices are a must either for emergencies or routine use. Personal respiratory protective devices are intended to serve as adjuncts to other control measures, not as substitutes for them. However, because a large variety of these devices are available commercially and may be had on short notice and at relatively low cost, such equipment is frequently improperly selected, misused, and abused. All too many select and use respiratory protective devices on faith, without knowing where and where not, when and when not, to use these devices or how to select and use them properly.

To know this, it is necessary to understand the nature and extent of the exposure and the degree of protection needed, as well as to be acquainted with the various types of respirators and their uses and limitations. The many new and unusual occupational diseases resulting from industrial processes in the atomic and space age have created a demand for many types of respiratory protective devices with a very high degree of protection; however, the state of development of respiratory protective devices exceeds the state of their selection and use by health and safety personnel. In fact, the state of knowledge of the performance of respiratory devices in relation to the situation of use is better than the use that is made of them.

The essentials for training in the use of any respirator are (1) discussion of airborne contaminants; (2) reasons for using respirator; (3) description of its construction, operating principles and limitations; (4) instructions in procedures for assuring that it is in proper working condition; (5) instruction in fitting and checking proper fit; (6) instruction in proper use and maintenance; and (7) discussion of importance of careful reading of labels on respirator and manufacturer's instruction.

USE OF RESPIRATORS

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Although the best procedures to prevent inhalation of harmful air contaminants are the elimination of the contaminants at their source of generation or the reduction of the contaminant concentration to levels sufficiently low not to cause bodily harm, there are situations where, for one reason or another, these procedures are inapplicable, impractical, impossible, or not adequately effective. In such situations, respirators are utilized to protect personnel.

Prior to using respirators, a study must be made of the contaminated atmosphere to determine the nature of the hazard. The effective use of respirators requires the establishment and operation of a planned respiratory protection program. The program should include the following essential

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parts; selection; training; use; supervision; maintenance; storage and issue; medical surveillance; and evaluation. This paper will cover the use of respirators only.

After the proper respirator has been selected and the wearer has been trained to use it properly, it is essential that the wearer be given an explanation of the character and magnitude of the hazard, the principles of operation of the respirator, the probable time that the respirator will offer protection, how to recognize faulty functioning of the respirator, and instructions of what to do under emergency conditions resulting from his work or by accidental injury to his respirator.

It should be remembered that the normal oxygen content of atmospheric air at sea level pressure is 20.9 per cent by volume. The symptoms of anoxia begin to appear in humans in atmospheric air at sea level pressure when the oxygen content drops to 16 per cent by volume. Thus, an oxygen deficiency for humans in atmospheric air at sea level pressure exists when the oxygen content is less than 16 per cent by volume. The adverse effects of an oxygen deficiency increase with decreasing atmospheric pressure or increasing altitude.

Whenever possible, respirators tested and approved by the U.S. Bureau of Mines or respirators tested and listed as acceptable by the U.S. Department of Agriculture should be used. Sometimes, a respirator user must employ a respirator that has not been approved or listed as acceptable because either the type of respirator he must use is not covered by a test schedule or the hazard for which the respirator is to provide protection against is not covered by a test schedule. When this occurs, the respirator user must assure himself that the respirator manufacturer or another reliable organization has tested the respirator for the intended application and that the respirator manufacturer maintains a high standard of quality control during production.

Fitting of Respirator Facepiece

Fitting of a respirator facepiece is essential. Often, little attention is given to this matter. Difficulty may be experienced in fitting a full facepiece if the wearer has hollow temples or facial irregularities. A satisfactory seal cannot be obtained if spectacle temple bars extend under the sealing edge of the full facepiece. Systems for mounting corrective lenses inside full facepieces are available and should be used. The corrective lenses should be mounted in the facepiece by a qualified person to insure good vision. Wearing of contact lenses with a full facepiece should not be allowed. The contact lens prevents air from contacting the cornea of the eye and this hampers cooling of the cornea which can lead to corneal damage.

Fitting difficulties with a half-mask facepiece may be encountered if the wearer has a small, heavily jowelled, or irregular face. Missing rear teeth or the absence of upper or lower dentures can cause problems in fitting a half-mask facepiece. It may be necessary to try two or more styles or sizes of half-mask facepieces in order to obtain a good fit.

Headbands employed with half-mask facepieces may consist of a single loop of elastic strapping which passes around the head either below the ears or above the ears or may consist of two loops of elastic strapping, one loop passing around the head below the ears and the other passing around the head above the ears. The double loop headband will give a facepiece fit superior to that obtained with a single loop headband. The best fit of a half-mask facepiece can be obtained with a double loop headband which is attached to the facepiece at four separate points, two points on each side of the facepiece. Adjustment of the tension of the upper loop will insure a good facepiece fit around the nose, while adjustment of the tension of the lower loop will result in a good facepiece fit around the mouth and chin. The elastic strapping may be either rubber or woven elastic braid. The rubber strap material will last longer than the woven elastic braid. However, a strap of woven elastic braid will not slip on the head as easily as a strap of rubber, and thus a headband using woven elastic braid may result in a more secure facepiece fit than that provided by a headband using rubber.

Such conditions as excessive growth of hair on the face—sideburns, moustache, or beard—will prevent a good facial seal of both a full facepiece or a half-mask facepiece.

Each time a respirator is w[illegible] facepiece must be carefully fitted t[illegible] ing and yet be comfortable. [illegible] requires proper location of the facepiece on the face and satisfactory adjustment of the tension of headband or head harness straps. Instructions given by the manufacturer should be followed to improve fit and comfort.

A recent publication by Burgess and Held gives comprehensive details for four facepiece fitting tests that may be carried out in the field.[1] Respirator users are urged to refer to this article for detailed instructions. A simple positive pressure test may be used if the respirator contains an inhalation valve system. The wearer merely blocks off the exhalation valve and gently exhales into the facepiece to create a slight positive pressure. The facepiece fit is considered to be satisfactory if the positive pressure remains within the facepiece without observable leakage at the facial sealing area.

Another simple facepiece fitting test involves a negative pressure within the facepiece. In this test, the inlet part of a filter, cartridge, or canister is closed off by covering with the hand or a breathing tube may be squeezed. The wearer then inhales gently and holds his breath for five to ten seconds. If the facepiece fit is satisfactory, the facepiece will collapse against the face and no inward leakage of air between the facepiece and the face will be detected.

Another facepiece fitting test involves wearing the respirator in an odorous atmosphere. This test can be used for self-contained breathing apparatus, hose masks, airline respirators, and with air-purifying respirators that can be equipped with an organic vapor canister or cartridge. Isoamyl acetate, commonly called banana oil, is used to provide the odor, since its odor can easily be detected in a concentration as low as one part vapor per million parts of air. A small quantity of isoamyl acetate is poured on a cloth and the cloth is moved slowly around the periphery of the facepiece. If the wearer cannot detect the odor of isoamyl acetate, he has a satisfactory facepiece fit.

A highly irritant smoke can be employed to check the facepiece fit of self-contained breathing apparatus, hose masks, airline respirators, and air-purifying respirators that are equipped with ultra-high efficiency particulate filters. In this test, a highly irritant smoke is generated by a commercially available smoke tube commonly used in testing ventilation systems.[2] Air is forced through the tube with a rubber squeeze bulb, and the moisture in the air reacts with the material in the tube, creating a dense white smoke with a particle size range of 0.1 to 3 microns. Smoke from the tube is directed at the sealing edge of the facepiece. Leakage between the facepiece and face is easily detected by noticing irritation of the nose and throat. When the fit of a half-mask facepiece is being checked, the wearer must be cautioned to close his eyes.

Use of Particulate-Removing Respirators

Particulate-removing respirators, commonly called mechanical filter respirators, protect personnel against inhalation of nonvolatile airborne particles in the form of dust, fume, spray, and mist. They do not provide protection against vapors, gases, or an oxygen deficiency. They should not be used against volatile particulates or particulates that hydrolyze or decompose to release a noxious vapor or gas. These respirators should never be used for protection during shot or sand blasting operations which involve exposure to very high concentrations of abrasive and rapidly moving airborne particulates. For such operations, a special form of an airline respirator called an abrasive blasting airline respirator should be utilized. The U.S. Bureau of Mines tests and approves particulate = removing respirators against various dust, fumes, spray, and mists.[3]

A knitted fabric covering for the periphery of the facepiece that contacts the face sometimes is employed to absorb perspiration and to prevent irritation of the skin when the respirator is worn in hot atmospheres or in atmospheres containing corrosive particulate. This covering should be used only when the respirator is employed against coarse dusts and sprays. Usually, the covering cannot be used in atmospheres containing very small size particles such as fume or mist because these particles may be able to penetrate the knitted fabric and enter the interior of the respirator.

The respirator filter may be designed for protection against one or more than one specific type of airborne particulate—dust, fume, spray, or mist. The filter may employ one or more than one fibrous media for

removal of particles from the inspired air, and the fibrous material may be in the form of a circular disc, a folded pad, a corrugated cylinder, etc. The fibrous filter sometimes is housed in a rigid container to protect material from damage and facilitates attachment of the filter to the respirator. The size, shape, and the fibrous media employed in the filter generally depend upon the type or types of airborne particulate which the filter must protect against. Usually, the filters are replaceable, but in some cases are a permanent part of the respirator. Most filters are designed to be used once and then discarded, while a few filters are designed so that they can be cleansed and reused. Reuseable filters may be cleaned by brushing or blasting with a jet of compressed air, but never by washing in an aqueous solution or organic solvent. Extreme care must be taken in selecting the proper type of filter for the intended operation.

The respirator filter has a useful service life that depends upon its shape, size, fibrous material, type of airborne particle, particle size, particle concentration, and the activity of the respirator user. The breathing resistance offered by the filter will increase progressively during use as its fibrous material becomes plugged with retained particulate, and eventually breathing becomes difficult. When this occurs, the respirator wearer should leave the contaminated area and replace the plugged filter with a new filter or clean a reuseable filter. Small size particles plug a filter to a greater degree than large size particles. The resistance to breathing offered by a filter generally will increase at a rapid rate if used in a moist atmosphere. The lack of an inhalation valve system in a respirator or damage of a respirator's inhalation valve system may cause condensation of moisture present in the exhaled air on the respirator filter and thereby increase the breathing resistance of the filter.

Usually, the respirator filter becomes more efficient for retention of particles during its use as the quantity of retained particulate increases. However, this may not always be true. The filtering efficiency of some types of filter materials may be adversely affected by liquid particles.

A wide variety of particulate-removing respirators popularly known as nuisance dust and nuisance paint spray respirators are available. They generally are recommended for protection against non-toxic dusts or non-toxic paint sprays. Many industrial hygienists and physicians feel that there is no such thing as a non-toxic dust or paint spray particulate, since inhaling copious quantities of so-called inert particles, especially for long periods of time, can result in adverse physiological effects. Most of these respirators have poor face-fitting characteristics. A recent publication by Revoir and Yurgilas shows that nuisance dust respirators permit particulate penetrations that are substantially greater than the penetrations allowed by dust respirators approved by the U.S. Bureau of Mines.[4] Unpublished test results obtained in the author's laboratory show that the nuisance paint spray respirators also permit significant penetrations of air-borne particulate. These nuisance paint spray respirators, of course, do not remove organic vapors present in paint sprays from inspired air and this can be dangerous. Therefore, nuisance dust and nuisance paint spray respirators are not recommended for respiratory protection.

Use of Chemical Cartridge Respirators

Chemical cartridge respirators consist of one or two small cartridge-shaped containers of granular adsorbents or catalysts attached to a half-mask facepiece or a full facepiece. These respirators protect against low concentrations of vapors or gases that are not immediately dangerous to life. They do not provide protection against airborne particulate or an oxygen deficiency. At the present time, the U.S. Bureau of Mines tests and approves chemical cartridge respirators equipped with a half-mask facepiece against organic vapors in air with concentrations up to 1,000 parts per million by volume.[5] The Bureau has proposed testing and approving these respirators for low concentrations of various acidic, alkaline, and other types of vapors and gases, but it may be another year before such testing and approving becomes official.[6] The Bureau is not considering the testing and approving of chemical cartridge respirators equipped with full facepieces because of the possibility of this device being used as a junior gas mask in a highly contaminated atmosphere which could result in serious injury or even death to the wearer.

The cartridge of a chemical cartridge respirator is designed for removal of a specific vapor or gas, a single group of vapors or gases, or a combination of two or more classes of vapors and gases. The cartridges may contain one or more adsorbents or catalysts in the form of granules or pellets for removal of vapors or gases from inspired air. Cartridges can vary somewhat in the quantity of adsorbent or catalyst they contain, usually 75 to 200 cubic centimeters. Much care should be taken in choosing the correct type of cartridge for the intended use.

Chemical cartridge respirators are useful for low concentrations of vapors and gases that may be discomforting, irritating, or toxic, but they should not be utilized for protection against concentrations of vapors and gases that are immediately dangerous to life. They should not be used against gaseous contaminants that lack the warning properties of odor or irritation in low, non-toxic concentrations. Following is a partial list of gaseous substances against which chemical cartridges should not be used because they may be highly toxic, lack adequate warning properties, or are not readily removed from air by adsorbents or catalysts: acrolein, acrylonitrile, arsine, boron hydrides, carbon dioxide, carbon monoxide, carbonyls, cyanogen, dimethyl sulfate, ethyl cyanide, fluorine, formaldehyde gas, hydrogen sulfide, methyl bromide, methyl chloride, methyl iodide, nitrogen oxides, nitromethane, perchlorethane, phosphine, phosphorus trichloride, stibine.

If a gaseous substance is irritating to the eyes, a gas-tight goggle must be used with a half-mask facepiece type chemical cartridge respirator or a chemical cartridge respirator equipped with a full facepiece should be used. A knitted fabric covering for the periphery of the facepiece that contacts the face should not be worn, since vapors and gases can penetrate the knitted fabric and enter the interior of the facepiece.

A chemical cartridge respirator provides respiratory protection for a period of time that depends upon the type and size of the cartridge or cartridges used, the type of vapor or gas, the concentration of the vapor or gas, and the activity of the wearer of the respirator. Cartridges must be replaced when an odor or irritation is detected.

Most adsorbents and catalysts are adversely affected by moisture. Thus, a chemical cartridge respirator must be equipped with an inhalation valve system to prevent contact of the adsorbent or catalyst in the cartridge with the moisture present in the exhaled air. The service life of cartridges employing adsorbents or catalysts detrimentally affected by moisture will be reduced when the respirator is used in a highly humid atmosphere.

The breathing resistance of a chemical cartridge usually does not increase during use. However, if it does increase, this may be due to a defective inhalation valve system, agglomeration of the granular contents of the cartridge due to chemical reaction with the vapor or gas, or the presence of particulate matter in the atmosphere. The breathing resistance of a chemical cartridge may be considered to be too high if the respirator facepiece distorts inwardly during inhalation or if inhalation becomes difficult.

If odor or irritation of the vapor or gas is detected immediately when the wearer enters the contaminated area, he should leave the area and check the facepiece fit and the tightness of the connection of the cartridge or cartridges to the facepiece. If the respirator offers a service life of only a very few minutes, consideration should be given to the use of a more effective device such as a gas mask or airline respirator for protection.

Use of Combination Particulate-Removing and Chemical Cartridge Respirators

Combination particulate-removing and chemical cartridge respirators offer respiratory protection against both airborne particulate and low concentrations of vapors and gases. They may be used for protection against volatile particulate that give off vapors or gases and against particulate that hydrolyze or decompose to emit vapors or gases. The appropriate comments given in the sections pertaining to the use of particulate-removing respirators and use of chemical cartridge respirators apply to the combination type respirator.

At the present time, the U.S. Bureau of Mines tests and approves combination particulate-removing and chemical cartridge respirators only against a combination of organic vapors in air with concentrations up to 1,000 parts per million by volume,

and airborne particulate in the form of dust, fume spray, and mist (including sprays of paint, enamel, and lacquer).[5] The Bureau has proposed testing and approving these respirators for combinations of dust, fume, spray, and mist plus low concentrations of various acidic, alkaline, and other types of vapors and gases.[6] Until recently, the Agricultural Research Service of the U.S. Department of Agriculture tested and listed as acceptable combination particulate-removing and chemical cartridge respirators designed to protect against pesticides during field handling.[7] As the result of a governmental interagency agreement, the U.S. Bureau of Mines will take over the testing and approving of respiratory protective devices for protection against pesticides.[8] It may be one or two years before this test and approval program of the Bureau becomes official.

Respirators with either independently replaceable filters for particulates and chemical cartridges for vapors and gases or chemical cartridges with built-in filters are available. Some people prefer the respirators with independently replaceable filters and cartridges because they find it more economical to replace filters and cartridges separately, depending upon which needs replacement. Others use the respirators employing cartridges with built-in filters, because they feel that these units reduce the chance for leakage of particulate around the filter due to a poor connection between filter and cartridge.

Use of Air-Purifying Mouthpiece Respirator

An air-purifying mouthpiece respirator is a compact device that can be carried on the user's body so as to be available for quick application if the atmosphere suddenly becomes contaminated. These respirators are available for protection against airborne particulate, vapors, and gases, or combinations of vapor and gases. At this time, the U.S. Bureau of Mines tests and approves an air-purifying mouthpiece respirator either for self-rescue against carbon monoxide gas in air with concentrations up to 10,000 parts per million by volume[9] or for protection against dust, fume, spray, and mist.[5] These respirators do not offer protection against an oxygen deficiency. The Bureau now is proposing that air-purifying mouthpiece respirators be tested and approved for protection against various organic, acidic, alkaline, and other vapors and gases, plus combinations of these gaseous contaminants and airborne particulate.[6]

The mouthpiece type respirators usually employ a small cartridge-shaped air-purifying element attached to a mouthpiece. However, some of these respirators have a large canister type air-purifying element attached either directly to a mouthpiece or connected by means of flexible tube to the mouthpiece. In use, the mouthpiece is held in the wearer's mouth, and a separate nose clamp is used to close the nostrils which means that the wearer breathes through his mouth. The mouthpiece respirator may be held ready for instant use by being suspended on the chest by means of a neckband passing around the wearer's neck, by attachment to the wearer's belt by means of a clip or a carrying pouch, or by being carried in a pocket of the wearer's garments.

The air-purifying mouthpiece respirator may be used for intermittent respiratory protection against low concentrations of air contaminants for short periods of time throughout the workday whenever the work area becomes contaminated with low concentrations of noxious contaminants. Another intermittent use of this respirator involves application of the respirator to pass through a work area having an atmosphere containing a low concentration of a contaminant. The air-purifying mouthpiece respirator may be applied for self-rescue whenever the work atmosphere suddenly becomes polluted with a hazardous concentration of contaminant. In the self-rescue application, the wearer immediately leaves the contaminated area, wearing the respirator. Inasmuch as a person cannot detect the odor of a vapor or gas when breathing through his mouth, the air-purifying element used against a gas or vapor in the intermittent application should be discarded at the end of a workday, and the air-purifying element used against a gas or vapor in the self-rescue application should be discarded after a single use.

Some air-purifying mouthpiece respirators employ an inhalation valve system, while others do not. The use of the inhalation valve system will protect the air-purifying element against moisture by preventing contact of the moisture in the exhaled air with the ingredients of the air-purifying element, and by preventing saliva which collects into the mouthpiece from entering the air-purifying element.

A person with dentures may have difficulty in retaining the mouthpiece respirator in their mouth. Thus, it is not advisable for such a person to use this type of respirator. Some users of air-purifying mouthpiece respirators claim that they can employ this type of respirator without using a nose clamp because they have trained themselves to breathe only through the mouth. This is a dangerous practice and it is not recommended.

Use of Gas Masks

A gas mask consists of a large size canister type air-purifying element attached to a full facepiece either directly or indirectly by means of a flexible tube. When the canister is connected to the facepiece by the flexible tube, a carrier harness is employed to support the canister on the wearer's chest or back. A canister may contain one or more adsorbents or catalysts in the form of granules or pellets to protect against a single vapor or gas, a single class of vapors or gases, or against a combination of two or more classes of vapors and gases. A canister also may contain a fibrous filter for protection against airborne particulate in addition to adsorbents or catalysts that protect against gaseous contaminants. A gas mask may protect against toxic vapors, gases, and particulate, but it does not protect against an oxygen deficiency. Therefore, it cannot be used in an atmosphere that lacks sufficient oxygen to support human life.

At the present time, the U.S. Bureau of Mines tests and approves gas masks equipped with chest-mounted or back-mounted canisters against various vapors, gases, and particulates.[9] Approvals are granted for protection against vapors and gases in concentrations up to 20,000 parts per million by volume and up to 30,000 parts per million by volume for ammonia gas. Canisters attached directly to the facepiece are smaller in size than the chest-mounted or back-mounted canisters, and the Bureau does not test and approve gas masks equipped with the smaller size canisters directly attached to the facepiece. The Bureau is considering testing and approving these units, but it may be a few years before this becomes official. Until recently the Agricultural Research Service of the U.S. Department of Agriculture tested and listed as acceptable gas masks designed to protect against pesticides applied in the field during mixing, provided that such enclosures contained sufficient oxygen to support life.[7] As noted earlier, a recent governmental interagency agreement provides for the U.S. Bureau of Mines to assume the task of testing and approving gas masks designed for protection against pesticides.[8] However, one or two years may pass before the Bureau's test and approval program becomes official.

Canisters for protection against vapors and gases usually are made in three sizes: *small*, containing 200 to 500 cubic centimeters of adsorbent of catalyst (usually attached directly to the facepiece and commonly called a chin-style canister); *regular* or *industrial*, containing 1,000 to 1,200 cubic centimeters of adsorbent or catalyst; and *large* or *super*, containing 1,500 to 2,000 cubic centimeters of adsorbent or catalyst. The small or chin-style canisters usually are used for protection against vapors and gases in air having concentrations not exceeding 5,000 parts per million by volume. The regular or industrial canisters and the large or super canisters may be used for protection against vapors and gases in air with concentrations not exceeding 20,000 parts per million by volume or 30,000 parts per million by volume for ammonia gas. The service lives of the different size canisters containing the same ingredients for the same atmospheric conditions will be approximately proportional to the canister size. If protection is required against a single vapor or gas or a single class of vapors or gases, it is more economical to utilize a canister designed specifically for use against the single hazard than a canister designed for use against a multiple of hazards. A large size canister designed to protect against a combination of airborne particulate such as dust, fume, spray, mist, fog, and smoke and vapors and gases such as organic vapors, acidic gases, ammonia, and carbon monoxide is known as a Type *N* canister (sometimes called an all service or universal canister). Gas mask canisters are color coded for identification according to the hazards they protect against.[10]

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A canister must be replaced whenever an odor or irritation is detected by the wearer or if the resistance offered to breathing becomes objectionable. The U.S. Bureau of Mines requires that gas masks for protection against carbon monoxide gas, including the Type *N* gas mask but excluding a self-rescue gas mask for emergency escape use, contain an indicator that tells when the canister ingredient that protects against carbon monoxide gas is exhausted. Indicators are in the form of a window panel in the side of the canister containing granular substance that changes color when the canister ingredient for carbon monoxide is exhausted, or in the form of a mechanical timer which has an indicating dial or which activates an audible or physical alarm. The window panel type indicator also is available for a few types of canisters for protection against vapors and gases other than carbon monoxide gas. The end seals on a canister should be left in place until the canister is attached to the gas mask. After a canister with a mechanical timer is secured to a gas mask, it must be replaced as soon as the mechanical timer indicates that it has been in use for the intended service life, even though it has never been exposed to a hazardous atmosphere. After a canister containing a built-in window panel indicator is attached to a gas mask, it must be replaced whenever the substance behind the window changes color, even though the canister may never have been applied in a contaminated atmosphere. The maximum time that any type of canister should be left attached to a gas mask is one year. Canisters which have been in storage with end seals intact for more than four years should be discarded. Some gas mask manufacturers date canisters with the recommended expiration date for canister use.

Mechanical damage which distorts a canister may result in leakage of a contaminant through the canister wall; crushing of the granules or pellets into finer particles, which increases the breathing resistance of the canister; or channeling of contaminants through areas of decreased resistance, which reduces the service life of the canister. Corrosion of the canister may result in leakage of a hazardous substance through the canister wall and thus reduce the canister's useful life. Mechanically damaged or corroded canisters should be replaced.

The gas mask wearer should enter the contaminated area cautiously. If he detects an odor or irritation or if he experiences difficulty in breathing, feels dizzy, or nauseated, he should go to an uncontaminated area immediately without removing the gas mask. He should ascertain the cause of failure of the device and correct the fault before returning to the hazardous atmosphere.

Gas masks are approved by the U.S. Bureau of Mines for use in atmospheres immediately hazardous to life, providing that the previously mentioned contaminant concentrations are not exceeded and providing that the contaminated atmosphere contains sufficient oxygen to support life. Fresh canisters should be used for protection in atmospheres immediately dangerous to life or health. A strict limit should be placed on the time period of use of a canister for protection against a contaminant that lacks adequate warning properties of odor or irritation.

Use of Airline Respirators

A source of compressed air, a compressor or a tank, is used to supply respirable air through a small diameter hose to the wearer of an airline respirator. Using this source of breathing air makes the wearer independent of the surrounding atmosphere. However, this dependence upon an external source of air which is not carried by the wearer means that there are definite limitations in regard to the use of an airline respirator.

There are three modes of air flow for airline respirators: continuous; demand; and pressure-demand. The continuous flow airline respirator supplies air to the respiratory inlet covering continuously even when the wearer exhales. The demand flow airline respirator supplies air to the respiratory inlet covering only when the wearer inhales. The pressure-demand flow airline respirator supplies air to the respiratory inlet covering until a predetermined air pressure is established in the respiratory inlet covering, and then supplies additional air when the wearer inhales, to maintain a positive pressure in the respiratory inlet covering.

The U.S. Bureau of Mines tests and approves airlines respirators.[11] The continuous flow airline respirator is approved for use with a tight-fitting respiratory inlet [illegible] such as a half-mask facepiece or [illegible] facepiece. The Bureau approves respirators equipped with suitable [illegible]tory inlet coverings that protect the head and neck against impact and abrasion of rebounding particulate occurring in shot or sand blasting operations. These airline respirators are known as abrasive blasting respirators. The Bureau will not approve an airline respirator with a respiratory inlet covering which has a direct mouth or nose connection. The Bureau does not approve an airline respirator which utilizes a complete air-supplied suit.

Approved airline respirators may use up to 250 feet of small diameter air-supply hose. An approved continuous flow airline respirator must supply a flow of air not less than 115 liters (four cubic feet) per minute to tight-fitting and not less than 170 liters (six cubic feet) per minute to loose-fitting respiratory inlet coverings through a maximum approved length of air-supply hose at the minimum approved specified air-supply pressure. An approved continuous flow airline respirator must supply a flow of air not to exceed 425 liters (15 cubic feet) per minute to either a loose-fitting or a tight-fitting respiratory inlet covering through a minimum approved length of air-supply hose at the maximum approved specified air-supply pressure.

Airline respirators are approved by the Bureau for use in atmospheres containing airborne particulate, vapors, and gases that are not immediately dangerous to life or health or from which the wearer could escape without the aid of the respirator. The reason for this limitation is that the respirator wearer is dependent upon an external source of respirable air which is subject to failure under some conditions such as accidental stopping of a compressor, depletion of compressed air in a tank, or accidental rupture of the air-supply hose. However, the Bureau now approves a combination airline respirator with an auxiliary self-contained air supply carried by the wearer for protection in atmospheres immediately hazardous to life or health, including an atmosphere with a deficiency of oxygen. Also, the Bureau now approves a combination airline respirator and air-purifying respirator, and the limitations for application of this device are determined by the application limitations of the air-purifying portion of the device.

A recently published paper of the Joint Respirator Committee of the American Industrial Hygiene Association and the American Conference of Governmental Industrial Hygienists lists certain procedures which must be taken to allow the use of airline respirators in atmospheres immediately hazardous to life or health.[12] This information was published because the Joint Respirator Committee recognized that conditions of a routine process or operational designs may occasionally preclude the utilization of respirators approved by the Bureau for use in immediately dangerous atmospheres and may dictate the employment of an airline respirator. It is not possible to list the detailed procedures here. Respirator users are urged to refer to the publication for instructions.

The airline respirator is considered to be the most versatile type of respirator because it can be used against a wide variety of air contaminants, both particulate and gaseous, with the limitations previously listed. Most airline respirators are light in weight, comfortable to wear compared to other types of respirators, offer little or no resistance to breathing, and the flow of air to the respiratory inlet covering usually provides a cooling and refreshing effect. An airline respirator may be worn for long periods of time without appreciable discomfort for prolonged work in hazardous atmosphere.

A major disadvantage of the airline respirator is the trailing air-supply hose, which limits the travel of the wearer. The trailing hose must be arranged so as to minimize kinking, becoming entangled in objects, and tripping the wearer. Also, precautions should be taken to protect the hose against damage such as cutting, crushing, or burning. An armored hose may be necessary under some conditions. Prior to using an airline respirator, the user should always examine the air-supply hose for defects and test it for blockage.

The pressure-demand flow and the continuous flow airline respirators always maintain a slight positive pressure in the respiratory inlet covering to prevent inward leakage of contaminants. Thus, they offer a higher degree of protection than the de-

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mand flow device, which will have a slight negative pressure in the respiratory inlet during inhalation which could permit an inward leakage of contaminant into the respiratory inlet covering in case the covering is not tightly fitted to the wearer's face. When it is necessary to use a tank of compressed air, the demand flow airline respirator is preferred, since it will conserve the supply of respirable air to a greater degree than the other types of airline respirators. The pressure-demand flow device also may be used with a tank of compressed air, although it will deplete the air supply at a faster rate than the demand flow unit. The constant flow airline respirator is recommended only for use with an air compressor as the source of respirable air.

The quality of the compressed air used as breathing air is the responsibility of the airline respirator user. Precautions must be taken to insure a clean supply of respirable air is available at the proper pressure and in sufficient quantity. The U. S. Bureau of Mines states that the approval of an airline respirator is valid only when it is supplied with compressed breathing air that meets the most recent requirements of Compressed Gas Association Specification G7.1 for Type 1, Class D gaseous air and shall contain less than five milligrams of oil vapor or oil particulates per cubic meter of air. The most recent specification, G7.1, was published in 1966.[13] Analytical methods which may be employed to test the quality of the compressed air are given in those specifications. If tanks of compressed air are purchased for use with airline respirators, the purchaser should specify that the vendor furnish tanks of compressed air meeting the mentioned specification.

Most air compressor systems employ internally oil-lubricated pistons for air compression. Oil and water droplets, scale and other foreign particles, and oil vapor may be present in the compressed air. These contaminants can be removed by mechanical and chemical compressed air filters. This type of compressor should be well maintained to prevent it from overheating due to excessive friction. An overheated compressor may form harmful amounts of carbon monoxide gas. The compressor should be equipped with a high temperature actuated alarm which warns if the compressor begins to overheat, and a carbon monoxide alarm which gives a warning that a harmful concentration of carbon monoxide is present in the compressed gas. The compressor manufacturer should be consulted for aid in making sure that the compressor will supply respirable air.

Certain types of air compressors which may be water lubricated or which may utilize non-lubricated diaphragms, graphite rings, or graphite vanes for air compression are available. These compressors are superior to oil lubricated compressors in supplying respirable air.

The compressor intake should be located in an area where the air is clean and uncontaminated. The compressor intake should be kept away from all sources of air contamination including engine exhaust. Chemical and mechanical filters for connection to the compressor intake are available. An air storage receiver of sufficient capacity to allow the airline respirator wearer to escape from the contaminated area in case of compressor failure is recommended for use with the compressor. If possible, an air compressor separate from that used to supply compressed air for industrial equipment is recommended for supplying air to airline respirators. This should be considered for installation in new operations or where major alterations to industrial operations justify it.

Couplings for attachment of airline respirators to the source of respirable air should be incompatible with couplings for other gas systems, to prevent accidental connection of airline respirators with sources of non-respirable gases or oxygen. The couplings for connecting airline respirators to the respirable compressed air sources should be clearly labelled for identification. If more than one airline respirator is being used simultaneously and their connections to the compressed air sources are close together, these connections should be identified to eliminate the possibility of a respirator wearer disconnecting another wearer's supply of breathing air. Oxygen should never be used with airline respirators.

If a tank of compressed air is used as the source of respirable air, the airline respirator wearer should check the quantity of air it contains prior to entering a contaminated atmosphere. He should make sure that the tank contains sufficient air for breathing during the period the respirator will be employed for protection.

It is important that the pressure of the supply air be maintained within the pressure limits specified for the airline respirator. Using too low a pressure may be dangerous because it may result in supplying an inadequate amount of air needed for breathing by the respirator wearer or it may result in a negative pressure inside the respiratory inlet covering to permit a significant leakage of contaminants into the covering. Too high a pressure may cause discomfort to the respirator wearer.

The airline respirator contains a quick-disconnect coupling for the air-supply hose which is secured by some means to the respirator wearer, often by attachment to a belt worn by the wearer. When this coupling is disconnected, the breathing tube connected to the respiratory inlet covering is left open to allow the wearer to breathe through the tube. Also, the portion of the coupling attached to the air-supply hose closes the outlet of the air-supply hose when the coupling is disconnected to prevent escape of the compressed air. If the source of compressed air fails while the wearer is in a contaminated area, he disconnects the coupling and breathes through the open tube while he quickly leaves the contaminated area.

Noise generated internally within an airline respirator by the flow of the supply air may be a problem with some airline respirators, especially those having respiratory inlet coverings that encase the wearer's head. Exposure to high noise levels is not only unpleasant but is harmful, since it can result in a loss of hearing. The American Conference of Governmental Industrial Hygienists has proposed a maximum level for broad band noise of 92 dBA.[15] Safety and health standards for Federal supply contracts under the Walsh-Healey Public Contracts Act issued by the U.S. Department of Labor list maximum permissable noise levels.[16]

Unpublished test results obtained in the author's laboratory indicate that some commercially available airline respirators equipped with hood type respiratory inlet coverings generated noise levels ranging from 86 dBA at the minimum air flow permitted by the U. S. Bureau of Mines to [illegible] dBA at the maximum air flow allowed by the Bureau. Airline respirator users should be careful to select airline respirators that do not generate excess internal noise. Airline respirator wearers may have to wear hearing protectors for protection against noise generated by external work operations such as grinding, discing, shot blasting, and sand blasting.

Use of Hose Masks

Hose masks are respirators which supply respirable air from an uncontaminated source through a strong, large diameter hose to a facepiece worn by the user. Two types of hose masks are available. One type of hose mask employs an air blower, either hand-operated or motor operated, which pushes respirable air at low pressure through the large diameter hose to the facepiece. The blower is designed so that it permits free entrance of air to the hose when the blower is not operated. Thus, if the blower fails to operate, the respirator user by normal breathing action can inspire respirable air through the hose and blower. The other type of hose mask does not have an air blower. The normal breathing action of the wearer of the hose mask without blower enables him to inspire respirable air from the uncontaminated source through the large diameter hose.

Hose masks, with and without blowers, are tested and approved by the U. S. Bureau of Mines.[11] The Bureau approves the hose mask with blower for use in atmospheres immediately hazardous to life or health, including atmospheres with an oxygen deficiency. The hose mask without blower is approved by the Bureau only for use in harmful atmospheres not immediately dangerous or from which the respirator wearer could escape without the aid of the respirator. Hose masks equipped with suitable head and neck covering and shielded facepiece lens to resist impact and abrasion of rebounding particulate are tested and approved by the Bureau for protection of personnel in shot blasting and sand blasting operations.

The principle parts of an approved hose mask with blower are: a hand operated or motor-operated blower that allows free entrance of air to the hose when the blower is not operated; a strong, large diameter hose having a low resistance to air flow,

a strong harness to be worn by the respirator user and to which the hose is attached; a life line attached to the harness for rescue of the user; and a full facepiece with both an inhalation valve system and an exhalation valve system. The principle parts of an approved hose mask without a blower are: a strong, large diameter hose having a low resistance to air flow; a terminal fitting for the hose which contains means to remove foreign matter suspended in the air and means to permit securing the fitting to a fixed position; a harness to be worn by the respirator user and to which the hose is attached; and full facepiece or half-mask facepiece with both an inhalation valve system and an exhalation valve system. An approved hose mask with blower may use air-supply hose up to a maximum length of 300 feet in multiples of 25 feet. An approved hose mask without blower may use a hose up to a length of 75 feet in multiples of 25 feet. The large diameter air-supply hose must be strong enough to resist collapsing and permanent deformation when a crushing force is applied against it. Also, the hose must resist attack by solvents such as gasoline.

Hose masks may be used for protection for long periods of time. The hose mask with blower may be used for respiratory protection in any hazardous atmosphere regardless of the type of concentration of contaminant and in an atmosphere with any degree of oxygen deficiency. The high degree of respiratory protection offered by the hose mask with blower makes it suitable for use in enclosures and confined spaces where very high concentrations of contaminants as well as oxygen deficiencies may exist. Hose masks with blowers are commonly used in tank cleaning operations in the petroleum, chemical, food, water, and transportation industries and in underground work by public utilities. The hose mask without blower may be used for respiratory protection against both particulate and gaseous contaminants but should not be used for protection in atmospheres immediately harmful or having an oxygen deficiency.

Whenever a hose mask with blower is used in an atmosphere immediately dangerous to life or health, at least one suitably trained standby man equipped with adequate respiratory protective equipment should be present in the uncontaminated area for emergency rescue of the hose mask wearer. The mobility and area of movement of the hose mask wearer is restricted by the large diameter air-supply hose and the wearer must emerge from the contaminated area in the same way as he entered it. The wearer must take care to prevent damage to the hose and to prevent it from becoming caught on objects.

Prior to using a hose mask, a number of precautions should be taken. It should be assured that the area where the blower or terminal end of the air-supply hose is located contains clean respirable air. The operation of the blower should be tested. The terminal of the air-supply hose of the respirator without blower should be firmly anchored to a fixed point. The air supply hose should be checked for defects and blockage. Hose connections should be inspected to insure that they are tight. Check for foreign matter in the hose and blower by operating the blower for a few minutes. Foreign matter may be eliminated by operating the blower at high speed for several minutes. Foreign matter in the hose of a respirator without blower may be checked and eliminated by blowing clean, compressed air through the hose. Inspect the life line to insure that it is in good condition and fastened securely to the harness. When the hose mask is being used, precautions must be taken to insure that the air-supply hose is not damaged and that the air supplied to the respirator is not contaminated by the exhaust from vehicles or any process.

Use of Self-Contained Breathing Apparatus

A self-contained breathing apparatus is a respirator which employs a self-contained supply of air, oxygen, or oxygen-generating material carried by the wearer to provide him with a respirable atmosphere. All self-contained breathing apparatus offers respiratory protection to the user against irrespirable vapors, gases, particulates, or combinations thereof, in any concentration and against any degree of oxygen deficiency. Self-contained breathing apparatus may be classified by design into the following classes and sub-classes: (1) closed-circuit (using oxygen only) — Compressed oxygen type; Liquid oxygen type; Oxygen-generating type; (2) open-circuit (using compressed or liquified air or oxygen) — [illegible] type; Pressure-demand type.

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Self-contained breathing apparatus [illegible] may be classified according to use: (1) for entry into or escape from oxygen deficient atmosphere or irrespirable vapors, gases, and particulates; (2) for escape only from oxygen deficient atmospheres or irrespirable vapors, gases, and particulates.

The U. S. Bureau of Mines tests and approves the various types of self-contained breathing apparatus.[1] The Bureau approves these devices for the periods of time that they will provide respiratory protection when the wearer is engaged in moderate work activities. Only apparatus classified for fifteen minutes or longer service life is approved for entry into and escape from a hazardous atmosphere. Only apparatus classified for thirty minutes or less service life is approved for self-rescue from a hazardous atmosphere. Apparatus classified for a service life less than one hour is not approved for use in underground mining, tunneling, and similar operations except as auxiliary equipment, which means that the wearer has ready access to fresh air and at least one crew of five or six men equipped with approved self-contained breathing apparatus preferably of two hours or longer service life is in reserve in an area of fresh air. Apparatus classified for a service life less than thirty minutes is not approved as auxiliary equipment.

A combination self-contained breathing apparatus for self-rescue having a service life of three or ten minutes and an airline respirator is approved for entry into a hazardous atmosphere providing that entry is made using the air supply of the airline portion of the device. A combination self-contained breathing apparatus for self-rescue having a service life of fifteen or thirty minutes is approved for entry into a hazardous atmosphere, proving that entry is made using the air supply of the airline portion of the device, or providing that not more than twenty per cent of the the available self-contained air supply is used for entry.

A closed-circuit self-contained breathing apparatus is a device in which the exhaled air is rebreathed by the wearer after the carbon dioxide in the exhaled air has been removed and the oxygen concentration of the air is restored. The compressed oxy or liquid oxygen closed circuit contained breathing apparatus operates the following manner: High pressure oxygen from a cylinder passes through a pressure reducing valve and, in some devi also through a low-pressure admission v into a breathing bag. Liquid oxygen f a container is converted to low pres gaseous oxygen and passes into a breath bag. The wearer inhales from the through a tube containing a one way ch valve connected to a facepiece or mou piece. Exhaled air passes from the facep or mouthpiece, through another tube c taining a one-way check valve, into a c tainer having a chemical which remo the carbon dioxide, and then into the brea ing bag. Oxygen enters the bag continuou ly or as the bag deflates to actuate admission valve. The device contains pressure relief system and a manual bypa system, and may contain a saliva t The oxygen-generating type closed circ self-contained breathing apparatus operat in the following manner: Exhaled air pas from the facepiece or mouthpiece throu a tube containing a one way check val through a container having a chemical wh removes carbon dioxide from the air a which reacts with the water vapor in t air to release oxygen. The air with a r plenished supply of oxygen then passes in a breathing bag. The wearer inhales from the breathing bag through a scru tube containing a one-way check valve whe connects to the facepiece or mouthpiece. T device contains a pressure relief system m may contain a saliva trap.

An open-circuit self-contained breathin apparatus is a device in which the exhal air is not rebreathed but instead is expell to the atmosphere. In the demand type open circuit self-contained breathing apparatu exhaled air passes into the atmosphe through a valve in the facepiece or mouth piece. The device is equipped with a de mand valve activated upon initiation of in halation, which permits the flow of th breathing atmosphere from a container of compressed or liquified oxygen to the face piece or mouthpiece only during inhalation. On exhalation, the pressure in the facepiece or mouthpiece becomes positive and this closes the demand valve. The pressure demand type apparatus is similar to the

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demand type unit except that it is equipped only with a full facepiece and a small positive pressure is maintained in the facepiece at all times. The small positive pressure is obtained by means of a spring-loaded or balanced demand regulator and a balanced exhalation valve. Both types of devices, except those used for self-rescue, employ a hand-operated bypass system to permit the wearer to breathe if the demand valve fails.

Self-contained breathing apparatus usually employ a full facepiece but sometimes a mouthpiece and nose clip are used. Apparatus using compressed or liquified air or oxygen, except those used for self-rescue, contain a gage visible to the wearer which indicates the remaining gas or liquid. A timer, which actuates an alarm, is used in the oxygen-generating device, except those employed for self-rescue. A remaining service life indicator or warning device is used by apparatus utilizing compressed air or oxygen, except those employed for self-rescue.

The U. S. Bureau of Mines states that a self-contained breathing apparatus is approved only if it supplies respirable breathing gas to the wearer.[11] Oxygen, both as a compressed gas and as a liquid, must meet the requirements of the United States Pharmacopeia for medical or breathing oxygen.[12] Compressed air must meet the most recent requirements of the Compressed Gas Association Commodity Specification for Air, G-7.1, Type II, Grade D, liquid air.[13] The breathing atmosphere supplied by the apparatus should never contain less than 20.5 per cent by volume of oxygen.

The self-contained breathing apparatus has no limitation in regard to the nature of the hazardous atmosphere in which it may be worn. It provides complete respiratory protection in any concentration of particulate or gaseous contaminant and in any condition of oxygen deficiency. Since the wearer carries his own supply of respirable atmosphere with him, he is independent of the surrounding atmosphere. The apparatus allows the wearer to move with comparative freedom and he is not limited to movement in a restricted area. The length of time that a wearer can remain in a contaminated area depends upon the amount of air or oxygen or oxygen-generating material in the apparatus and the activity of the wearer. The service life ratings of the devices should be used only as guides.

The chief limitations of self-contained breathing apparatus are high weight, bulkiness, limited service life, and the need for a high degree of training for both safe use and maintenance. The self-contained breathing apparatus provides only respiratory protection. Contaminants that are irritating or corrosive to the skin or which readily penetrate the skin and are absorbed by the blood of the circulatory system of the body require the use of proper protective clothing in addition to the wearing of the apparatus.

Open circuit type self-contained breathing apparatus are considered to be relatively inefficient when compared with the closed-circuit type unit since the open-circuit unit releases exhaled oxygen to the atmosphere instead of being reused.

The breathing atmosphere supplied to wearer by self-contained breathing apparatus using liquified air or liquified oxygen is cool, which may be an advantage when the apparatus is employed in hot atmosphere.

The demand-type self-contained breathing apparatus produces a negative pressure in a facepiece during inhalation which may permit inward leakage of contaminants into the facepiece. The pressure-demand type self-contained breathing apparatus maintains a positive pressure in the facepiece even during inhalation, which prevents inward leakage of contaminants into the facepiece.

The ambient atmospheric pressure affects the service life of open-circuit type self-contained breathing apparatus. Increased ambient atmospheric pressures mean reduced service lives. Doubling the ambient atmospheric pressure cuts the service life in half.

Oxygen should never be used in self-contained breathing apparatus that have previously employed air. The air might have contained a low concentration of oil. When oxygen contacts oil, an explosion or fire could occur. Partly used cylinders or containers of compressed air or oxygen or liquified air or oxygen should not be kept for reuse. Once a cylinder or container has been used, even for a short time, it should be recharged before reuse.

When a person wearing a self-contained breathing apparatus enters a confined space containing a highly hazardous atmosphere, he should wear a suitable harness with an attached life line. At least one suitably trained standby man equipped with a self-contained breathing apparatus should be present in an uncontaminated area for emergency rescue of the man in the hazardous atmosphere.

Use of Respirators in Dangerous Atmospheres

Procedures covering the safe use of respirators in atmospheres immediately dangerous to life or health encountered in normal operations or in emergencies should be established. Personnel must be thoroughly familiar with these procedures. Whenever a respirator is used in an atmosphere immediately hazardous to life or health, at least one suitably trained standby man with a self-contained breathing apparatus should be present in the nearest uncontaminated area for emergency rescue. The standby man should be trained in the methods of resuscitation. Communications by voice, hand signals, or signal line should be maintained between the respirator user and the standby man. The respirator used should be equipped with a safety harness and line for lifting or removing him from the hazardous atmosphere. The standby man should be provided with the means for summoning assistance if an emergency should occur.

Use of Respirators in Confined spaces

Confined spaces are enclosures having limited means of egress, such as storage tanks, tank cars, process vessels, boilers, ducts, sewers, underground utility tunnels, pipelines, pits, and tubs. Confined spaces may contain atmospheres that are immediately hazardous to life due to the presence of toxic contaminants or the deficiency of sufficient oxygen to support life. Before anyone is allowed to enter a confined space, tests should be carried out to determine the concentration of any flammable vapor or gas present, the concentration of any toxic airborne particulate, vapor, or gas, and the concentration of oxygen.

Forced ventilation should be used to keep the concentration of a flammable substance at a safe limit. A person should not be allowed to enter a confined space without wearing adequate respiratory protective equipment if the concentration of any contaminant is above the Threshold Limit V or if an oxygen deficiency exists. U the concentration of contaminants in a confined space is found to be below Thr Limit Values and sufficient oxygen is pr ent, the safest procedure is to contin ventilate the enclosure and to contin monitor the concentration of contamin and oxygen concentration if personnel to work in the enclosure without wea respiratory protective devices. Air puri type respiratory protective devices may worn by personnel in a confined spac tests indicate that the atmosphere in the closure contains sufficient oxygen to sup life and if the concentration of air con nants is below levels of immediate dan to life or health. While personnel are o air-purifying type respirators are in enclosed space, the atmosphere in the sp should be continuously monitored. If t indicate that the enclosure contains a c taminant concentration that is immedia hazardous to life or health or has an oxy deficiency, then personnel who are requ to enter the enclosure should wear one the following types of respirators: s contained breathing apparatus, hose m with blower, combination airline respira and self-rescue type self-contained brea ing apparatus. The best safety prac would be only to permit people to wea self-contained breathing apparatus, he mask with blower, or combination airli respirator and self-rescue type self-contai breathing apparatus to enter a confine space.

Use of Respirators in Low and High Temperatures

Low temperatures will result in fogging of the lens in a full facepiece by the mois ture in the exhaled air. Coating the insi surface of the lens with an antifog com pound will prevent fogging at low temper tures approaching 32°F but severe fogging may occur at temperatures below 0°F. Ful facepieces are available with nose cups th direct the moist exhaled air through the exhalation valve without contacting the len and should provide satisfactory vision a temperatures as low as -30°F. At very low temperatures, the exhalation valve of a respirator may freeze open due to moisture. Dry respirable air should be used with an airline respirator and self-contained breath

ing apparatus that employ air when these devices are utilized at low temperatures.

A person working in an area of high temperature is under stress. Additional stress due to the wearing of a respirator should be minimized by selecting and using a respirator of minimum weight and low breathing resistance. Airline respirators are recommended for use in high temperature areas.

Skin Protection

Respirators protect only the respiratory systems against air contaminants. Some contaminants are very irritating or corrosive to the skin and may produce painful burns. Other contaminants are capable of penetrating the skin and then are absorbed by the blood, producing serious injury and possibly death. If the respirator wearer is exposed to such contaminants, he should wear protective clothing made of impermeable material along with the respirator. For such exposure, an air-supplied suit of suitable design and material should be considered for use.

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RESPIRATOR TESTING AND APPROVAL

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Among other services to the mining, mineral, and allied industries, the U.S. Bureau of Mines tests and approves respiratory protective devices. These devices are accepted only from responsible applicants and must meet a variety of machine and man tests. In addition to providing respirator performance requirements, the approval system includes provisions for upgrading of respirators by manufacturers and a continual checking of the manufacturer's conformance to approval requirements. The following article describes this program in general terms. The interested reader may obtain additional information from the published testing and approval schedules and respirator lists mentioned in this article.

The Bureau currently is expanding its respirator testing and approval program and is making improvements in its basic testing procedures. The program expansion and changes are described briefly in this article.

Since 1918, the Bureau of Mines has tested and approved oxygen breathing apparatus for mine rescue operations. The first respirator approval schedule, No. 13, for self-contained breathing apparatus, was issued in March 1919. Schedule 14, for gas masks, was also issued in 1919. The Bureau was subsequently asked to expand its approval program to include other devices. Schedule 19 for supplied-air respirators and Schedule 21 for dust, fume, and mist respirators, were issued in 1934. Schedule 23, for chemical-cartridge respirators, appeared in 1944. Now, in 1969 and 1970, the Bureau is again expanding its respirator approval program.

Under the authority of these approval schedules or their revisions, the Bureau tests and approves or rejects devices that are submitted to it by responsible applicants. The adjective "responsible" is important. After approval, the applicant (usually the manufacturer) is held responsible for the quality of the approved respirator. It is not unusual for respirators to be used daily under hazardous or emergency conditions.

Each new respirator must be accompanied by a fee to cover testing costs, by complete drawings and specifications which serve as a record of the device tested and approved, and by the manufacturer's test data. The latter data prove that the applicant has performed or had performed for him the same tests which will be made by the Bureau, and serve as an indication that he will be able to control the quality of his respirator.

When the Bureau is satisfied that its preliminary requirements are met, it accepts the respirator for extensive and exhaustive tests to prove the suitability of the device. These tests, and the requirements on which they are based, insure reliable respirator performance. Only rarely are design requirements incorporated in the Bureau's schedules, since such requirements tend to restrict development and improvement in respirator design and function.

Current revisions of the Bureau's respirator approval schedules are as follows: Schedule 13E—Self-Contained Breathing Apparatus; Schedule 14F—Gas Masks; Schedule 19B and Amendments—Supplied-Air Respirators; Schedule 21B and Amendments—Dust, Fume, and Mist Respirators; Schedule 23B—Chemical-Cartridge Respirators. Copies of these schedules may be obtained from the Bureau of Mines, Publications Distribution Section, Pittsburgh, Pa.

When approval tests are satisfactory, the Bureau issues a certificate of approval to the applicant. This permits him to sell his respirator as being approved by the Bureau of Mines. It also obligates him to adhere to the approved drawings and specifications in production. To permit the manufacturer to improve his product, or make changes required by production, the Bureau will retest a revised device. If the changes are satisfactory, an extension of approval is issued to cover them. The manufacturer, however, must not make the change until it is approved by the Bureau of Mines.

To help the user ascertain that a device is approved by the Bureau, the manufacturer is authorized to affix an approval label on each respirator. This label describes the

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*Past General Chairman.



STATE OF TEXAS §
§
COUNTY OF TRAVIS §

CERTIFICATE

I, the undersigned, hereby certify that in my official capacity as General Counsel, Texas Department of Health, I am authorized to make this certification. I further certify that the attached is a true, correct and exact copy of the following described document:

Occupational Health Regulation No. 3 entitled
"Maximum Permissible Concentrations of
Atmospheric Contaminants in Places of Employment"
as adopted by the Texas [State] Board of Health
on June 9, 1958, effective July 1, 1958,

as contained in the official records of the Texas Department of Health.

Witness my hand and the seal of the Texas Department of Health on this the 29th day of April, 1987.

EXHIBIT NO. 1
WITNESS: Hulla
DATE: 10-17-97

Hal L. Nelson
General Counsel
Texas Department of Health

DEPOSITION EX. 34
Hammond
9-8-95 IM

OCCUPATIONAL HEALTH REGULATIONS

NO. 3

MAXIMUM PERMISSIBLE CONCENTRATIONS OF ATMOSPHERIC CONTAMINANTS IN PLACES OF EMPLOYMENT

Effective July 1, 1958

CONSULT LOCAL HEALTH DEPARTMENTS AND PHYSICIANS

FOR

INFORMATION AND ADVICE

ON METHODS OF CONTROL OVER

HEALTH HAZARDS TO ALL WORKERS

AND

INDUSTRIAL DISEASES AND INJURIES

CERTIFIED
TEXAS DEPARTMENT OF HEALTH
Hal L. Nelson
General Counsel

TEXAS STATE DEPARTMENT OF HEALTH
DIVISION OF OCCUPATIONAL HEALTH
Austin, Texas

OH-13-2
July 1958
(Supersedes OH-13-1
September 1957)

These standards were amended and adopted by
The Texas State Board of Health on June 9, 1958
in accordance with the authority granted in
Article 4418-A of the Revised Civil Statutes, State of Texas,
and are promulgated also in accordance with
Article 4477, Section 19.

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MAXIMUM PERMISSIBLE CONCENTRATIONS OF ATMOSPHERIC CONTAMINANTS IN PLACES OF EMPLOYMENT

I. Scope; Purpose; Availability of Pertinent References

Scope: This regulation applies to all places of employment in Texas. It does not cover maximum permissible dose of radiation or the minimum environmental sanitation requirements, nor include measures required for control of community external air pollution or air pollution nuisances.

Purpose: The purpose of this regulation is to prescribe to employers the maximum average atmospheric concentration of contaminants to which they are permitted to expose employees during an eight-hour working day in their places of employment, including industrial establishments.

Pertinent References: Copies of related laws, regulations, opinions of the Attorney General of Texas, and Advisory Standards currently applicable will be provided to any citizen of Texas upon request.

II. Applicability of Figures Listed Herein

Individual people react differently after excessive exposures to atmospheric concentrations of contaminants in places of employment. Listed herein are weighted average concentrations generally safe in places of employment during an eight-hour working exposure. These are not maximum values which cannot be exceeded momentarily depending upon, but not limited to, such factors as nature of contaminant; frequency of occurrence of high concentration; variable durations of exposure; probability of acute poisoning from high concentration for even short periods; cumulative effects. Employers shall consider these factors prior to exceeding values listed herein.

III. Revision

Values listed herein are based upon information obtained from recent experience, experimental study reports, or a combination of the two. Regular review will result in revision as justified. The State Board of Health solicits and will consider pertinent data based upon facts and experiences received from individuals, industries, governmental agencies, or others.

IV. Definitions

1. Industrial Establishment is defined to mean an institution, a place, building or location related to manufactures or to the product of industry or labor.

2. Places of Employment is defined to mean any place where two or more persons are directly or indirectly employed by another for direct or indirect gain or profit.

V. MAXIMUM PERMISSIBLE CONCENTRATIONS DURING ONE WORKING DAY

A. Gases and Vapors	P.P.M.*	Approx. Mg. per Cu. M.†
Acetaldehyde	200	360
Acetic acid	10	25
Acetic anhydride	5	20
Acetone	1,000	2,400
(t)Acetylene tetrabromide	1	14
Acrolein	0.5	1.2
Acrylonitrile	20	45
Allyl alcohol	5	12
Allyl chloride	5	15
(t)Allyl glycidyl ether (AGE)	10	45
Allyl propyl disulfide	2	12
Ammonia	100	70
Amyl acetate	200	1,050
Amyl alcohol (isoamyl alcohol)	100	360
Aniline	5	19
Arsine	0.05	0.2
Benzene (benzol)	25	80
Benzyl chloride	1	5
(t)Boron trifluoride	1	3
Bromine	1	7
Butadiene (1,3-buradiene)	1,000	2,200
Butanone (methyl ethyl ketone)	250	740
Butyl acetate (n-butyl acetate)	200	950
Butyl alcohol (n-butanol)	100	300
(t)Butyl glycidyl ether(BGE)(n-butyl glycidyl ether)	50	270
Butylamine	5	15
Butyl cellosolve (2-butoxyethanol)	50	240
(t)Butyl mercaptan	10	35
Carbon dioxide	5,000	9,000
Carbon disulfide	20	60
Carbon monoxide	100	110
Carbon tetrachloride	25	160
Cellosolve (2-ethoxyethanol)	200	740
Cellosolve acetate (2-ethoxyethyl acetate)	100	540
Chlorine	1	3
(a)(t)Chlorine dioxide	0.1	0
Chlorine trifluoride	0.1	0.4
(t)Chloroacetaldehyde	1	3
Chlorobenzene (monochlorobenzene)	75	350
(t)Chlorobromomethane ($ClBrCH_2$)	400	2,100
Chloroform (trichloromethane)	100	490
1-Chloro-1-nitropropane	20	100
Chloropicrin	1	7

*Parts of vapor or gas per million parts of air by volume.

†Approximate milligrams per cubic meter of air.

(t)Toxicological information or injury reports on these items is of recent origin and most probably will require revision at an early date.

(a)New - Added 1958.

	A. Gases and Vapors (Cont.)	P.P.M.*	Approx. Mg. per Cu. M.†
	Chloroprene (2-chloro-1,3-butadiene)	25	90
	Cresol (all isomers)	5	22
	Cyclohexane	400	1,400
	Cyclohexanol	100	410
	Cyclohexanone	100	400
	Cyclohexene	400	1,350
	Cyclopropane	400	690
	Decaborane	0.05	0.3
	Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50	240
	Diborane	0.1	0.1
	o-Dichlorobenzene	50	300
	Dichlorodifluoromethane	1,000	4,950
	1,1-Dichloroethane	100	400
	1,2-Dichloroethane (ethylene dichloride)	100	400
	1,2-Dichloroethylene	200	790
	Dichloroethyl ether	15	90
	Dichloromonofluoromethane	1,000	4,200
	1,1-Dichloro-1-nitroethane	10	60
	Dichlorotetrafluoroethane	1,000	7,000
	Diethylamine	25	75
	Difluorodibromomethane	100	860
(t)	Diglycidyl ether (DGE)	10	55
	Diisobutyl ketone	50	290
	Dimethylaniline (n-dimethylaniline)	5	25
(t)	Dimethyl formamide	20	60
(a)(t)	1-1 Dimethylhydroxine	0.5	1
	Dimethylsulfate	1	5
	Dioxane (diethylene dioxide)	100	360
(t)	Dipropyleneglycolmethylether	100	600
(a)(t)	Epichlorohydrin	25	90
	Ethyl acetate	400	1,400
	Ethyl acrylate	25	100
	Ethyl alcohol (ethanol)	1,000	1,900
(t)	Ethyl mercaptan	250	640
	Ethyl amine	25	45
	Ethylbenzene	200	870
	Ethyl bromide	200	890
	Ethyl chloride	1,000	2,600
	Ethyl ether	400	1,200
	Ethyl formate	100	300
	Ethyl silicate	100	850
	Ethylene chlorohydrin	5	16

*Parts of vapor or gas per million parts of air by volume.

†Approximate milligrams per cubic meter of air.

(t)Toxicological information or injury reports on these items is of recent origin and most probably will require revision at an early date.

(a)New - Added 1958.

A. Gases and Vapors (Cont.)	P.P.M.*	Approx. Mg. per Cu. M.†
Ethylenediamine	10	30
Ethylene dibromide (1,2-dibromoethane)	25	190
Ethylene imine	5	9
Ethylene oxide	50	90
Fluorine	0.1	0.2
Fluorotrichloromethane	1,000	5,600
Formaldehyde	5	6
Furfural	5	20
(t) Furfuryl alcohol	50	200
Gasoline	500	2,000
(t) Glycidol	50	150
Heptane (n-heptane)	500	2,000
Hexane (n-hexane)	500	1,800
Hexanone (methyl butyl ketone)	100	410
Hexone (methyl isobutyl ketone)	100	410
(a)(t) sec-Hexyl acetate	100	590
Hydrazine	1	1.3
Hydrogen bromide	5	17
Hydrogen chloride	5	7
Hydrogen cyanide	10	11
Hydrogen fluoride	3	2
Hydrogen peroxide, 90%	1	1.4
Hydrogen selenide	0.05	0.2
Hydrogen sulfide	20	30
Iodine	0.1	1
Isophorone	25	140
(t) Isopropyl glycidyl ether (IGE)	50	240
Isopropylamine	5	12
(n) Mesityl oxide	25	200
Methyl acetate	200	610
Methyl acetylene	1,000	1,650
Methyl acrylate	10	35
Methyl alcohol (methanol)	200	260
Methyl bromide	20	80
Methyl cellosolve (2-methoxyethanol)	25	80
Methyl cellosolve acetate (ethylene glycol monomethyl ether acetate)	25	120
Methyl chloride	100	210
Methylal (dimethoxymethane)	1,000	3,100
Methyl chloroform (1,1,1-trichloroethane)	500	2,700
Methylcyclohexane	500	2,000
Methylcyclohexanol	100	470
Methylcyclohexanone	100	460

*Parts of vapor or gas per million parts of air by volume.

†Approximate milligrams per cubic meter of air.

(t)Toxicological information or injury reports on these items is of recent origin and most probably will require revision at an early date.

(n)New value, 1958.

(a)New - Added 1958.

A. Gases and Vapors (Cont.)	P.P.M.*	Approx. Mg. per Cu. M.†
Methyl formate	100	250
Methyl isobutyl carbinol (methyl amyl alcohol)	25	100
(t) Methyl mercaptan	50	100
(t) Methyl styrene	100	480
Methylene chloride (dichloromethane)	500	1,750
(t) Monomethyl aniline	2	9
Naphtha (coal tar)	200	800
Naphtha (petroleum)	500	2,000
Nickel carbonyl	0.001	0.007
Nitric acid	5	25
P-Nitroaniline	1	6
Nitrobenzene	1	5
Nitroethane	100	310
Nitrogen dioxide	5	9
Nitroglycerin	0.5	5
Nitromethane	100	250
2-Nitropropane	50	180
Nitrotoluene	5	30
Octane	500	2,350
Ozone	0.1	0.2
Pentane	1,000	2,950
Pentanone (methyl propyl ketone)	200	700
Perchloroethylene (tetrachloroethylene)	200	1,350
(t) Perchloromethyl mercaptan	0.1	0.8
Phenol	5	19
(t) Phenyl glycidyl ether (PGE)	50	310
Phenylhydrazine	5	22
Phosgene (carbonyl chloride)	1	4
Phosphine	0.05	0.07
Phosphorus trichloride	0.5	3
Propyl acetate	200	840
Propyl alcohol (isopropyl alcohol)	400	980
Propyl ether (isopropyl ether)	500	2,100
(a)(t) n-Propyl nitrate	25	110
Propylene dichloride (1,2-dichloropropane)	75	350
Propylene imine	25	60
(t) Propylene oxide	100	240
Pyridine	10	30
Quinone	0.1	0.4
Stibine	0.1	0.5
Stoddard solvent	500	2,900
Styrene monomer (phenylethylene)	100	420
Sulfur dioxide	5	13

*Parts of vapor or gas per million parts of air by volume

†Approximate milligrams per cubic meter of air.

(t)Toxicological information or injury reports on these items is of recent origin and most probably will require revision at an early date.

(a)New - Added 1958.

A. Gases and Vapors (Cont.)	P.P.M.*	Approx. Mg. per Cu. M.†
Sulfur hexafluoride	1,000	6,000
Sulfur monochloride	1	6
Sulfur pentafluoride	0.025	0.25
p-Tertiary butyl toluene	10	60
(t) Tertiary butyl alcohol	100	300
1,1,2,2-Tetrachloroethane	5	35
Tetrahydrofuran	200	590
Tetranitromethane	1	8
Toluene (toluol)	200	750
o-Toluidine	5	22
(t) Tolylene-2,4-diisocyanate	0.1	0.7
Trichloroethylene	200	1,050
(a)(t) Trichloropropane	50	300
(t) Triethyl amine	25	100
Trifluoromonobromomethane	1,000	6,100
Turpentine	100	560
Vinyl chloride (chloroethylene)	500	1,300
(t) Vinyl toluene	100	480
Xylene (xylol)	200	870
(t) Xylidine	5	25
(#)(t) Teflon decomposition products	0	0
(#)(t) Pentaborane (B_5H_9)	0	0

B. Toxic Dusts, Fumes, and Mists	Mg. per Cu. M.†
Aldrin (1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-dimethanonaphthalene)	0.25
Ammate (ammonium sulfamate)	15
Antimony	0.5
ANTU (alpha naphthyl thiourea)	0.3
Arsenic	0.5
Barium (soluble compounds)	0.5
(t) Beryllium	0.002
Cadmium oxide fume	0.1
Calcium arsenate	0.1
Chlordane (1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-4,7-methanoindane)	2
Chlorinated camphene, 60%	0.5
Chlorinated diphenyl oxide	0.5

*Parts of vapor or gas per million parts of air by volume.

†Approximate milligrams per cubic meter of air.

(t)Toxicological information or injury reports on these items is of recent origin and most probably will require revision at an early date.

(a)New - Added 1958.

(#)Until more data are forthcoming, it is important that atmospheric concentrations of these materials to which workers are exposed must be kept at as near 0 as possible.

†Milligrams of dust, fume, or mist per cubic meter of air.

B. Toxic Dusts, Fumes and Mists (Cont.)

		Mg. per Cu. M. *
	Chlorodiphenyl (42% chlorine)	1
	Chlorodiphenyl (54% chlorine)	0.5
	Chromic acid and chromates (as CrO_3)	0.1
	Crag herbicide (sodium 2-/2,4-dichlorophenoxy/ ethanol hydrogen sulfate)	15
	Cyanide (as CN)	5
	2,4-D(2,4-dichlorophenoxyacetic acid)	10
	DDT (2,2-bis/p-chlorophenyl/ -1,1,1-trichloroethane)	1
	Dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8, 8a-octahydro-1,4,5,8-dimethanonaphthalene)	0.25
	Dinitrobenzene	1
	Dinitrotoluene	1.5
	Dinitro-o-cresol	0.2
	EPN (O-ethyl O-p-nitrophenyl thionobenzenephosphonate)	0.5
	Ferbam (ferric dimethyl dithiocarbamate)	15
	Ferrovanadium dust	1
	Fluoride	2.5
	Hydroquinone	2
	Iron oxide fume	15
	Lead	0.2
	Lead arsenate	0.15
	Lindane (hexachlorocyclohexane, gamma isomer)	0.5
(t)	Lithium hydride	0.025
	Magnesium oxide fume	15
	Malathion (O,O-dimethyl dithiophosphate of diethyl mercaptosuccinate)	15
	Manganese	6
	Mercury	0.1
	Mercury (organic compounds)	0.01
	Methoxychlor (2,2-di-p-methoxyphenyl-1,1,1-trichloroethane).	15
	Molybdenum (soluble compounds)	5
	(insoluble compounds)	15
	Nicotine	0.5
(t)	Paradichlorobenzene	450
	Parathion (O,O-diethyl O-p-nitrophenylthiophosphate)	0.1
	Pentachloronaphthalene	0.5
	Pentachlorophenol	0.5
(a)(t)	Phosphoric Acid	1
	Phosphorus (yellow)	0.1
	Phosphorus pentachloride	1
	Phosphorus pentasulfide	1
	Picric acid	0.1

*Milligrams of dust, fume, or mist per cubic meter of air.

(a)Toxicological information or injury reports on these items is of recent origin and most probably will require revision at an early date.

(a)New - Added 1958.

B. Toxic Dusts, Fumes and Mists (Cont.)	Mg. per Cu. M. *
Pyrethrum	2
Rotenone	5
Selenium compounds (as Se)	0.1
Sodium hydroxide	2
Sodium fluoroacetate (1080)	0.1
Strychnine	0.15
Sulfuric acid	1
TEDP (Tetraethyl dithionopyrophosphate)	0.2
TEPP (Tetraethyl pyrophosphate)	0.05
Tellurium	0.1
Tetryl (2,4,6-trinitrophenylmethylnitramine)	1.5
Thiram (tetramethyl thiuram disulfide)	5
Thallium (soluble compounds)	0.1
Titanium dioxide	15
Trichloronaphthalene	5
Trinitrotoluene	1.5
(a) Triorthocresyl phosphate	0.1
Uranium (soluble compounds)	0.05
(insoluble compounds)	0.25
Vanadium	
(V_2O_5 dust)	0.5
(V_2O_5 fume)	0.1
Warfarin (3-[a-acetonylbenzyl] -4-hydroxycoumarin)	0.5
(c) Yttrium and inorganic compounds	5
Zinc oxide fumes	15
Zirconium compounds (as Zr)	5

C. Mineral Dusts	M.P.P.C.F.**
Aluminum oxide	50
Asbestos	5
Dust (nuisance, no free silica)	50
Mica (below 5% free silica)	20
Portland cement	50
Talc	20
Silica	
High (above 50% free SiO_2)	5
Medium (5 to 50% free SiO_2)	20
Low (below 5% free SiO_2)	50
Silicon carbide	50
Soapstone (below 5% free SiO_2)	20

*Milligrams of dust, fume, or mist per cubic meter of air.

(c)Toxicological information or injury reports on these items is of recent origin and most probably will require revision at an early date.

**Millions of particles per cubic foot of air.

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Title 41—PUBLIC CONTRACTS

Chapter 50—Division of Public Contracts, Department of Labor

PART 50–204—SAFETY AND HEALTH STANDARDS FOR FEDERAL SUPPLY CONTRACTS

The Walsh-Healey Public Contracts Act (49 Stat. 2036, 41 U.S.C. 35 et seq.) requires that contracts entered into by any agency of the United States for the manufacture or furnishing of materials, supplies, articles, and equipment in any amount exceeding $10,000 must contain, among other provisions, a stipulation that no "part of such contract will be performed nor will any of the materials, supplies, articles, or equipment to be manufactured or furnished under said contract be manufactured or fabricated in any plants, factories, buildings or surroundings or under working conditions which are unsanitary or hazardous or dangerous to the health and safety of employees engaged in the performance of said contract".

A single standard of safety and health conditions is thus required for all work subject to the Act. An objective description of the working conditions encountered, established by a preponderance of the reliable, probative, and substantial evidence, is, of course, essential to the administrative application of this standard. A second question which must be resolved is whether conditions of the type described are "unsanitary or hazardous or dangerous to the health or safety of employees". This is a question of fact. For assistance in its resolution, the act provides a special rule of evidence: "Compliance with the safety, sanitary, and factory inspection laws of the State in which the work or part thereof is to be performed shall be prima-facie evidence of compliance with this subsection."

The statutory provision concerning "prima-facie evidence" does not purport to take the place of the uniform national standard. It has application only to issues which require evidence. In the absence of opposing evidence, it authorizes resolution of such issues compatibly with the prima-facie evidence. Also, rules concerning prima-facie evidence obviously have no application in situations where evidence is not required. Where, therefore, the common experience of men is all that is needed to lead a rational and prudent person to the conclusion that certain conditions of employment are incompatible with the safety and health of employees, no defense is provided by the statutory "prima-facie evidence" rule merely because such conditions may not be specifically prohibited in the State safety, sanitary, and factory inspection laws, or the regulations hereby proposed. Neither is it necessary to call a witness to testify concerning the hazardous nature of such conditions.

The statutory rule of "prima-facie evidence" was not designed to deter the Secretary of Labor from diligent inquiry even beyond the safety, sanitary, and factory inspection laws of the several states to discover more directly what are the "working conditions which are unsanitary or hazardous or dangerous to the health and safety of employees." This is demonstrated by the provisions in sections 4 and 5 of the Act, directing the Secretary to administer it and authorizing him to appoint experts, make investigations, hold hearings, compel the production of evidence, and make findings of fact. Accordingly, following enactment of the Act, experts were appointed and their testimony used in the administrative enforcement proceedings conducted under section 5 of the Act. Differences of opinion over what conditions of employment fail to meet the statutory standard have thus been resolved with the assistance of expert testimony on a case-by-case basis in nearly a quarter of a century of hearings and findings under the Act. These have been conducted in accordance with sections 5, 7, and 8 of the Administrative Procedure Act since its enactment.

The hazardous characteristic of a particular working condition, is, of course, the likelihood that it will cause illness or injury in the employment situation. This characteristic is not always immediately apparent. Causative analysis of injury frequency rates in industry has shed much light on the importance of certain precautions not fully appreciated by those responsible for the operation of industrial establishments. The Department's discovery and evaluation of these hazards and the development of the regulations herein promulgated has relied quite extensively on the outstanding contributions of the private and public organizations which are generally accepted as preeminent in this field. Among these are the publications of American Standards Association, Inc., American Society of Mechanical Engineers, National Fire Protection Association, National Board of Fire Underwriters, the Public Health Service of the United States Department of Health, Education, and Welfare, the Bureau of Mines of the United States Department of the Interior, and the Atomic Energy Commission.

Section 7(d) of the Administrative Procedure Act recognizes that, even in the most formal type of administrative adjudications, agency decision may rest on "official notice of a material fact not appearing in the evidence in the record," but it requires that "any party shall on timely request be afforded an opportunity to show the contrary". The Attorney General's Manual on the Administrative Procedure Act points out (p. 80) that this authority "extends properly to all matters as to which the agency by reason of its functions is presumed to be expert, such as technical or scientific facts within its specialized knowledge. Cf. H.R. Rep. p. 38 (Sen. Doc. p. 272). * * * The matters thus noticed become a part of the record and, unless successfully controverted, furnish the same basis for findings of fact as does 'evidence' in the usual sense."

The hazardous characteristics of many working conditions, thus being facts of a "technical or scientific" nature, and having come within the Department's "specialized knowledge" by reason of its experience, proof of them in administrative adjudications by official notice is appropriate. The facts declared in these regulations are soundly based in the experience of the Department and in the experience of outstanding public and private experts in their specialized divisions of the field of health and safety engineering. The regulations herewith promulgated extend, however, into areas in which reasonable men may differ. Any party to an administrative adjudication who is adversely affected by them will, therefore, have the opportunity to contest them by presenting the issue in

his responsive pleading and introducing such evidence as he will be able to muster for consideration at his hearing.

Publication of standards which will underline the enforcement policy of the agency which administers the Walsh-Healey Public Contracts Act will promote observance of the safety and health requirements by curtailing uncertainty on the part of those whose duty it is to comply. Such publication will permit the administrative adjudication of many safety and health cases without the necessity of calling an expert witness to the place of hearing to testify to the hazardous nature of the working conditions denounced in the regulations. Except in cases where a party gives notice of intent to challenge the safety standards expressed in the regulation at hearing, as provided in the regulations herein promulgated, this element of possible controversy, and occasion of possible variety in decision, will be eliminated. These are the considerations which prompt this use of the authority expressed in section 4 of the Walsh-Healey Public Contracts Act to make "such rules and regulations as may be necessary to carry out the provisions of this Act."

Radiation standards for inclusion in the regulations herein promulgated as amendments are currently being drafted. They will apply the recommendations of the Federal Radiation Council approved by the President for the guidance of federal agencies May 13, 1960 (25 F.R. 4402).

As these regulations are rules of agency procedure or practice delineating facts which will be officially noticed in enforcement proceedings under section 5 of the Act, notice of proposed rule making and public proceedings in their adoption are not required by subsections 4 (a) and (b) of the Administrative Procedure Act.

In accordance with section 4 of the Administrative Procedure Act (60 Stat. 238, 5 U.S.C. 1003), therefore, and under the authority of section 4 of the Walsh-Healey Public Contracts Act (49 Stat. 2038, 41 U.S.C. 38), effective 30 days after publication in the FEDERAL REGISTER, a new Part 50-204—Safety and Health Standards for Federal Supply Contracts, is hereby added to 41 CFR, Chapter 50.

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Authority: §§ 50–204.1 to 50–204.300 issued under sec. 4, 49 Stat. 2038, 41 U.S.C. 38. Interpret or apply sec. 1, 49 Stat. 2036, 41 U.S.C. 35.

§ 50–204.1 Scope and application.

(a) The Walsh-Healey Public Contracts Act (49 Stat. 2036, 41 U.S.C. 35 et seq.) requires that contracts entered into by any agency of the United States for the manufacture or furnishing of materials, supplies, articles, and equipment in any amount exceeding $10,000 must contain, among other provisions, a stipulation that "No part of such contract will be performed nor will any of the materials, supplies, articles, or equipment to be manufactured or furnished under said contract be manufactured or fabricated in any plants, factories, buildings or surroundings or under working conditions which are unsanitary or hazardous or dangerous to the health and safety of employees engaged in the performance of the contract." This Part 50–204 of this chapter expresses certain minimum safety and health standards which will be applied in the administration and enforcement of the Act, including proceedings under its section 5 and 41 CFR Part 50–203, Subpart A, to determine whether particular contracts subject to the Act are being, or have been, performed in compliance with its safety and health requirements.

(b) In all administrative, enforcement, and investigative proceedings conducted by the United States Department of Labor under the Act, official notice will be taken of the fact that failure to comply with the requirements expressed in this Part 50–204 of this chapter results in working conditions which are "unsanitary or hazardous to employees" within the meaning of section 1(e) of the Act, and contracts incorporating the stipulation it requires.

(c) In formal enforcement proceedings under section 5 of the Act, respondents will be permitted to demonstrate, by reliable, substantial, and probative evidence, that their failure to comply with the requirements expressed in Part 50–204 of this chapter did not result in working conditions which were "unsanitary or hazardous or dangerous to employees," but only if the answer to the complaint, filed under 41 CFR 50–203.3, makes express allegation to that effect, identifying the particular code unit challenged and setting out the factual basis for the challenge. In the event such issue is drawn, and reliable, substantial, and probative evidence is introduced in support of the challenge, the pertinent portions of the publications of the American Standards Association, Inc., American Society of Mechanical Engineers, National Fire Protection Association, National Board of Fire Underwriters, the Public Health Service of the United States Department of Health, Education, and Welfare, the Bureau of Mines of the United States Department of the Interior, and the Atomic Energy Commission will be considered, together with any other evidence that may be adduced in support of the regulation, on the issue whether the preponderance of the reliable, substantial, and probative evidence supports a finding that the working conditions prohibited in the regulation are unsanitary or hazardous or dangerous to the health and safety of employees.

(d) The standards expressed in Part 50–204 of this chapter are for application to ordinary employment situations, and do not preclude proof or recognition of the necessity of higher standards for employment situations of extraordinary hazard. Neither do the standards expressed in this Part 50–204 of this chapter purport to describe all of the working conditions which are unsanitary or hazardous or dangerous to the health and safety of employees. Other working conditions may be found to be unsanitary or hazardous or dangerous to the health and safety of employees on evidence to that effect, or without such evidence, where such unsanitary or hazardous or dangerous characteristic should be apparent to a rational and prudent person of common experience.

(e) Compliance with the standards expressed in Part 50–204 of this chapter will not relieve anyone from any obligation to comply with any more strict standard stemming from any other source whatsoever.

Buildings and Appurtenances

§ 50–204.2 Buildings.

Buildings and all appurtenances thereto, including bridges, towers, balconies, runways, and platforms, shall be structurally safe to prevent collapse.

§ 50–204.3 Floors.

(a) No floor or platform shall be so loaded as to have a factor of safety of less than four. That is, the weight placed upon a floor or platform shall not exceed one-fourth of the breaking strength of the platform or floor.

(b) Floors, other than those resting directly on solid ground, when used for heavy storage shall be clearly posted to show maximum safe floor loads.

(c) All floor surfaces shall be kept clean and dry and maintained in a smooth (free from holes or projections that might cause tripping and reasonably nonslippery) condition.

(d) Where the type of operation necessitates working on floor areas which would be otherwise wet or slippery, such areas shall be covered with mats, grates, cleats, or other high friction floor coverings.

(e) Safe means of access, suited to conditions, shall be provided to every overhead point to which employees are called upon to go in connection with their employment.

§ 50–204.4 Building egress.

(a) *Exits.* Not less than two means of egress (other than ladders or elevators) as remote from each other as possible, shall be provided on every floor, including basements and cellars of every building or section where persons are employed. On the street floor at least one of these shall be a door leading directly outside the building, and the other may be a door leading outside the building, or a standard horizontal exit. On upper floors and basements, one exit shall be an enclosed stairway or smokeproof tower and the other or others may be inside stairways or horizontal exits or fire escape stairs.

(b) *Exit doors.* Doors shall swing in the direction of exit and open in such a manner as not to obstruct passageways or corridors used as ways of egress. No chairs or seats, fixtures, chutes, materials, or equipment shall block or in any way jeopardize the use of ways and means provided for egress. All exit doors and windows used as means of egress in case of fire or panic shall be so arranged as always to be opened readily from the inside. Locks on doors and windows, if provided, shall not require the use of a key to open.

(c) *Exit signs.* All exits or means of egress shall be provided with a sign having on it the word "EXIT" which shall be in letters at least five inches in height and plainly indicate to persons within the building the location of such egress.

Directional signs to the means of egress should be provided where necessary.

STAIRWAYS OR STEPS

§ 50-204.9 Stair width of treads and height of risers.

There shall be no variation in the width of treads and height of risers in any flight. Where variation in heights of risers in different flights is necessary on account of varying story heights, such variations shall not exceed ⅜ inch. All treads shall be at least 10 inches wide.

§ 50-204.10 Stairway maintenance.

Every stairway or step shall be maintained in good repair, free from protruding bolts, screws, nails, dirt, or slippery conditions, and no storage shall be permitted on stairways.

§ 50-204.11 Treads.

Treads shall be renewed when the surface, including the nosing, shows wear to the extent of ¼ inch or more. All metal treads shall have a surface which will reasonably prevent slipping.

§ 50-204.12 Stairway railings and handrails.

Every flight of stairs having four or more risers shall be equipped with a stair railing or handrails constructed to conform to the requirements of sections 50-204.28 and 50-204.29 under the following conditions:

(a) On stairways of width less than 44 inches and having both sides enclosed—at least one handrail on the right side descending.

(b) On stairways of width less than 44 inches and having one side open—at least one stair railing that shall be on the open side.

(c) On stairways of width less than 44 inches and having both sides open—one stair railing on each side.

(d) On stairways of width 44 inches or more but less than 88 inches—one handrail on each enclosed side and one stair railing on each open side.

(e) On stairways 88 inches or more in width—one handrail on each enclosed side, one stair railing on each open side and one intermediate stair railing located approximately midway of the width.

(f) Winding stairs shall be equipped with a handrail so offset as to prevent walking on any portions of the treads having width less than 6 inches.

GUARDING OF FLOOR OPENINGS AND FLOOR HOLES

§ 50-204.17 Stairway floor openings.

A railing constructed to conform to the requirements of sections 50-204.28 and 50-204.29 shall be provided on all exposed sides of stairway floor openings (except at entrance to stairway). Standard toe boards shall be provided also, except in stair towers.

§ 50-204.18 Ladderway floor openings.

Every ladderway floor opening shall be guarded by a standard railing with standard toe board on all exposed sides, except at entrance to opening.

§ 50-204.19 Hatchway and chute floor.

Every hatchway and chute floor opening shall be guarded either by:

(a) Hinged floor-opening cover of standard strength and construction equipped with railing constructed in accordance with sections 50-204.27 and 50-204.29 so as to leave no exposed side. When the opening is not in use the cover shall be closed.

(b) A removable railing with toe boards on not more than two sides of the opening and permanent railings with toe boards on all other exposed sides both constructed in accordance with sections 50-204.27 and 50-204.29. The removable railings shall be kept in place when the opening is not in use.

(c) Where operating conditions necessitate the feeding of material into any hatchway or chute opening from all sides, the guarding requirements will be satisfied if bars, chains, or other adequate protection is provided to prevent a person from falling through the opening.

§ 50-204.20 Floor hole.

Every floor hole except those described in sections 50-204.17, 50-204.18, 50-204.19 shall be guarded either by:

(a) A railing constructed in conformance with the requirement in sections 50-204.27 and 50-204.29 with standard toe board on all exposed sides; or

(b) A floor opening cover, hinged in place. While the cover is open, floor holes shall be constantly attended by someone or shall be protected by a portable enclosing railing.

GUARDING OF OPEN-SIDED FLOORS, PLATFORMS AND RUNWAYS

§ 50-204.25 Open-sided floor and platform.

(a) Every open-sided floor shall be guarded by a railing constructed in accordance with sections 50-204.27 and 50-204.29 on all open sides 5 feet or more above the adjacent floor or ground level, except where there is entrance to a ramp, stairway or fixed ladder. The railing shall be provided with a toe board wherever, beneath the open sides,

(1) Persons can pass,

(2) There is moving machinery, or

(3) There is equipment with which falling materials could create a hazard.

(b) The intermediate railing and toe board required by sections 50-204.27 and 50-204.29 may be omitted where materials have to be regularly passed over the edge of the floor (as in lumber storage), or where the railing is set back 12 inches or more from the edge.

(c) The entire railing may be temporarily removed from particular sections of open-sided floors where regular operating conditions make a permanent railing wholly impracticable.

§ 50-204.26 Runway guarding.

Every runway shall be guarded by a railing constructed in accordance with sections 50-204.27 and 50-204.29 on all open sides 5 feet or more above floor or ground level. Wherever tools, machine parts or materials are likely to be used on the runway, a toe board shall also be provided on each exposed side.

(a) Runways used exclusively for special purposes (such as oiling, shafting or filling tank cars), may have the railing on one side omitted where operating conditions necessitate such omission, providing there is no falling hazard.

RAILINGS AND GUARDS

§ 50-204.27 Standard railing.

A standard railing shall consist of top rail, intermediate rail and posts, having a vertical height of 42 inches from upper surface of top rail to floor, platform, runway or ramp level. The top rail shall be smooth surfaced throughout the length of the railing. The intermediate rail shall be approximately halfway between the top rail and floor, platform, runway or ramp. The ends of the rails shall not overhang the terminal posts except where such overhang does not constitute a projection hazard.

§ 50-204.28 Stair railing.

A stair railing shall be of construction similar to a standard railing but the vertical height shall be not more than 34 inches nor less than 30 inches from upper surface of top rail to surface of tread in line with face of riser at forward edge of tread.

(a) Intermediate rails shall not be required where stairways are 22 inches or less in width.

§ 50-204.29 Strength of standard railing and stair railing.

The strength of standard railings and stair railings under different types of construction is specified as follows:

(a) Wood railing: For wood railings, the posts shall be of at least 2 inch by 4 inch stock spaced not to exceed 8 feet; the top rails shall be of at least 2 inch by 4 inch stock or of two right angle pieces of at least 1 inch by 4 inch stock and the intermediate rails shall be of at least 2 inch by 2 inch stock or of at least 1 inch by 4 inch stock.

(b) Pipe railing: For pipe railings, the posts and top rails shall be metal pipe of at least 1½ inches inside diameter and the intermediate rails shall be metal pipe of at least 1 inch inside diameter. The spacing of posts shall not exceed 8 feet.

(c) Structural metal railings: For structural metal railings, the posts and top rails shall be angle iron of at least 1½ inches by 1½ inches by ⅜ inch or other structural shapes of equivalent bending strength; and the intermediate rails shall be angle iron of at least 1½ inches by 1½ inches by ⅛ inch or other structural shapes of equivalent bending strength. The spacing of posts shall not exceed 8 feet.

(d) *Anchor posts:* The anchoring of posts and framing of members for railings of all types shall be of such construction that the completed structure shall be capable of withstanding a load of at least 200 pounds applied in any direction at any point of the top rail.

(e) *Toe board:* A toe board shall be 4 inches in vertical height from top edge to the level of the floor, platform, runway, or ramp. It shall be securely fastened in place and with not more than ¼ inch clearance above floor level. It may be made of any substantial material

either solid or with openings not over 1 inch in length.

ELEVATORS

§ 50–204.34 Elevator inspection.

Elevator inspection by a competent elevator inspection service or maintenance contract on an annual basis will be acceptable as evidence of satisfactory installation and maintenance.

§ 50–204.35 Hoistways.

All hoistway openings at the floor level to the elevator shall be protected by doors or gates either manually or mechanically operated, and interlocked with the elevator control so that it is impossible to start the elevator until the door or gate is locked in the closed position, and also so that it is impossible to open the door or gate when the car is not at the landing.

§ 50–204.36 Under car safety device.

All elevators other than hydraulic elevators shall be equipped with an under car safety device operated by speed governor control that will hold the elevator in case of cable failure or over speeding.

§ 50–204.37 Hatch limit controls.

All types of elevators shall be equipped with upper and lower travel limit devices that will normally bring the car to rest at either terminal, and a final limit switch that will prevent the movement in either direction if opened by the car as the result of excessive over travel in either direction.

ILLUMINATION

§ 50–204.42 Minimum standards.

(a) Illumination shall be provided and distributed to all working areas as required in these regulations.

(b) Seeing tasks requiring discrimination of fine detail under conditions of fair contrast and where the nature of the work is very exacting and prolonged shall be provided with a minimum of 100 foot-candles of illumination.

(c) Seeing tasks requiring discrimination of detail over prolonged periods of time and under conditions of moderate contrast shall be provided with a minimum of 50 foot-candles of illumination.

(d) Seeing tasks requiring moderate discrimination of detail over intermittent periods of time and under conditions of normal contrast shall be provided with a minimum of 30 foot-candles of illumination.

(e) Casual seeing tasks not involving discrimination of fine detail shall be provided with a minimum of 10 foot-candles of illumination.

(f) Rough seeing tasks not requiring critical seeing shall be provided with a minimum of 5 foot-candles of illumination.

LADDERS

§ 50–204.47 Construction and use of portable ladders.

Portable ladders shall be substantially built, set level and well secured.

§ 50–204.48 Rails of portable ladders.

Rails of portable ladders shall always project at least three feet above working level and shall be of sound material.

§ 50–204.49 Painting of wooden ladders.

Wooden ladders shall not be painted, as painting covers up defects. Linseed oil or oil stain shall be used instead.

§ 50–204.50 Stepladders.

All stepladders shall be provided with an automatic locking device or spreader of not more than 40 degrees to hold the front and back sections in open position.

§ 50–204.51 Fixed ladders.

(a) Rest platforms: If fixed ladders are used to ascend to heights exceeding 30 feet, a landing or rest platform shall be provided for each 30 feet or fraction thereof unless the ladder is provided with safety cages.

(b) Rails: Rails of fixed ladders to landings shall extend a distance of at least 3 feet above the landing.

(c) Rungs: The rungs may be omitted above the landing. Where an employee must step a greater distance than 14 inches from the ladder to roof, tank, hoist, etc., a landing shall be provided.

(d) Guard rails: All fixed ladder landings shall be equipped with a standard guard rail and toe boards, so arranged as to give the safest possible access to the ladder. Such platforms shall not be less than 24 inches in width.

AISLES AND PASSAGEWAYS

§ 50–204.56 Maintenance.

Permanent aisles and passageways shall be kept clear and in good repair, with no obstructions across or in aisles that might cause tripping. Where, due to lack of proper identification, aisles and passageways are likely to become hazardous, they shall be clearly defined by painted lines, curbings, or other methods of marking.

§ 50–204.57 Aisle widths.

Where industrial trucks are in customary use, one-way traffic aisles shall be at least 2 feet wider than the widest vehicle. Two-way aisles shall be at least 3 feet wider than twice the width of the widest vehicle.

MATERIAL STORAGE

§ 50–204.62 Height.

(a) All material in bags, containers, or bundles, stored in tiers, shall be stacked, blocked, interlocked, and limited in height so that it is stable, so that it is secure against sliding or collapse.

(b) Where automatic sprinkler protection is provided, clearance of at least 18 inches shall be maintained between the tops of materials and the underside of lowest beams or other overhead structures. Where reliance is placed on hose streams, clearance of at least 3 feet shall be maintained between the tops of piles and the underside of the lowest beams, girders, or other obstructions which restrict the play of hose streams over the material.

§ 50–204.63 Small articles.

Small articles shall be stored in containers suitable to the material, such as small cans or trays that can be stacked.

§ 50–204.64 Pipe and other long stock.

Pipe and other long stock shall be stored in suitable racks or blocked to prevent spreading or rolling. Projecting ends shall be protected by location, railings, or barriers.

§ 50–204.65 Hazardous chemicals.

Hazardous chemicals shall be distinctively marked to indicate their nature and stored in containers or locations suitable to the material.

§ 50–204.66 Gases in cylinders.

(a) Cylinders shall be supported in an upright position so as to prevent them from falling or rolling.

(b) Cylinders shall be kept away from excessive heat, such as the direct rays of the sun.

(c) Cylinders shall be stored away from combustible materials.

(d) Empty cylinders shall be plainly marked "EMPTY," and the valves shall be closed. The empty cylinders shall be segregated from the full cylinders and returned to the supplier as soon as practicable.

(e) Valve covers shall be kept in place at all times when the cylinder is not in use.

OUTDOOR STORAGE

§ 50–204.71 Aisle spacing.

Aisles shall be maintained between piles, between buildings, and between piles and the boundary of the storage site. Aisles shall be wide so as to reduce the danger of spread of fire from pile to pile and to permit ready access for fire fighting or emergency removal of material.

§ 50–204.72 Housekeeping.

The entire storage site shall be kept free from unnecessary accumulations of combustible materials. Weeds and grass shall be kept down and the area kept clean.

§ 50–204.73 Drainage.

Proper drainage shall be provided.

§ 50–204.74 Clearance signs.

Clearance signs to warn of clearance limits shall be provided.

§ 50–204.75 Derail and bumper blocks.

Derail and bumper blocks shall be provided on spur tracks.

§ 50–204.76 Traffic control signs.

Traffic control signs to warn pedestrian, vehicular, and railroad traffic shall be provided.

§ 50–204.77 Open pits, tanks, vats, ditches, etc.

Covers or guard rails shall be provided to protect all open pits, tanks, vats, ditches, etc., near which people are regularly employed.

FLAMMABLE LIQUIDS

§ 50–204.82 Sources of ignition.

All sources of ignition shall be prohibited in areas where flammable liquids are stored, handled, and processed. Suitable warning and "No Smoking" signs shall be posted in all such areas.

§ 50-204.83 Vegetation removal.

The areas where flammable liquids are stored, handled, or processed shall be left clear of rubbish, brush, long grass, or other combustible material at all times.

§ 50-204.84 Housekeeping.

Accumulations of flammable liquids on floors, walls, and other surfaces, are prohibited. All spills of flammable liquids shall be cleaned up immediately.

§ 50-204.85 Electrical lighting.

Electrical lighting shall be the only means used for artificial illumination in areas where flammable liquids, vapors, fumes, dust, or gases are present. All electrical equipment and installations shall be of the explosion proof type.

§ 50-204.86 Ventilation.

All buildings, rooms and compartments where flammable liquids are stored, processed, or used shall be properly ventilated to prevent accumulation of flammable vapors.

§ 50-204.87 Refuse storage.

In buildings, shops, or rooms where flammable liquids are handled or stored, a self-closing metal refuse can shall be provided and maintained in good condition.

§ 50-204.88 Open flame devices prohibited.

Open flame heating devices shall not be used in areas where flammable liquids are present.

§ 50-204.89 Bonding and grounding.

Storage tanks and systems shall be electrically bonded and grounded.

§ 50-204.90 Relief vents.

Storage tanks shall be equipped with proper relief vents. Tank vents shall not be located close to open flames, stacks, heating apparatus, or any other source of ignition. Vent screens shall not be painted.

§ 50-204.91 Storage in other than flammable storage buildings.

A ventilated steel cabinet or a cabinet lined with noncombustible material shall be provided for the storage of more than a total of 10 gallons of flammable liquids in buildings used for other than storage. Not more than a total of 50 gallons shall be stored in any one cabinet, nor shall any individual container exceed 5 gallon capacity in such a cabinet. Containers must be of metal and kept tightly closed. Storage in drums of over 60 gallons of flammable liquids shall be outside the work room.

§ 50-204.92 Safety containers.

Handling of all flammable liquids by hand containers shall be in approved type safety containers substantially constructed to avoid the danger of leakage and designed to minimize the likelihood of spilling.

PAINTS AND PAINTING

§ 50-204.97 Storage of paints, varnishes, lacquers, thinners, etc.

Packages containing paints, varnishes, lacquers, thinners, or other volatile materials shall be kept tightly closed when not in actual use.

§ 50-204.98 Storage locations.

Sealed containers of paints, varnishes, lacquers, thinners, and other flammable paint materials, shall be kept in a well-ventilated location, free from excessive heat, smoke, sparks, flame, or direct rays of the sun.

§ 50-204.99 Storage of flammable paint materials in opened containers.

Flammable paint materials, when in excess of 10 gallons and not exceeding 50 gallons, shall be stored in a ventilated steel cabinet, or a cabinet lined with noncombustible material. Containers shall be kept tightly closed when not in use.

§ 50-204.100 Paint-soiled clothing and drop cloth.

Paint-soiled clothing and drop cloths, when not in use, shall be stored in well-ventilated steel cabinets.

§ 50-204.101 Housekeeping.

Paint scrapings and paint saturated debris shall be removed from the premises daily.

§ 50-204.102 Ventilation of harmful substances.

Ventilation adequate to reduce the concentration of harmful substances in the atmosphere shall be provided, as referred to in section 50-204.86.

§ 50-204.103 Ventilation of flammable vapors.

Ventilation adequate to prevent the accumulation of flammable vapors to hazardous levels of concentration shall be provided in all areas where spray painting, dipping or similar processes are performed.

§ 50-204.104 Smoking or open flames prohibited.

No smoking, open flame, exposed flame heating elements, or other sources of ignition of any kind shall be permitted in areas or rooms where spray painting, paint dipping or similar processes are done.

§ 50-204.105 Electrical equipment.

When electric lights, switches, or electrical equipment are necessary where indoor spray painting, paint dipping or similar processes are performed, they shall be of the explosion-proof type.

§ 50-204.106 Electric motors.

Electric motors driving exhaust fans shall not be placed inside booths or ducts exhausting flammable materials.

§ 50-204.107 Enclosure driving belts.

Belts shall not enter duct or booth exhausting flammable materials unless belt and pulley within the duct or booth are thoroughly enclosed.

§ 50-204.108 Storage of combustible and flammable cleaning materials.

Combustible and flammable cleaning materials at the establishment shall be stored in tightly closed metal containers.

FIRE PREVENTION

§ 50-204.113 Equipment general.

Fire fighting equipment suitable to the conditions and hazards involved shall be provided and maintained in an effective operating condition. A systematic inspection of these devices is required.

§ 50-204.114 First-aid fire fighting extinguishers, general rules.

The following general rules shall be applied to all types of first-aid fire extinguishers:

(a) Persons who may have occasion to use any fire extinguisher shall have knowledge of the proper way to use the device effectively.

(b) The instructions of the manufacturer of the extinguisher as to charging, maintenance and operations shall be followed exactly. All extinguishers shall be examined at least once a year to determine positively that they are in operating condition.

(c) Frequent inspections shall be made to determine that extinguishers are in their designated places, are readily accessible, have not been damaged or tampered with, and that nozzles are not clogged.

§ 50-204.115 Classification of extinguishers.

Listed below are various classes of fires and the extinguishing equipment which shall be maintained appurtenant to the various materials identified.

(a) *Class "A" Fires.* Fires in ordinary combustible materials where the quenching and cooling effects of quantities of water or solutions containing large percentage of water are of first importance. Required extinguishing equipment—soda and acid, pump tank extinguishers or water barrels and buckets.

(b) *Class "B" Fires.* Fires in flammable liquids, greases, and similar materials, where blanketing effect is essential. Required extinguishing equipment—foam, carbon tetrachloride, CO_2, dry powder type extinguishers, or sand buckets and scoops. Carbon tetrachloride extinguishers shall not be used in a confined area.

(c) *Class "C" Fires.* Fire in electrical equipment where the use of nonconducting extinguishing agent is of first importance. Required extinguishing equipment—CO_2, or dry powder pressure-type extinguishers.

PRESSURE VESSELS

§ 50-204.120 Boilers.

Boiler inspection and approval on an annual basis by a recognized boiler inspection service will be acceptable evidence of satisfactory installation and maintenance.

§ 50-204.121 Steam cookers, digester, glue pots, etc.

All pressure vessels to which steam is supplied from an outside source shall be designed for the maximum line pressure to which the vessel will be subjected. On such vessels it is required that, in addition to the necessary pressure reducing valve, a safety valve be installed on the vessel itself or on the line between

it and the pressure reducer. There shall be no means of cutting off or bypassing this safety valve. Inspection and adequate maintenance of the vessel, including regular testing of the safety valve, are mandatory.

§ 50–204.122 Unfired pressure vessels.

(a) Air receivers shall be so installed that all drains, handholes, and manholes therein are easily accessible.

(b) Air receivers shall be supported with sufficient clearance to permit a complete external inspection and to avoid corrosion of external surfaces.

(c) Under no circumstances shall air receivers be buried underground or located in an inaccessible place.

(d) The receiver shall be located as close to the compressor or aftercooler as is possible to keep the discharge short.

(e) The receiver shall be located in a cool place to facilitate the condensation of moisture and oil vapors.

TOOLS AND EQUIPMENT

§ 50–204.127 Maintenance.

Each employer shall be responsible for the safe condition of the tools used by his employees, whether furnished by him or by them, and be sure that such tools are suited by safe design and construction for the work to be done.

§ 50–204.128 Portable electric power tools.

(a) Electric power tools showing worn, deteriorated or inadequate insulation, split or chipped plugs, worn or bent plugs, terminals, defective switch, shall be repaired.

(b) Portable electric power tools shall be effectively grounded to maintain at all times an effective ground on the noncurrent carrying parts of the tools.

§ 50–204.129 Portable pneumatic tools.

(a) The operating trigger on portable hand-operated pneumatic equipment shall be so located as to minimize the possibility of accidental operation and shall be arranged to close the air inlet valve automatically when the pressure of the operator's hand is removed.

(b) A tool retainer shall be installed on each piece of pneumatic equipment which, without such a retainer, may eject the tool.

(c) No tool change or work other than regular operations shall be made or done on any piece of portable hand-operated pneumatic equipment unless the stop valve in the air line supplying that equipment is closed.

§ 50–204.130 Cables, ropes, and chains.

(a) Chains, ropes, cables, hooks, rings, slings, and other devices and accessories used for hoisting and lifting shall not be subjected to greater working loads than recommended by their manufacturers. They shall be frequently inspected and shall be renewed when inspection reveals unsafe conditions.

(b) Bolts or nails shall not be used to connect, splice, or shorten chains. Knots shall not be tied in the chain.

(c) A hoist cable shall be considered unsafe and shall be replaced when upon inspection 10 percent or more of the total number of wires are broken in a length equal to eight diameters of the cable, or when the wires on the crown of the strand are worn down to less than 60 percent of their original diameter.

(d) Crane hoist cable shall be lubricated and inspected at frequent intervals.

VENTILATION AND PROTECTION IN WELDING AND CUTTING

§ 50–204.135 Welding and cutting in confined spaces.

For the purpose of this section a confined space shall mean:

(a) A space of less than 10,000 cubic feet per welder, or

(b) A space having an overhead height of less than 16 feet, or

(c) A space in which there are structural barriers to the extent that they significantly obstruct cross ventilation.

§ 50–204.136 Ventilation in confined spaces.

All welding and cutting operations carried on in confined spaces shall be adequately mechanically ventilated to prevent the accumulation of toxic gases or possible oxygen deficiency or air supplied respirators approved by the U.S. Bureau of Mines shall be provided to the welder and all other personnel in the immediate vicinity.

§ 50–204.137 Mechanical ventilation.

Mechanical ventilation shall consist of either general ventilation systems or local exhaust systems.

(a) General ventilation shall be at the minimum rate of 2,000 cubic feet per minute per welder.

(b) Local exhaust shall consist of freely movable hoods intended to be placed by the welder as near as practicable to the work being welded and provided with a rate of air flow sufficient to maintain a velocity in the direction of the hood of 100 linear feet per minute in the zone of welding when the hood is at its most remote distance from the point of welding.

§ 50–204.138 Welding and cutting involving metals of toxic significance.

(a) Welding and cutting involving the following metals whether or not in confined spaces or in other enclosed spaces shall be done in accordance with the provisions of sections 204.136 and 204.137.

(1) Zinc-bearing base of filler metals or metals coated with zinc-bearing materials.

(2) Lead base metals.

(3) Cadmium-bearing filler materials.

(b) Welding or cutting involving the following metals in confined spaces shall be done using local exhaust ventilation or air-line respirators approved by the U.S. Bureau of Mines:

(1) Metals containing lead, other than as an impurity, or metals coated with lead-bearing materials, including paint.

(2) Cadmium-bearing or cadmium-coated base metals.

(3) Metals coated with mercury-bearing metals, including paint.

(4) Beryllium-containing base or filler metals. Because of its high toxicity, work involving beryllium shall be done with both local exhaust ventilation and air-line respirators.

§ 50–204.139 Protection to other employees.

In all cases employees in the immediate vicinity of welding operations shall be protected in accordance with sections 50–204.135 and 50–204.136.

§ 50–204.140 Inert-gas metal-arc welding.

Since the inert-gas metal-arc welding process involves the production of ultraviolet radiation of intensities five to thirty times that produced during shielded metal-arc welding, the decomposition of chlorinated solvents by ultraviolet rays, and the liberation of toxic fumes and gases, employees shall not be permitted to engage in, or be exposed to the process unless:

(a) The use of chlorinated solvents is kept at least 200 feet from the exposed arc; surfaces prepared with chlorinated solvents are thoroughly dry before welding is permitted on such surfaces.

(b) Shaded goggles with side shields are worn by helpers and others in the area, not protected from the arc by screening.

(c) Protective clothing is worn by welders and others within the area exposed to radiation so that the skin is covered completely to prevent burns and other damage by ultraviolet rays; shirts worn are dark in color to reduce reflection to the face from underneath the helmet; exposed cotton clothing is covered since it disintegrates rapidly when exposed to high intensities of ultraviolet rays; welding helmets and hand shields are free of leaks and openings, and free of highly reflective surfaces.

(d) Local exhaust ventilation or supplied air respirators are provided in all cases when doing inert-gas metal-arc welding of stainless steel to protect against dangerous concentrations of nitrogen dioxide.

§ 50–204.141 General welding and cutting.

Welding and cutting not involving conditions or materials described in sections 50–204.135 and 50–204.138 may normally be done without special precautions, but where, because of unusual physical or atmospheric conditions, a harmful accumulation of contaminants would exist, mechanical ventilation or suitable respiratory protective equipment shall be provided.

ELECTRICAL INSTALLATION AND EQUIPMENT

§ 50–204.148 Electrical installation and equipment.

Electrical conductors and equipment installed within or on buildings and other premises and the conductors that connect the installation to a supply of electricity and other outside conductors adjacent to the premises shall conform to the minimum requirements of the National Electrical Code, 1959 Edition, National Fire Protection Association.

MECHANICAL POWER TRANSMISSION APPARATUS

§ 50–204.153 Flywheels.

Flywheels located so that any part is 7 feet or less above floor or platform shall be guarded in one of the following ways:

(a) With an enclosure of sheet, perforated, or expanded metal, or woven wire. For standards, see sections 50–204.179 and 50–204.180.

(b) With guard rails placed not less than 15 inches nor more than 20 inches from rim. When flywheel extends into pit or is within 12 inches of floor, a standard toe board shall also be provided. For standards, see section 50–204.185.

(c) An adjustable guard to be used for starting the engine or for running adjustment may be provided at the flywheel of gas or oil engines. A slot opening for the jack bar will be permitted.

(d) Wherever flywheels are above working areas, guards shall be installed having sufficient strength to hold the weight of the flywheel in the event of a shaft or wheel mounting failure.

§ 50–204.154 Cranks and connecting rods.

Cranks and connecting rods, when exposed to contact, shall be guarded in accordance with sections 50–204.179 and 50–204.180 or by a guard rail as described in section 50–204.185.

§ 50–204.155 Tail rods or extension piston rods.

Tail rods or extension piston rods shall be guarded in accordance with sections 50–204.179 and 50–204.181 or by a guard rail on sides and end, with a clearance of not less than 15 nor more than 20 inches when rod is fully extended.

§ 50–204.156 Governor balls.

Governor balls 8 feet or less from the floor or other working level, when exposed to contact shall be provided with an enclosure extending to the top of the governors balls when at their highest position. The material used in the construction of this enclosure shall conform to sections 50–204.179 and 50–204.181.

§ 50–204.157 Shafting installation.

(a) Each continuous line of shafting shall be secured in a position against excessive end-wise movement.

(b) Inclined and vertical shafts, particularly inclined idler shafts, shall be securely held in position against endwise thrust.

§ 50–204.158 Guarding horizontal shafting.

(a) All exposed parts of horizontal shafting 7 feet or less from floor or working platform, excepting runways used exclusively for oiling, or running adjustments, shall be protected by a stationary casing enclosing shafting completely or by a trough enclosing sides and top or sides and bottom of shafting as location requires.

(b) Wherever shafting extends over a driveway, it shall be protected as stated above unless it is located 15 feet or more above driveway.

(c) Shafting under bench machines shall be enclosed by a stationary casing, or by a trough at sides and top or sides and bottom, as location requires. The sides of the trough shall come within at least 6 inches of the underside of table, or if shafting is located near floor, within 6 inches of floor. In every case the sides of the trough shall extend at least 2 inches beyond the shafting or protuberance. For requirements regarding materials and construction, see sections 50–204.179 and 50–204.181.

§ 50–204.159 Guarding vertical and inclined shafting.

Vertical and inclined shafting 7 feet or less from floor or working platform, excepting maintenance runways, shall be enclosed with a stationary casing in accordance with requirements of sections 50–204.179 and 50–204.181.

§ 50–204.160 Projecting shaft ends.

(a) Projecting shaft ends shall present a smooth edge and end and shall not project more than one-half the diameter of the shaft unless guarded by nonrotating caps or safety sleeves.

(b) Unused key-ways shall be filled up or covered.

§ 50–204.161 Power-transmission apparatus located in basements.

All mechanical power transmission apparatus located in basements, towers, and rooms used exclusively for power transmission equipment shall be guarded in accordance with these standards, except that the requirements for safeguarding belts, pulleys, and shafting may be omitted, if the following conditions are met:

(a) The basement, tower, or room occupied by transmission equipment is locked against unauthorized entrance.

(b) The vertical clearance in passageways between the floor and power transmission beams, ceiling, or any other objects, is not less than 5 feet 6 inches.

(c) The footing is dry, firm, and level.

(d) The route followed by the oiler is protected in such manner as to prevent accidents.

§ 50–204.162 Pulleys.

Any parts of which are 7 feet or less from the floor or working platform shall be guarded in accordance with the standards specified under section 50–204.179 and 50–204.181. Pulleys serving as balance wheels (e.g., punch presses) on which the point of contact between belt and pulley is more than 8 feet 6 inches from the floor or platform may be guarded with a disk covering the spokes. See section 50–204.180.

§ 50–204.163 Horizontal belts, ropes and chain drives.

(a) Where both runs of horizontal belts are 7 feet or less from the floor level, the guard shall extend to at least fifteen inches above the belt or to a standard height (see table, section 50–204.181) except that where both runs of a horizontal belt are 42 inches or less from the floor, the belt shall be fully enclosed in accordance with sections 50–204.179 and 50–204.181. In power plants or power-development rooms, a guard rail may be used in lieu of the requirement in section 50–204.183.

(b) Overhead horizontal belts, with lower part 7 feet or less from the floor or platform, shall be guarded on sides and bottom in accordance with section 50–204.183.

(c) Horizontal overhead belts more than 7 feet above floor or platform shall be guarded for their entire length under the following conditions:

(1) If located over passageways or work places and traveling 1800 feet or more per minute.

(2) If center to center distance between pulleys is 10 feet or more.

(3) If belt is 8 inches or more in width. For detail of guard construction and for sizes of material see section 50–204.183 and table following section 50–204.184.

(d) Where the upper and lower runs of horizontal belts are so located that passage of persons between them would be possible, the passage shall be either:

(1) Completely barred by a guard rail or other barrier in accordance with sections 50–204.179 and 50–204.181, or

(2) Where passage is regarded as necessary, there shall be a platform over the lower run guarded on either side by a railing completely filled in with wire mesh or other filler, or by a solid barrier. The upper run shall be so guarded as to prevent contact therewith either by the worker or by objects carried by him. In power plants, only the lower run of the belt need be guarded.

§ 50–204.164 Overhead chain and link belt drives.

Overhead chain and link belt drives are governed by the same rules as overhead horizontal belts and shall be guarded in the same manner as belts (section 50–204.163).

§ 50–204.165 Vertical and inclined belts.

(a) Vertical and inclined belts shall be enclosed by a guard conforming to standards in sections 50–204.179 and 50–204.181.

(b) All guards for inclined belts shall be arranged in such a manner that a minimum clearance of 7 feet is maintained between belt and floor at any point outside of guard.

§ 50–204.166 Vertical belts.

Vertical belts running over a lower pulley more than 7 feet above floor or platform shall be guarded at the bottom in the same manner as horizontal overhead belts, if conditions are such as stated in section 50–204.163(c) (1), (2), and (3).

§ 50–204.167 Cone-pulley belts.

(a) The cone belt and pulley shall be equipped with a belt shifter so constructed as to guard adequately the nip-point of the belt and pulley. If the frame of the belt shifter does not adequately guard the nip-point of the belt and pulley, the nip-point shall be further protected by means of a vertical guard placed in front of the pulley and extending at least to the top of the largest step of the cone.

(b) If the belt is of the endless type or laced with rawhide laces, and a belt shifter is not desired, the nip-point of the belt pulley shall be protected by a nip-point guard located in front of the cone extending at least to the top of the largest step of the cone, and formed to show the contour of the cone in order

to give the nip-point of the belt and pulley the maximum protection.

(c) If the cone is located less than 3 feet from the floor or working platform, the cone pulley and belt shall be guarded to a height of 3 feet regardless of whether the belt is endless or laced with rawhide.

§ 50–204.168 Gears.

Gears shall be guarded in accordance with one of the following specifications:

(a) A complete enclosure.

(b) A standard guard as described in section 204.181 at least 7 feet high extending 6 inches above the mesh point of the gears.

(c) By a band guard covering the face of the gear and having flanges extended inward beyond the root of the teeth on the exposed side or sides. Where any portion of the train of gears guarded by a band guard is less than 6 feet from the floor a disk guard or a complete enclosure to the height of 6 feet shall be required.

§ 50–204.169 Sprockets and chains.

All sprocket wheels and chains shall be enclosed unless more than 7 feet above the floor or platform. Where the drive extends over other machines or working areas, protection against falling shall be provided.

§ 50–204.170 Openings for oiling.

When frequent oiling must be made, openings with hinged or sliding self-closing covers shall be provided. All points not readily accessible shall have oil feed tubes if lubricant is to be added while machinery is in motion.

§ 50–204.171 Friction drives.

(a) The driving point of all friction drives when exposed to contact shall be guarded.

(b) All arm or spoke friction drives and all web friction drives with holes in the web shall be entirely enclosed.

(c) All projecting bolts on friction drives where exposed to contact shall be guarded.

§ 50–204.172 Keys, set screws, and other projections.

All projecting keys, set screws and other projections in revolving parts shall be removed or made flush or guarded by metal covers. This does not apply to keys or set screws within gear or sprocket casings or other enclosures, nor to keys, set screws, or oil cups in hubs of pulleys less than twenty inches in diameter where they are within the plane of the rim of the pulley.

§ 50–204.173 Collars.

All revolving collars, including split collars, shall be cylindrical, and screws or bolts used in collars shall not project beyond the largest periphery of the collar.

§ 50–204.174 Couplings.

(a) Shaft couplings shall be so constructed as to present no hazard from bolts, nuts, set screws, or revolving surfaces.

(b) Bolts, nuts, and set screws will, however, be permitted where they are covered with safety sleeves or where they are used parallel with the shafting and are countersunk or else do not extend beyond the flange of the coupling.

GUARD STANDARDS FOR MECHANICAL POWER TRANSMISSION

§ 50–204.179 Materials.

(a) Standard conditions will be secured by the use of the following materials: Expanded metal, perforated or solid metal or wire mesh on a frame of angle iron or iron pipe securely fastened to floor or to frame of machine (see section 50–204.181).

(1) All metal shall be free from burrs and sharp edges.

(2) Wire mesh shall be of the type in which the wires are securely fastened at every cross point either by welding, soldering, or galvanizing, except in case of diamond or square wire mesh made of No. 14 gauge wire, ¾ inch mesh or heavier.

(b) Design of guards:

(1) Where it is necessary to change belts, make adjustments or apply oil or grease, guards shall have hinged sections or be removable.

(2) Guards shall be designed so as not to interfere with the usual machine operations, but give the maximum protection to the operator.

(c) Methods of manufacture:

(1) Filler material shall be expanded metal, sheet, or perforated metal, or wire mesh and be securely fastened to frame.

(2) By welding to frame every 4 inches. By weaving through channel or angle frame, or if No. 14 gauge ¾ inch mesh or heavier is used, by bending entirely around rod frames.

(3) Where openings in pipe railing are to be filled in with expanded metal, wire or sheet metal, the filler material shall be made into panels with rolled edges or bound with "V" or "U" edging of No. 24 gauge or heavier sheet metal fastened to the panels with bolts or rivets spaced not more than 5 inches center to center. The bound panels shall be fastened to the railing by sheet-metal clips spaced not more than 8 inches center to center.

(4) Where the design of guards requires filled material of greater area than 12 square feet, additional frame members shall be provided to maintain panel area within this limit.

(5) All joints of framework shall be made equivalent in strength to the material of the frame.

§ 50–204.180 Disk, shield, and "U" guards.

(a) Disk guard: A disk guard shall consist of a sheet-metal disk not less than No. 22 gauge fastened by "U" bolts or rivets to spokes of pulleys, flywheels, or gears. Where possibility of contact with sharp edges of the disk exists, the edge shall be rolled or wired. In all cases the nuts shall be provided with lock nuts which shall be placed on the unexposed side of the wheel.

(b) Shield guards.

(1) A shield guard shall consist of a frame filled in with wire mesh, expanded, perforated, or solid sheet metal.

(2) If area of shield does not exceed 6 square feet the wire mesh or expanded metal may be fastened in a framework of ⅜ inch solid rod, ¾ inch x ¾ inch x ⅛ inch angle iron or metal construction of equivalent strength.

(3) Metal shields may have edges entirely rolled around a ⅜ inch solid iron rod. All material of shield guard shall meet the requirements of section 50–204.181.

(c) "U" Guards: A "U" guard consisting of a flat surface with edge members shall be designed to cover the under surface and lower edge of a belt, multiple chain, or rope drive. It shall be constructed of materials specified in table of section 50–204.181 and shall conform to the requirements of sections 50–204.183 and 50–204.184. Edges shall be smooth, and if size of guard requires, these edges shall be reinforced by rolling, wiring, or by binding with angle or flat iron.

§ 50–204.181 Approved materials.

(a) Minimum Requirements. The materials and dimensions specified in this section shall apply to all guards except horizontal overhead belts, rope, cable or chain guards more than 7 feet above floor, or platform. (For the latter, see table following section 50–204.184.)

TABLE OF STANDARD MATERIALS AND DIMENSIONS

Material	Clearance from moving part at all points	Largest mesh or opening allowable	Minimum gauge (U.S. standard) or thickness	Minimum height of guard from floor or platform level
Woven wire	Under 3"	½"	No. 16	7'0".
	3"–6"	¾"	No. 14	7'0".
	Under 6"	1"	No. 14	7'0".
	6"–15"	2"	No. 12	7'0".
Expanded metal	Under 6"	1"	No. 12	7'0".
	6"–15"	2"	No. 11	7'0".
Perforated metal	Under 6"	1"	No. 14	7'0".
	6"–15"	2"	No. 12	7'0".
Sheet metal	Under 6"		No. 22	7'0".
	6"–15"		No. 20	7'0".
Wood or metal strip crossed	Under 6"	½"	Wood ¾" Metal No. 14	7'0".
	6"–15"	2"	Wood ¾" Metal No. 14	7'0".
Wood or metal strip not crossed	Under 6"	1½" width	Wood ¾" Metal No. 14	7'0".
	6"–15"	1" width	Wood ¾" Metal No. 14	7'0".
Std. rail	Min. 15" Max. 20"	See Standard for Railings Section 204.186.		

(b) Framework:

(1) Minimum dimensions of material for the framework of all guards except as noted in subparagraph (5) of this paragraph shall be angle iron 1 inch x 1 inch x ⅛ inch, metal pipe of ¾ inch inside diameter or metal construction of equivalent strength.

(2) All guards shall be rigidly braced every 3 feet or fractional part of their height to some fixed part of machinery or building structure. Where guard is exposed to contact with moving equipment additional strength is necessary.

(3) The framework for all guards fastened to floor or working platform and without other support or bracing shall consist of 1½ inch x 1½ inch x ⅛ inch angle iron, metal pipe or 1½ inch inside diameter or metal construction of equivalent strength. All rectangular guards shall have at least 4 upright frame members each of which shall be carried to the floor and be securely fastened thereto.

(4) Cylindrical guards shall have at least 3 supporting members carried to floor.

(5) Guards thirty inches or less in height and with a total surface not in excess of ten square feet may have a framework of ⅜ inch solid rod, ¾ inch x ¾ inch x ⅛ inch angle or metal construction of equivalent strength. The filling material shall correspond to the requirements of the table contained in paragraph (a) of this section.

(c) The specifications given in paragraphs (a) and (b) of this section are the minimum requirements; where guards are exposed to unusual wear, deterioration or impact, heavier material and construction shall be used to protect amply against the specific hazards involved.

§ 50–204.182 Wood guards.

(a) Wood guards may be used in the woodworking and chemical industries, in industries where the presence of fumes or where manufacturing conditions would cause the rapid deterioration of metal guards; also in construction work and in locations outdoors where extreme cold or extreme heat makes metal guards and railings undesirable. In all other industries, wood guards will not be allowed.

(b) Material and construction.

(1) Wood shall be sound, tough, and free from any loose knots.

(2) Guards shall be made of planed lumber not less than one inch rough board measure and edges and corners rounded off.

(3) Wood guards shall be securely fastened together with wood screws, hard wood dowel pins, bolts, or rivets.

(4) While no definite dimensions are given under this heading for framework or filler materials, wood guards shall be equal in strength and rigidity to metal guards specified in section 50–204.181(a)(b)(c).

(5) For construction of standard wood railing, see section 50–204.185.

§ 50–204.183 Guards for horizontal overhead belts.

(a) Guards for horizontal overhead belts shall run the entire length of the belt and follow the line of the pulley to the ceiling or be carried to the nearest wall, thus enclosing the belt effectively. Where belts are so located as to make it impracticable to carry the guard to wall or ceiling, construction of the guard shall be such as to enclose completely the top and bottom runs of belt and the face of pulleys. See section 50–204.183 (b) and (c).

(b) The guard and all its supporting members shall be securely fastened to wall or ceiling by gimlet-point lag screws or through bolts. In case of masonry construction, expansion bolts shall be used.

(c) Suitable reinforcement shall be provided for the ceiling rafters or overhead floor beams, where such is necessary, to sustain safely the weight and stress likely to be imposed by the guard. The interior surface of all guards, by which is meant the surface of the guard with which a belt will come in contact, shall be smooth and free from all projections of any character, except where construction demands it; protruding shallow round-head rivets may be used. Overhead belt guards shall be at least one-quarter wider than the belt which they protect, except that this clearance need not in any case exceed 6 inches on each side. Overhead rope drive and block and roller-chain-drive guards shall be not less than 6 inches wider than the drive on each side.

In overhead silent chain-drive guards where the chain is held from lateral displacement on the sprockets, the side clearances required on drives of 20 inch centers or under shall not be less than ¼ inch from the nearest moving chain part and on drives of over 20 inch centers a minimum of ½ inch from the nearest moving chain part.

(d) The table following section 50–204.184 gives sizes of materials to be used and general construction of guards for belts 10 inches or more in width. No material for overhead belt guards should be smaller than that specified in this table for belts 10 to 14 inches wide, even if the belt is less than 10 inches in width. However, No. 20 gauge sheet metal may be used as a filler on guards for belts less than 10 inches wide. Expanded metal, because of the sharp edges, shall not be used as a filler in horizontal belt guards.

(e) For clearance between guards and belts, ropes or chains of various center to center dimensions between the shafts, see bottom of table following section 50–204.184.

§ 50–204.184 Guards for horizontal overhead rope and chain drives.

Overhead-rope and chain-drive guard construction shall conform to section 50–204.183 for overhead-belt guard construction of similar width, except that the filler materials shall be of the solid type as shown in table following section 50–204.181(a) unless the fire hazard demands the use of open construction. A side guard member of the same solid filling material shall be carried up in a vertical position 2 inches above the level of the lower run of the rope or chain drive and 2 inches within the periphery of the pulleys which the guard encloses thus forming a trough. These side filler members shall be reinforced on the edges with 1½ inch x ¼ inch flat steel, riveted to the filling material at not greater than 8 inch centers; the reinforcing strip shall be fastened or bolted to all guard supporting members with at least one ⅜ inch rivet or bolt at each intersection, and the ends shall be secured to the ceiling with lag screws or bolts. The filling materials shall be fastened to the framework of the guard and the filler supports by ⅜₁₆ inch rivets spaced on 4 inch centers. The width of the multiple drive shall be determined by measuring the distance from the outside of the first to the outside of the last rope or chain in the group accommodated by the pulley.

§ 50–204.185 Guard rails and toe boards.

(a) Guard rails shall be 42 inches in height, with mid-rail between top rail and floor.

(b) Posts shall be not more than 8 feet apart; they are to be permanent and substantial, smooth, and free from protruding nails, bolts, and splinters. If made of pipe, the post shall be 1¼ inches inside diameter, or larger. If made of metal shapes or bars, their section shall be equal in strength to that of 1½ by 1½ by ⅛ inch angle iron. If made of wood, the posts shall be 2 x 4 inches or larger. The upper rail shall be 2 x 4 inches or two 1 x 4 strips, one at the top and one at the side of posts. The mid-rail shall be 1 x 4 inches or more. The rails (metal shapes, metal bars, or wood), shall be on that side of the posts which gives the best protection and support. Where panels are filled with expanded metal or wire mesh as noted in table, section 204.181 the middle rails may be omitted. Where guard is exposed to contact with moving equipment, additional strength may be necessary.

(c) Toe boards shall be 4 inches or more in height, of wood, metal, or of metal grill not exceeding 1 inch mesh.

MISCELLANEOUS MACHINE GUARDING

§ 50–204.190 Lathes and automatic screw machines.

(a) Chucks and face plates shall be free from projections, and dogs, if used, shall be of the safety type only—circular in shape with no projections beyond the periphery.

(b) Chip guards to catch flying chips, particularly in the case of the high speeds used in the softer metals, shall be provided.

(c) Rotating stock in turret lathes and automatic screw machines shall be completely enclosed in pipe long enough to contain the longest stock used.

(d) Suitable shields and oil catchers shall be provided to prevent slipperiness from oil thrown from the automatic screw machines.

§ 50–204.191 Drill presses.

(a) All projections on the rotating spindle and as much as possible of the spindle itself should be guarded.

(b) Spindle drive belts, when in range of the operator's head or body, shall be guarded to protect the operator from both contact and breakage.

GUARD REQUIREMENTS FOR HORIZONTAL OVERHEAD BELTS, ROPES, AND CHAINS 7 FEET OR MORE ABOVE FLOOR OR PLATFORM

Members	Width			Material
	Over 10" to 14" incl.	Over 14" to 24" incl.	Over 24"	
Framework	1½" x 1½" x ⅛"	2" x 2" x 5/16"	2" x 2" x 5/16"	Angle iron.
Filler (belt guards)	1½" x ⅛"	2" x 5/16"	2" x 5/16"	Flat iron.
Filler and vertical side members	No. 20 A.W.G.	No. 18 A.W.G.	No. 18 A.W.G.	Solid sheet metal.
Filler supports	2" x ⅛" flat iron.	2" x ¼" flat iron.	2½" x 2½" x ¼" angle.	Flat & Angle.
Guard supports	2" x ⅛"	2" x ¼"	2½" x ¼"	Flat iron.
FASTENINGS				
Filler supports to framework	(2) ⅜".	(2) ½".	(2) ½".	Rivets.
Filler flats to supports (belt guards)	(1) ⅜".	(1) ½".	(2) ½".	Flush rivets.
Filler to frame and supports (rope and chain guards).	⅜" rivets spaced 8" centers on sides and 4" centers on bottom.			
Guard supports to framework (guard and supports to overhead ceiling.	(2) ½". ⅛" x 2½" lag screws or ½" bolts.	(2) ½". ¼" x 4" lag screws or ½" bolts.	(2) ½". ¼" x 6" lag screws or ½" bolts.	Rivets or bolts. Lag screws or bolts.
DETAILS—APRONS, ETC.				
Width of guards	one-quarter wider than belt, rope, or chain drive.			
Spacing between filler supports	20" C. to C.	16" C. to C.	16" C. to C.	
Spacing between filler flat (belt guards).	2" apart.	2½" apart.	3" apart.	
Spacing between guard supports	20" C. to C.	20" C. to C.	20" C. to C.	
OTHER BELT GUARD FILLETS PERMITTED				
Sheet metal fastened as in rope and chain guards.	No. 20 A.W.G.	No. 18 A.W.G.	No. 18 A.W.G.	Solid or perforated.
Woven wire, 2" mesh	No. 12 A.W.G.	No. 10 A.W.G.	No. 8 A.W.G.	

CLEARANCE FROM OUTSIDE OF BELT, ROPE, OR CHAIN DRIVE TO GUARD

Distance center to center of shafts	Up to 15' incl.	Over 15' to 25' incl.	Over 25' to 40' incl.	Over 40'.
Clearance from belt, rope, or chain to guard.	6"	10"	15"	20".

§ 50-204.192 Planers and shapers, (metal).

(a) The spaces between the ways of planer frames shall be filled in smoothly with heavy sheet metal to eliminate the shear hazard.

(b) Where there is not a 12-inch clearance between a fixed object and the planer table and the work carried on the table, a railing shall be provided between the fixed object and the table and the work on the table to protect workers passing between the fixed object and the planer.

§ 50-204.193 Shears.

(a) Alligator shears shall be guarded by running a heavy U-shaped metal strap horizontally around the moving (upper) jaw with the lower edge of the strap just far enough above the cutting edge of the fixed (lower) jaw to allow the material to be inserted in the shears.

(b) Squaring shears shall be provided with a fixed barrier which clears the top of the table by not more than ⅜ inch plus the minimum thickness of material for which used. Automatic clamps shall be acceptable as guards when cutouts are filled in so that fingers of the operator cannot enter the danger zone.

§ 50-204.194 Guillotine cutters, power-driven.

(a) Power-driven guillotine cutters shall be equipped with a guard or device which will prevent the hands of the workers from entering the zone traveled by the knife while the knife is in motion. This may be a fixed barrier or it may consist of a two-handed device requiring the simultaneous use of the worker's two hands at points outside the zone of danger.

(b) In addition to the point of operation guard or device described in section 50-204.194(a), the power-driven guillotine cutter shall be provided with an arrangement which will prevent the cutter from making a second stroke until the lever or two-handed device is again used.

§ 50-204.195 Power presses.

(a) *Safeguarding classification.* One or more means of safeguarding the press at the point of operation shall be provided and used on every power press, depending upon the method of feeding, in accordance with the following:

SAFEGUARDING CLASSIFICATION

Method of feeding press	*Safeguarding required*
Automatic feed: Automatic roll feed. Automatic push, pull or dial feed.	Fixed barrier guard or gate guard (section 50-204.185 (c), (d)
Semiautomatic feed: Chute feed (both gravity and follow feed). Slide or push feed. Sliding dies. Dial feed. Revolving dies.	Fixed barrier guard or gate guard (section 50-204.185 (c), (d)
Manual feed	Fixed barrier guard or gate guard, two-hand tripping device, or pull-out guard, electronic sweep guard (section 50-204.185 (c), (d), (e), (f), (g), (h))

(b) *General requirements for point of operations guarding.* Every point of operation guarding device shall be simple and reliable in construction, application, and adjustment. It shall be permanently attached to the press or the die. It shall not offer any accident hazard in itself.

(1) The device shall be designed and constructed so that it is impossible for the operator to place or permit his hand or fingers to remain within the danger zone created by the movement of the ram.

(2) Care shall be used in the selection of the method of guarding for each particular job. Guards shall be installed, maintained, and adjusted to produce safe operation at each setting of the press.

(3) Guards which are attached to the ram and which move downward so that the operator's hand or fingers might be caught between gate and lower die shall not be used [illegible]

(c) *Fixed barrier guard.* (1) A fixed barrier guard is an enclosure to prevent the hands or fingers of the operator from entering the area between the dies. It may be attached to the press or individual guards may be attached to the dies.

(2) There shall be no exposed shear points between the guard and any moving part.

(3) Openings in the guard or between the guard and working surface shall not be greater than those shown in the Table below:

PERMISSIBLE OPENINGS (INCHES)

Distance of opening from nip point:	*Maximum width of opening*
0½ to 1½	¼
1½ to 2½	⅜
2½ to 3½	½
3½ to 5½	⅝
5½ to 6½	¾
6½ to 7½	⅞
7½ to 8½	1⅛

(4) For the portion of the guard between the operator and the die or working area, it is required that ⅜-inch minimum vertical steel rods, vertically slotted material, or shatterproof, nonflammable, transparent material be used. Mesh, or perforated plate shall not be used between the operator and the die.

(5) Any hinged or movable section of a fixed barrier guard shall be connected to an interlocking device that will prevent tripping the press while the section is open.

(d) *Gate guards.* (1) A gate guard is a movable barrier arranged so that it completes the enclosure of the point of operation before the operating clutch can become engaged.

(2) Openings in the barrier of the gate guard shall be not greater than those specified for the openings in fixed barrier guards in section 50-204.185(c)(2). The mechanism of the guard shall be designed so that there will be no positive linkage or other close motion which may trap the hand of the operator.

(3) Gate guards shall include either fixed or movable side enclosures around the die.

(4) When the speed of the ram is so slow that an operator might beat the ram on the down stroke after the press has been tripped, the gate guard shall be designed so that the gate remains closed until the ram has completed the down stroke.

(c) *Two-hand tripping device.* (1) Two-hand tripping devices include only those which make it impossible to trip the press without the simultaneous use of both hands outside the danger zone. It shall be designed, located, and arranged so as to prevent tying, wedging, or otherwise securing one handle or button or operating it with any gesture or device and tripping the press while the other hand may be in the danger zone.

(2) On friction-clutch-operated presses, the controls shall be arranged so that if any hand is removed from a control during the down stroke of the ram, it will be instantly stopped.

(3) Where two or more persons are engaged in the operation of a single press, separate two-hand controls shall be provided for each person, except that an auxiliary foot control (air or electric) may be used in lieu of one set of two-hand controls, provided the foot control is located so that the nip point is out of the reach of the operator, but the foot controls shall in no case be less than a distance of 36 inches measured horizontally from the nip point.

(f) *Pull-out guards.* (1) Pull-out guards shall be so constructed as to be attached to the operator's hands or arms and connected to the ram, plunger, or outer slide of the press in such a way that the operator's hands and fingers will be withdrawn from the danger zone before the ram, plunger, or outer slide descends to a hazardous point.

(2) Where the open distance between the top of the work and the lower extremity of the punch is less than 2 inches the multiplying action of this guard shall be such that the hands will be withdrawn a safe distance before this open distance is ¼ closed.

(g) *Electronic safety device.* (1) An electronic safety device shall be so designed and installed that when the operator's hand or any part of the body is in the die zone, the press cannot be tripped and if the hand or any part of the body is inserted while the ram is in a downward motion, it will immediately stop the ram.

(2) These guards shall be operated from a circuit wired so that interruption of the electric current will automatically prevent the press from tripping until the current has been restored.

(3) Electronic safety devices shall not be used on positive clutch presses where the ram continues for a complete stroke after each tripping of the press.

(h) *Sweep guards.* (1) Sweep guards may be provided with either single or double sweep arms. The sweep arm, or arms, shall be connected to the ram in such a way as to forcibly sweep the hands of the operator from the die zone as the ram or plunger descends and before there is danger of injury.

(2) Sweep guards shall be so designed and operated that the operator cannot reach behind the guard in the danger zone before the ram has completed its downward stroke.

(3) The sweep or sweeps shall not offer any hazard of or in themselves by creating a shear hazard between the sweep arm and press tie rods, die straps, or other parts of the press or guard.

(i) *One-hand tripping device.* Whenever a press is set up so as to require tripping the ram or plunger by one hand, additional guarding as specified in section 50–204.195 shall be provided.

(j) *Special hand tools.* Hand tools for placing and removing material shall be such as to permit easy handling of material without the operator's placing a hand in the danger zone. Such tools shall not be accepted in lieu of other guarding as provided in this section.

§ 50–204.196 Foot presses.

Foot presses shall be guarded by one or more of the guards described in section 50–204.195 (a) to (d), inclusive.

(a) *Fixed barrier guards.* Fixed barrier guards shall conform to section 50–204.195(c).

(b) *Limitation of stroke.* If a foot or kick press is guarded by limitation of the ram stroke, the adjustment must be set and locked securely in position to limit the maximum travel of the ram to ⅜ inch on each stroke. There shall be no pinching or crushing hazards between other parts of the ram or die shoe.

(c) *Gate guards.* A gate shall be designed to close the opening at the front of the press before the foot lever can be operated.

(d) *Two-hand operation.* Two-hand operations shall conform to section 50–204.195(e).

(e) *Sweep guards.* Sweep guards shall conform to section 50–204.195(h).

(f) *Pull-out guards.* Pull-out guards shall conform to section 50–204.195(f).

(g) *Location.* Foot presses shall not be located in a position which will permit the operating lever to extend into an aisle or passageway.

(h) *Mounting.* Foot presses shall be securely bolted to the floor.

§ 50–204.197 Other power-press safety devices.

(a) *Treadle guard.* A substantial guard shall be placed over the treadle of every foot-operated power press to prevent accidental tripping.

(b) *Foot treadle.* The use of tension springs or counterweights on any treadle shaft or tension springs on any treadle-shaft lever is prohibited.

(c) *Latch on hand-operating lever.* Hand-operated power presses, shall be equipped with a spring latch on the operating lever to prevent accidental or premature tripping.

(d) *Interlocking device.* Each hand-operated power press, if tended by more than one person at one time shall conform to the requirements of section 50–204.195(e) (1) and (3).

(e) *Single-stroke attachments.* On positive-type clutch presses a single-stroke attachment shall be provided, by which the treadle or operating lever is disconnected after each stroke.

§ 50–204.198 Platen presses.

Platen presses shall be provided with an automatic feed device, an automatic stop device, a guard gate or sweep motion device, or another device, all as defined in this section.

(a) An automatic feed device is one which does not require the operator's hand to be placed between the platen and bed.

(b) An automatic stop device is one which will prevent the platen from closing if the hand or hands of the operator are caught between the platen and the bed.

(c) A guard, gate or sweep motion device, is one which will throw the operator's hands out of the way before the press closes. If the guard is of the type which lifts the hands out of the danger zone, it shall rise at least 4 inches above the platen before the press closes. The guard shall be arranged so that it will prevent a shear between the guard and the top of the platen.

(d) "Another device" is one that will prevent the platen from closing on the operator's hands before they are removed from between the platen and the bed.

§ 50–204.199 Abrasive wheels.

(a) The machine shall be securely mounted on substantial floors, benches, foundations or other adequate structures.

(b) *Guards.* Every stationary abrasive wheel and portable wheel used in stationary position shall be equipped with a hood or band guard strong enough to withstand the shock of a bursting wheel. A guard of this type shall also be used on every portable wheel where the nature of the work will permit.

(c) *Spindle.* The spindle and nut and flange projection, if any, shall be guarded.

(d) *Mountings and fastenings.* Hoods shall be mounted so as to maintain proper alignment with the wheels, and the strength of the fastenings shall exceed the strength of the hood.

(e) *Dust exhaust provisions.* Hoods on machines used for dry grinding and other operations where dust is produced shall have provisions made for connection to an exhaust system.

(f) *Work rests.* Work rests shall be kept adjusted close to the wheel with a maximum distance of ⅛ inch to prevent the work from being caught between the wheel and the rest.

§ 50–204.200 Revolving drums and cylinders.

Every revolving barrel, drum or other revolving container shall be guarded by an enclosure which is interlocked with the driving mechanism, so that the barrel or drum cannot revolve unless the guard enclosure is in place.

§ 50–204.201 Fans.

When the periphery of the blades of a fan is less than 7 feet above the floor or working level the blades shall be guarded.

WOODWORKING MACHINERY

§ 50–204.208 Circular table saws.

(a) *Guards.* Each circular saw shall be guarded by a hood which shall com-

pletely enclose that portion of the saw above the table and shall be arranged so that the hood will automatically adjust itself to the thickness of, and remain in contact with, the material being cut. Where there is a possibility of contact with a portion of a circular saw beneath or behind the saw table, that portion shall be covered with a guard to prevent accidental contact with the saw.

(b) *Spreaders.* Each circular ripsaw shall be furnished with a spreader to prevent material from squeezing the saw or being thrown back on the operator. A spreader need not be used for work which is restricted to grooving, dadoing, or rabbeting.

(c) *Non-kickback fingers or dogs.* Each circular ripsaw shall be provided with non-kickback fingers or dogs so located as to oppose the thrust or tendency of the saw to pick up the material or to throw it back toward the operator.

§ 50–204.209 Swing and sliding cut-off saws.

The requirements expressed in this section apply to all swing cut-off saws and to those sliding cut-off saws which are mounted above the table.

(a) *Hood.* Each of the saws to which this section applies shall be provided with a hood that shall completely enclose the upper half of the saw, the arbor end, and the point of operation at all positions of the saw. The hood shall be constructed in such a manner and of such material that it will protect the operator from flying splinters and broken saw teeth. It shall be designed so that it will auto natically cover the lower portion of the blade, so that when the saw is returned to the back of the table the hood will rise on top of the fence, and when the saw is moved forward the hood will drop on top of and remain in contact with the table or material being cut.

(b) *Counterweights.* Each of the saws to which this section applies shall be provided with an effective device to return the saw automatically to the back of the table when released at any point in its travel.

(c) *Limit stops.* Limit chains or other equally effective devices shall be provided to prevent the saw from swinging beyond the front or back edges of the table.

(d) *Latches.* A latch or equivalent device shall be provided to prevent the saw from rebounding upon its return to the rear of the table.

§ 50–204.210 Inverted swing cut-off saws (jump saws).

Inverted swing-cut-off saws shall be provided with a hood that will cover the part of the saw that protrudes above the top of the table or above the material being cut. It shall automatically adjust itself to the thickness of, and remain in contact with, the material being cut.

§ 50–204.211 Radial saws.

(a) *Hoods and guards.* The upper hood shall completely enclose the upper portion of the blade down to a point that will include the end of the saw arbor. The upper hood shall be constructed in such a manner and of such material that it will protect the operator from flying splinters, broken saw teeth, etc., and will deflect sawdust away from the operator. The sides of the lower exposed portion of the blade shall be guarded to the full diameter of the blade by a device that will automatically adjust itself to the thickness of the stock and remain in contact with stock being cut to give maximum protection possible for the operation being performed.

(b) *Spreaders.* When radial saws are used for ripping, a spreader shall be provided meeting the requirements expressed in section 50–204.208(b).

(c) *Non-kickback fingers or dogs.* Each radial saw used for ripping shall be provided with non-kickback fingers or dogs located on both sides of the saw so as to oppose the thrust or tendency of the saw to pick up the material or to throw it back toward the operator.

(d) *Adjustable stops and return devices.* An adjustable stop shall be provided to prevent the forward travel of the blade beyond the position necessary to complete the cut in repetitive operations.

§ 50–204.212 Portable circular saws.

All portable power-driven saws shall be equipped with guards above and below the base plate or shoe. The upper guard shall cover the saw to the depth of the teeth, except for the arc required to permit the base to be tilted. The lower guard shall cover the saw to the depth of the teeth, except for the minimum arc required to allow proper retraction and contact with the work. When the tool is withdrawn from the work, the lower guard shall automatically and instantly return to covering position.

§ 50–204.213 Band saws and band resaws.

(a) *Enclosing band-saw blades.* All portions of the saw blade shall be enclosed or guarded, except for the working portion of the blade between the bottom of the guide rolls and the table. Band-saw wheels shall be fully encased. The outside periphery of the enclosure shall be solid. The front and back of the band wheels shall be either enclosed by solid material or by wire mesh or perforated metal. Such mesh or perforated metal shall be not less than 0.037 inch (U.S. Gauge No. 20), and the openings shall be not greater than ⅝ inch. Solid material used for this purpose shall be of an equivalent strength and firmness. The guard for the portion of the blade between the sliding guide and the upper-saw-wheel guard shall protect the operator from the saw blade at the front and outer side. Brakes shall be provided to stop the wheel in case of blade breakage.

(b) *Tension.* Each band-saw machine shall be provided with a tension control device to indicate a proper tension for the standard saws used on the machine.

(c) *Feed rolls.* Feed rolls of band resaws shall be protected with a guard to prevent the hands of the operator from coming in contact with the in-running rolls at any point.

§ 50–204.214 Jointers.

(a) *Point of operation.* (1) Each hand-fed planer and jointer with horizontal head shall be equipped with a cylindrical cutting head, the knife projection of which shall not exceed ⅛ inch beyond the cylindrical body of the head.

(2) The clearance between the edge of the rear table and the cutter head shall be not more than ⅛ inch. The table throat opening shall be not more than 2½ inches when tables are set or aligned with each other for zero cut.

(b) *Automatic guards.* (1) Each hand-fed jointer with a horizontal cutting head shall have an automatic guard which will cover all the section of the head on the working side of the fence or gage. The guard shall keep the operator's hand from coming in contact with the revolving knives. The guard shall automatically adjust itself to cover the unused portion of the head and remain in contact with the material at all times.

(2) Each hand-fed jointer with horizontal cutting head shall have a guard which will cover the section of the head back of the gage or fence.

(3) Each wood jointer with vertical head shall have either an exhaust hood or other guard so arranged as to enclose completely the revolving head, except for a slot of such width as may be necessary and convenient for the application of material to be jointed.

§ 50–204.215 Wood shapers, hand-fed panel raisers, and similar machines.

(a) The cutting heads of each wood shaper, hand-fed panel raiser, or other similar machine not automatically fed, shall be enclosed with a cage or adjustable guard designed to keep the operator's hands away from the cutting edge. The diameter of circular shaper guards shall be not less than the greatest diameter of the cutter. In no case shall a warning device of leather or other material attached to the spindle be acceptable.

(b) Cylindrical heads shall be used whenever the nature of the work will permit.

(c) All double-spindle shapers shall be provided with a starting and stopping device for each spindle.

§ 50–204.216 Planing, molding, sticking and matching machines.

(a) Each planing, molding, sticking, and matching machine shall have all cutting heads, and saws if used, covered by a metal guard. If such guard is constructed of sheet metal, the material used shall be not less than 1/16 inch in thickness; and, if cast iron is used, it shall be not less than 3/16 inch in thickness.

(b) Where an exhaust system is used, the guards shall form part or all of the exhaust hood and shall be constructed of metal of a thickness not less than that specified in paragraph (a) of this section.

(c) Feed rolls shall be guarded by a hood or suitable guard to prevent the hands of the operator from coming in contact with the in-running rolls at any point. The guard shall be fastened to the frame carrying the rolls so as to remain in adjustment for any thickness of stock.

(d) Surfacers or planers used in processing multiple pieces of material simultaneously shall be provided with sec-

tional infeed rolls having sufficient yield in the construction of the sections to provide feeding contact pressure on the stock, over the permissible range of variation in stock thickness specified or for which the machine is designed. In lieu of such yielding sectional rolls, suitable section kickback finger devices shall be provided at the infeed end.

§ 50–204.217 Sanding machines.

(a) *Feed rolls.* Feed rolls of self-feed sanding machines shall be protected with a semi-cylindrical guard to prevent the hands of the operator from coming in contact with the in-running rolls at any point. The guard shall be constructed of heavy material firmly secured to the frame carrying the rolls so as to remain in adjustment for any thickness of stock. The bottom of the guard shall come down to within ½ inch of a plane formed by the bottom or contact face of the feed roll, where it touches the stock.

(b) *Drum sanding machines.* Each drum sanding machine shall have an exhaust hood, or other guard, arranged to enclose the revolving drum, except for that portion of the drum above the table, if a table is used.

(c) *Disk sanding machines.* Each disk sanding machine shall have the exhaust hood, or other guard if no exhaust system is required, arranged to enclose the revolving disk, except for that portion of the disk above the table, if a table is used.

(d) *Belt sanding machines.* Belt sanding machines shall be provided with guards at each nip point where the sanding belt runs on to a pulley. The unused run of the sanding belt shall be guarded against accidental contact.

HOUSEKEEPING

§ 50–204.229 General.

All phases of employment, passageways, storerooms, and service rooms shall be kept clean and orderly and in a sanitary condition.

§ 50–204.230 Floors.

(a) Floors of every workroom shall be maintained in a clean, and, so far as possible, a dry condition. Where wet processes are used, drainage shall be maintained, and false floors, platforms, mats, or other dry standing places should be provided where practicable.

(b) Cleaning and sweeping shall be done in such a manner as to minimize the contamination of the air with dust and, so far as is practicable, should be done outside of working hours.

(c) Every floor, working place, and passageway shall be kept free from protruding nails, splinters, holes, or loose boards.

§ 50–204.231 Flammable materials.

Oily rags, oily waste, waste paper and other flammable and combustible material shall be stored in tightly closed metal containers. Magnesium and other flammable metal scraps shall not be mixed with other scrap. All flammable scrap material of any kind shall be removed from the work areas daily.

§ 50–204.232 Tools and other materials.

Tools, materials, or debris shall not be strewn about in a manner which may cause tripping or other hazards.

§ 50–204.233 Receptacles for waste disposal.

Any receptacle used for decaying solid or liquid waste or refuse shall be so constructed that it does not leak and may be conveniently and thoroughly cleaned, and it shall be maintained in a sanitary condition. Such a receptacle shall be equipped with a tight-fitting cover.

§ 50–204.234 Sweeping and refuse removal.

All sweepings, solid or liquid waste, refuse, and garbage shall be removed in such a manner as to avoid creating a nuisance or menace to health and as often as necessary to maintain the place of employment in a sanitary condition.

TOILET FACILITIES AND WASH ROOMS

§ 50–204.239 Separate toilet for each sex.

Every place of employment shall be provided with adequate toilet facilities which are separate for each sex.

§ 50–204.240 Location.

Toilet facilities shall be provided so as to be readily accessible to all employees. Toilet facilities so located that employees must use more than one floor-to-floor flight of stairs are not considered as readily accessible.

§ 50–204.241 Water closets.

Water closets, or chemical closets or privies where permitted by local law, shall be provided for each sex and shall be in accordance with the following table. The number to be provided for each sex shall in every case be based on the maximum number of persons of that sex employed at any one time at work on the premises for which the facilities are furnished. When persons other than employees are permitted the use of toilet facilities on the premises, a reasonable allowance shall be made for such other persons in computing the minimum number of toilet facilities required.

(a)

Number of persons	Minimum number of facilities
1 to 9	1
10 to 24	2
25 to 49	3
50 to 74	4
75 to 100	5
Over 100	(1)

(1) 1 for each additional 30 persons.

Where 10 or more are employed, one water closet less than the number specified in the foregoing may be provided for men for each urinal, except that the number of water closets in such cases may not be reduced to less than two-thirds of the number specified in the foregoing. Two feet of trough urinal shall be considered as equivalent to one individual urinal.

(b) An adequate supply of toilet paper with holder shall be provided for every water closet.

(c) Covered receptacles shall be kept in all toilet rooms used by women.

§ 50–204.242 Construction of toilet rooms.

(a) Each toilet facility (closet) shall occupy a separate compartment, equipped with a door, latch, and clothes hook.

(b) The walls of compartments or partitions between fixtures may be less than the height of room walls, but the top shall not be less than six feet from the floor and the bottom not more than one foot from the floor.

(c) The door to every toilet room shall be fitted with an effective self-closing device, and the entrance to the toilet rooms shall be so screened that the interior of the toilet room is not visible from the workroom.

(d) The floors, walls, ceilings, partitions, and doors of all toilet rooms shall be of a finish that can be easily cleaned.

(e) Toilet rooms, except those in work places accessible to men only, shall be completely enclosed with solid material that is nontransparent from the outside.

§ 50–204.243 Chemical closets and privies.

When chemical closets or privies are permitted by local law they shall be of a type approved by the health authorities having jurisdiction and shall be maintained in a sanitary condition.

§ 50–204.244 Washing facilities.

Adequate facilities for maintaining personal cleanliness shall be provided in every place of employment. These shall be convenient for the employees for whom they are provided and shall be maintained in a sanitary condition.

(a) At least one lavatory (wash basin) with adequate hot and cold water, shall be provided for every 20 employees (men or women) or portion thereof, up to 100 persons, and one lavatory (wash basin) for each additional 25 persons or portion thereof. Twenty-four inches of sink with individual faucet shall be considered as equal to one lavatory. In all instances, a suitable cleansing agent shall be provided at each wash place.

(b) Where employees are exposed to skin contamination by poisonous, infectious, or irritating material, one lavatory supplied with hot and cold water, shall be provided for every 5 employees.

(c) One shower bath with ample supply of hot and cold water from one fixture shall be supplied for every 15 workers, or portion thereof, exposed to excessive heat or to skin contamination by poisonous, infectious, or irritating material.

(d) Individual hand towels, or sections thereof, of cloth or paper, or mechanical apparatus for drying the hands, shall be provided. Proper receptacles or other sanitary means shall be maintained for the disposal of used towels. Towels for common use shall not be provided.

(e) Adequate washing facilities shall be provided in every toilet room or adjacent thereto.

§ 50–204.245 Change rooms.

Separate change or dressing rooms shall be provided for each sex wherever it is the practice to change from street clothes or wherever it is necessary to change because the work performed involves exposure to excessive dirt, heat, fumes, vapor, or moisture. Where change rooms are not provided, facilities shall be furnished for hanging outer garments:

(a) Where employees' work clothes are exposed to contamination by poisonous, infectious, or irritating material, facilities shall be provided in change rooms so that street and work clothes will not be stored in contact with each other.

(b) Where the process in which the worker is engaged is such that his working clothes become wet or have to be washed between shifts, provision shall be made to insure that such clothing is dry before re-use.

§ 50–204.246 Retiring rooms for women.

Where 10 or more women are employed at any one time, at least one retiring room shall be provided.

(a) Where less than 10 women are employed and a retiring room is not furnished, some equivalent space shall be provided which can be properly screened for privacy and made suitable for the use of women employees.

(b) At least one couch or bed shall be provided in every place where women are employed. The number of such beds or couches required shall be as follows:

	Beds
1 to 100	1
100 to 250	2

1 additional bed for each additional 250 women employees. A minimum of 60 square feet per bed shall be provided.

LUNCH ROOMS AND FOOD HANDLING

§ 50–204.251 Location.

In all places of employment where employees lunch on the premises, an adequate space suitable for that purpose shall be provided for the maximum number of employees who may use such space at one time. Such space shall be separate from any location where there is exposure to toxic materials.

§ 50–204.252 Waste food disposal.

A covered receptacle shall be provided and shall be used by employees for the disposal of all waste food.

§ 50–204.253 Presence of toxic materials.

No employee shall be permitted to store or eat any part of his lunch or other food at any time where there are present any toxic material or other substance that may be injurious to health.

DRINKING WATER

§ 50–204.258 Potable water.

(a) An adequate supply of potable water, approved as to source and distribution by appropriate authority, shall be provided for drinking, washing and cooking purposes in all places of employment.

(b) In all instances where water is cooled by ice made from non-potable water the construction of the container shall be such that the ice does not come in direct contact with the water.

(c) Open containers such as barrels, pails, or tanks for drinking water from which the water must be dipped or poured, whether or not they are fitted with a cover, shall not be allowed.

(d) The common drinking cup is prohibited.

(e) Where single service cups are supplied, a sanitary container for the unused cups and a receptacle for disposing of the used cups shall be provided.

§ 50–204.259 Non-potable water.

Outlets for non-potable water, such as water for industrial or fire-fighting purposes only, shall be posted to indicate that the water is unsafe and is not to be used for drinking, washing, or cooking purposes.

MEDICAL SERVICES

§ 50–204.264 Medical services.

(a) The employer shall assure the ready availability of qualified medical personnel for advice and consultation on plant health problems, for emergency medical services, and for the supervision of first-aid attendants.

(b) In the absence of an infirmary, a person trained to render first aid and a kit containing the following items shall be available at every place of employment.

1 Adhesive Plaster ½" x 5 yd. Roll.
1 Adhesive Plaster, 1 x 5 yd. Roll.
2 Absorbent Cotton, 2-ounce packages.
1 Absorbent Gauze, 1 yd.
1 Activol Soap, 2-ounce bottle.
100 Adhesive Bandages, 1".
1 Aromatic Spirits of Ammonia, 2-ounce bottle.
1 Boric Acid Solution, 2-ounce bottle.
1 Castor Oil, 2-ounce bottle.
12 Compress Bandages, 2".
4 Compress Bandages, 4".
12 Cotton Wound Applicators.
1 Eye Cup.
1 Eye Dropper.
6 Finger Cots.
6 Pottle for Burns, ⅛ oz. tubes.
1 Pottle for Burns, 2-ounce bottle.
6 Gauze Roller Bandages 1" x 6 yds.
6 Gauze Roller Bandages 2" x 6 yds.
6 Gauze Roller Bandages 3" x 6 yds.
10 Gauze Sterilized, 12" x 12".
1 Merthiolate, Tincture, 2-ounce bottle.
1 Medicine Glass.
1 Manual First Aid Instruction.
1 Scissors Pair 4" Bandage.
1 Tweezers Pair 3½".
12 Safety Pins.
1 Spoon.
1 Tourniquet.
2 Triangular Bandages 40".
6 Wood Splints for Fractures.
12 Wood Tongue Depressors.

EYE PROTECTION

§ 50–204.269 General requirement.

Eye protection shall be provided where persons are exposed to any hazard which may cause injury to the eyes from the following operations: chipping, caulking, coarse grinding, riveting, sledging, scaling, light grinding, stone dressing, spot welding, woodworking, metal-working, babbitting, casting, dipping in hot metal baths, handling of acids and caustics, electric arc welding, oxyacetylene and oxyhydrogen welding and cutting, furnace tending, and irradiation with ultraviolet light.

§ 50–204.270 First-aid for chemical burns.

Where workers' eyes may be exposed to injurious chemical materials such as acids, caustics, etc., suitable facilities for quick drenching or flushing of the eyes shall be provided within the workroom, for immediate emergency use.

ENVIRONMENTAL CONDITIONS

§ 50–204.275 Toxic gases, vapors, fumes, dusts, and mists.

No employee shall be exposed to any of the gases, vapors, mists, dusts, or fumes on the list in section 50–204.276 which exceed the limits there stated when applied to him on an average basis for an eight hour workday, unless he is protected therefrom by respiration equipment approved for the purpose by the United States Bureau of Mines of the United States Department of the Interior and operated in accordance with the recommendations of its manufacturer. Exposures without such equipment which exceed such limits temporarily, without exceeding them on a daily average basis, or which involve more than one such toxic substance, regardless of the degree of its concentration, are also hazardous unless they are undertaken in strict conformity with prior written approval of a qualified industrial hygienist who has studied the particular circumstances of exposure and the toxic substances and concentrations involved.

§ 50–204.276 Threshold limit values.

Gases and vapors—Substance	Parts per million parts of air by volume	Milligrams per cubic meter of air
Acetaldehyde	200	360
Acetic acid	10	25
Acetic anhydride	5	20
Acetone	1,000	2,400
Acrolein	.5	1.2
Acrylonitrile	20	44
Allyl alcohol	4	12
Allyl chloride	1	3
Allyl propyl disulfide	2	12
Ammonia	100	70
Amyl acetate	200	1,050
Amyl alcohol (isoamyl alcohol)	100	360
Aniline	5	19
Arsine	.05	.2
Benzene (benzol)	25	80
Benzyl chloride	1	5
Bromine	1	7
Butadiene (1,3-butadiene)	1,000	2,200
Butanone (methyl ethyl ketone)	200	700
Butyl acetate (n-butyl acetate)	200	950
Butyl alcohol	100	300
Butylamine	5	15
Butyl cellosolve (2-butoxyethanol)	50	240
Carbon dioxide	5,000	9,000
Carbon disulfide	20	60
Carbon monoxide	100	110
Carbon tetrachloride	25	160
Cellosolve (2-ethoxyethanol)	200	740
Cellosolve acetate (2-ethoxyethyl acetate)	100	540
Chlorine	1	3
Chloroform (trichloromethane)	.1	.4
Chloroprene (monochlorobutadiene)	25	100
Cresol (all isomers)	5	22
Cyclohexane	400	1,400
Cyclohexanol	100	410

Gases and vapors—Substance	Parts per million parts of air by volume	Milligrams per cubic meter of air
Cyclohexanone	100	400
Cyclohexene	400	1,200
Cyclopropane	400	690
Decaborane	.05	.3
Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50	240
Diborane	.1	.1
o-Dichlorobenzene	50	300
Dichlorodifluoromethane	1,000	4,950
1,1-Dichloroethane	100	400
1,2-Dichloroethane (ethylene dichloride)	100	400
1,2-Dichloroethylene	200	790
Dichloroethyl ether	15	90
Dichloromonofluoromethane	1,000	4,200
1,1-Dichloro-1-nitroethane	10	60
Dichlorotetrafluoroethane	1,000	7,000
Diethylamine	25	75
Difluorodibromomethane	100	860
Diisobutyl ketone	50	290
Dimethylaniline (N-dimethyl-aniline)	5	25
Dimethylaniline	1	5
Dioxane (diethylene dioxide)	100	360
Ethyl acetate	400	1,400
Ethyl acrylate	25	100
Ethyl alcohol (ethanol)	1,000	1,900
Ethylamine	25	45
Ethylbenzene	200	870
Ethyl bromide	200	890
Ethyl chloride	1,000	2,600
Ethyl ether	400	1,200
Ethyl formate	100	300
Ethylidene chloride	100	400
Ethylene chlorohydrin	5	16
Ethylenediamine	10	25
Ethylene dibromide (1,2-dibromoethane)	25	190
Ethylene imine	5	9
Ethylene oxide	50	90
Fluorine	.1	.2
Fluoro trichloromethane	1,000	5,600
Formaldehyde	5	6
Furfural	5	20
Gasoline	500	2,000
Heptane (n-heptane)	500	2,000
Hexane (n-hexane)	500	1,800
Hexanone (methyl butyl ketone)	100	410
Hexane (methyl isobutyl ketone)	100	410
Hydrazine	1	1.3
Hydrogen bromide	5	17
Hydrogen chloride	5	7
Hydrogen cyanide	10	11
Hydrogen fluoride	3	2
Hydrogen peroxide, 90%	1	1.4
Hydrogen selenide	.05	.2
Hydrogen sulfide	20	30
Iodine	.1	1
Isophorone	25	140
Isopropylbenzene	50	250
Mesityl oxide	50	200
Methyl acetate	200	610
Methyl acetylene	1,000	1,650
Methyl acrylate	10	35
Methyl alcohol (methanol)	200	260
Methyl bromide	20	80
Methyl cellosolve (2-methoxyethanol)	25	80
Methyl cellosolve acetate (ethylene glycol monomethyl ether acetate)	25	120
Methyl chloride	100	210
Methylal (dimethoxymethane)	1,000	3,100
Methyl chloroform (1,1,1-trichloroethane)	350	2,700
Methylcyclohexane	500	2,000
Methylcyclohexanol	100	470
Methylcyclohexanone	100	460
Methyl formate	100	250
Methyl isobutyl carbinol (Methyl amyl alcohol)	25	100
Methyl styrene	100	480
Methylene chloride (dichloromethane)	500	1,730
Monomethyl aniline	2	9
Naphtha (coal tar)	200	800
Naphtha (petroleum)	500	2,000
Nickel carbonyl	.001	.007
Nitric acid	1	2
p-Nitroaniline	1	6
Nitrobenzene	1	4
Nitroethane	100	310
Nitrogen dioxide	5	9
Nitroglycerin	.5	2
Nitromethane	100	250
2-Nitropropane	50	180
Nitrotoluene	5	30
Octane	500	2,350
Ozone	.1	.2
Pentachlorethane	25	470
Pentane	1,000	2,950
Pentanone (methyl propyl ketone)	200	700
Perchloroethylene (tetrachloroethylene)	200	1,320
Phenol	5	19
Phenylhydrazine	5	22
Phosgene (carbonyl chloride)	1	4
Phosphine	.05	.07
Phosphorus trichloride	.5	3
Propyl acetate	200	840
Propyl alcohol (isopropyl alcohol)	400	980
Propyl ether (isopropyl ether)	500	2,100
Propylene dichloride (1,2-dichloropropane)	75	350
Propylene imine	25	60
Propylene oxide	100	240
Pyridine	10	30
Quinone	.1	.4
Silane	.1	.3
Stoddard solvent	200	2,900
Styrene monomer (phenylethylene)	100	420
Sulfur dioxide	5	13
Sulfur hexafluoride	1,000	6,000
Sulfur monochloride	1	6
Sulfur pentafluoride	.025	.25
Tertiary butyl alcohol	100	300
p-Tertiary butyltoluene	10	60
1,1,2,2-Tetrachloroethane	5	35
Tetrahydrofuran	200	590
Tetramethyl lead	1	5
Toluene (toluol)	200	750
o-Toluidine	5	22
Trichloroethylene	200	1,080
Triethylamine	25	100
Trifluorotrichloroethane	1,000	6,200
Turpentine	100	500
Vinyl chloride (chloroethylene)	500	1,300
Vinyl toluene	100	490
Xylene (xylol)	100	430
Xylidine	5	25

TOXIC DUSTS, FUMES, AND MISTS

Substance	Milligrams per cubic meter of air
Aldrin (1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-dimethanonaphthalene)	0.25
Ammate (ammonium sulfamate)	15
Antimony	.5
ANTU (alpha naphthyl thiourea)	.3
Arsenic	.5
Barium	.5
Beryllium	2μg/m³
Cadmium oxide fume	.1
Calcium arsenate	.1
Chlordane (1,2,4,5,6,7,8,8-octachloro-2a,4,7,7a-tetrahydro-4,7-methanoindane)	2
Chlorinated camphene, 60%	.5
Chlorinated diphenyl oxide	.5
Chlorodiphenyl (42% chlorine)	1
Chlorodiphenyl (54% chlorine)	.5
Chromic acid and chromates (as CrO_3)	.1
Crag herbicide (sodium 2-[sodium 2-[2,4-dichlorophenoxy] ethanol hydrogen sulfate)	15
Cyanide (as CN)	5
2,4-D(2,4-dichlorophenoxyacetic acid)	10
DDT (2,2-bis [p-chlorophenyl]-1,1,1-trichloroethane)	1
Dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-dimethanonaphthalene)	.25
Dinitrobenzene	1
Dinitrotoluene	1.5
Dinitro-o-cresol	.2
EPN (O-ethyl O-p-nitrophenyl thionobenzenephosphonate)	.5
Ferbam (ferric dimethyl dithiocarbamate)	15
Ferrovanadium dust	1
Fluoride	2.5
Hydroquinone	2
Iron oxide fume	15
Lead	.2
Lead arsenate	.15
Lindane (hexachlorocyclohexane, gamma isomer)	.5
Magnesium oxide fume	15
Malathion (O,)-dimethyl dithiophosphate of diethyl mercaptosuccinate)	15
Manganese	5
Mercury	.1
Mercury (organic compounds)	.01
Methoxychlor (2,2-di-p-methoxyphenyl-1,1,1-trichloroethane)	15
Molybdenum:	
soluble compounds	5
insoluble compounds	15
Nicotine	.5
Parathion (O,O-diethyl O-p-nitrophenyl thiophosphate)	.1
Pentachloronaphthalene	.5
Pentachlorophenol	.5
Phosphorus (yellow)	.1
Phosphorus pentachloride	1
Phosphorus pentasulfide	1
Picric acid	.1
Pyrethrum	2
Rotenone	5
Selenium compounds (as Se)	.1
Sodium hydroxide	2
Sodium fluoroacetate (1080)	.1
Strychnine	.15
Sulfuric acid	1
TEDP (tetraethyl dithionopyrophosphate)	.2
TEPP (tetraethyl pyrophosphate)	.05
Tellurium	.1
Tetryl (2,4,6-trinitrophenylmethylnitramine)	1.5
Thiram (tetramethyl thiuram disulfide)	5
Thallium (soluble compounds)	.1
Titanium dioxide	15
Trichloronaphthalene	5
Trinitrotoluene	1.5
Uranium:	
soluble compounds	.05
insoluble compounds	.25
Vanadium:	
V_2O_5 dust	.5
V_2O_5 fume	.1
Warfarin [3-[acetonylbenzyl]-4-hydroxycoumarin]	.5
Zinc oxide fume	15
Zirconium compounds (as Zr)	5

MINERAL DUSTS

Substance	Millions of particles per cubic meter of air
Aluminum oxide	50
Asbestos	5
Dust (nuisance, no free silica)	50
Mica (below 5% free silica)	20
Portland cement	50
Silica:	
High (above 50% free SiO_2)	5
Medium (5 to 50% free SiO_2)	20
Low (below 5% free SiO_2)	50
Silicon carbide	50
Soapstone (below 5% free SiO_2)	20
Talc	20

VENTILATION

§ 50-204.288 General ventilation and temperature requirements.

(a) Outside air shall be provided to all workrooms at the rate of 15 cubic feet per minute per person, or one and one-half air changes per hour, whichever is greater. In most instances, leakage through walls, doors, and windows will produce at least one and one-half air changes per hour.

(b) A minimum air temperature of 60° F. should be maintained at all workrooms where work of a strenuous nature is performed, and a minimum air tem-

perature of 65° F. should be maintained in all other workrooms unless prohibited by process requirements.

§ 50–204.289 Local exhaust ventilation.

(a) Every local exhaust ventilation system shall produce and maintain a movement of air toward the opening, sufficient to prevent escape of contaminant to the workroom during working hours, beyond the limits shown in section 50–204.276.

(b) Air flow through branch and main ducts shall be sufficient to transport the contaminant through the system without settling.

(c) Piping shall be located so as to be accessible for inspection and maintenance.

(d) Air flow equipment including hoods, pipes, fans, motors, and collectors shall be effectively grounded.

(e) Two or more operations involving more than one substance shall not be permitted to be connected to the same exhaust system when a combination of the substances removed may constitute a fire hazard, an explosion hazard, or otherwise dangerous mixture.

(f) Those processes or operations using or generating flammable dusts, gases, fumes, vapors, mists, fibers or other impurities shall be completely protected from all sources of ignition.

(g) The capacity of an exhaust system shall be calculated on the basis of all hoods, booths, and enclosures connected to the system being open, except where the system is so interlocked that only a portion of it can be operated at a given time, in which case the capacity should be calculated on the basis that all the hoods in the group requiring the greatest volume rate of exhaust are open.

(h) Suitable air inlets shall be provided for replacement of exhausted air.

(i) Exhaust systems handling dusts and discharging to the outer air shall be provided with suitable air-cleaning devices to remove air contaminants prior to the discharge to the outer air, except under unusual circumstances.

(j) The discharge from any exhaust system shall be such that no air contamination therefrom will enter any window, door, or other opening of any work space in quantities sufficient to create a health hazard to such space or create a nuisance to surrounding areas.

(k) Collected materials shall be removed at intervals frequent enough to insure that the exhaust system will meet the requirements of section 50–204.282 (a), at all times.

NOISE

§ 50–204.293 Noise.

Noise shall be reasonably reduced or eliminated as a means of preventing fatigue or accidents.

PERSONAL PROTECTIVE EQUIPMENT

§ 50–204.296 Personal protective equipment.

Personal protective equipment or protective shields or barriers shall be provided and maintained in usable condition whenever substances, radiation, or mechanical irritants are encountered in a manner capable of causing injury or impairment in function of any part of the body through skin or mucous membrane absorption.

BITUMINOUS COAL AND LIGNITE MINES

§ 50–204.300 Federal Mine Safety Code.

The Federal Mine Safety Code for Bituminous Coal and Lignite Mines of the United States, Part I—Underground Mines, and Part II—Strip Mines, as published by the Bureau of Mines, United States Department of Interior is hereby adopted by reference as the safety and health standard required for observance in the bituminous coal and lignite mining to which section 1(a) of the Walsh-Healey Public Contracts Act has application.

Signed at Washington, D.C., this 12th day of December 1960.

JAMES P. MITCHELL,
Secretary of Labor.

[F.R. Doc. 60-11680; Filed, Dec. 27, 1960; 8:48 a.m.]

Manual L-1 Seventh Edition — 1970

Guide to Precautionary Labeling of Hazardous Chemicals

MCA

Manufacturing Chemists Association
1825 Connecticut Avenue, N.W.
Washington, D. C. 20009

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GUIDE
TO
PRECAUTIONARY LABELING
OF
HAZARDOUS CHEMICALS

MCA

MANUAL L-1

Seventh Edition—1970

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PREFACE TO SEVENTH EDITION

It is the policy of the MCA Labels and Precautionary Information Committee to review and make necessary revisions to Manual L-1 to reflect the best current thinking in the field of precautionary labeling. It is only in this way that the manual can be made to serve effectively the needs of those who use it. A review and general description of revisions to the Sixth Edition follows.

Major changes are addition of fire-extinguishing statements for ignitable products, addition of instructions for cleaning up spills or leaks, replacement of many specific chemical label texts with label texts based upon specific hazards or combinations of hazards, the omission of Part III, Illustrative Labels for Pesticides, and revision of Table I.

In this edition Table I provides a more specific guide to the selection of label language. The revised table lists the most common hazardous properties of chemicals and suggests the Signal Word, Statements of Hazard, Precautionary Measures, and Instructions in Case of Contact or Exposure. The new form of Table I promotes the uniformity in label language expressed in the General Principles.

The illustrations of precautionary texts are expressed not in terms of specific *chemicals*, but in terms of specific *hazards* or combinations of hazards. This approach emphasizes the fact that a precautionary label should be based upon hazards that the product is known to possess as expressed in the General Principles.

Part III, Illustrative Labels for Pesticides, has been omitted because the requirements for precautionary labeling of pesticides are clearly defined by Interpretation 18 of the regulations for the enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act, and the Pesticides Regulation Division of the U.S. Department of Agriculture requires rigid adherence to these texts.

Instructions are presented that may be used in the precautionary texts as steps to be taken in case of fire, spill, or leak.

Additional changes include the following:

1. Definitions for the following terms have been added: antidote, first aid, flammable solid, flammable gas, median lethal dose or concentration, pressure-generating substance, and pyroforic substance. The term "oxidizing material" has been changed to "strong oxidizer," and the term "sensitizer" has been changed to "strong sensitizer."

2. The definition of a "poison" has been modified slightly to incorporate the concept of the median lethal dose or median lethal concentration (LD_{50} or LC_{50}). The term "highly toxic substance" has been introduced as the equivalent of the term "poison," and the definition is indexed under the former term.

3. The definition of a "toxic substance" has been replaced by one based on ranges of LD_{50}'s and LC_{50}'s. In this respect the definition is expressed in terms similar to those used for a "highly toxic substance."

4. First-aid statements are provided in Table I as an integral part of the label text for those chemicals that are highly toxic, toxic, corrosive, or which are irritants or strong sensitizers to skin.

5. Lists of label statements not appearing in Table I are provided for certain hazards that are less common than those which are dealt with in Table I.

6. Examples of antidote statements are given.

7. Examples of "notes to physicians" are given.

A REVIEW OF PRECAUTIONARY LABELING ACTIVITY

Accidental experience and willful experiment led man early to recognize the hazards which typify some substances. In 1150, Scotland enacted one of the first statutes governing product hazard. The Court Apothecary then ruled "that all persons are forbidden under the pain of treason to bring home poisons for any use by which Christian man or woman can take harm." From such beginnings came today's laws and regulations covering the identification of hazardous substances.

One of the earliest United States statutes in the chemical field was the Federal Caustic Poison Act (1927). It covered eleven caustic or corrosive substances in certain concentrations, in containers "suitable for household use." Administration was by the Food and Drug Administration. In its simplest terms, packages of the specified materials were required by law to carry labels containing the word "POISON" in particular type size along with an "antidote" statement. The Federal Hazardous Substances Act as amended (1966) repealed the Federal Caustic Poison Act except with respect to these substances as they might be used in food, drug, or cosmetic applications.

The year 1932 saw the introduction into Congress of a Volatile Poisons Bill. A first draft contained a general definition of hazardous materials. A subsequent one followed the earlier plan of listing specific chemicals. The second draft authorized the Surgeon General to enlarge the list after investigation. While these bills did not become law, they marked a sharp acceleration in the evolution of precautionary labeling with its recognition by statutory requirement in the United States. With this came renewed awareness of responsibility by producers and by industry groups such as the Manufacturing Chemists Association (MCA).

From such group activity came the Chemical Products Agreement Committee appointed by the Surgeon General. The work of this group evolved the voluntary "Surgeon General's Agreements" entered into by the U.S. chemical industry in 1934-35. The texts of the precautionary labels to be used on specific products were agreed upon and made a part of executed agreements. These continued in effect and were honored by industry until 1952. The Surgeon General then agreed to their replacement by broader and more widely applicable practices formulated through the continued work of MCA and its Labels and Precautionary Information (LAPI) Committee.

MCA had early recognized the place of precautionary labeling in relations both with its customers and with state and federal governments. There were numerous strong reasons for taking the initiative in this phase of chemical marketing. The industry had an outstanding safety record in its manufacturing units. MCA members believed this safety record could be projected to the plants and homes of their customers to their mutual benefit. There was always the shadow of litigation that faces any producer as the result of real or alleged injury by a product. Chemical manufacturers had already seen the possible alternative of federal and state legislation which might or might not be wisely framed. MCA chose the path of self-regulation. In 1944 it convened a conference on a chemical precautionary labeling code. Attended by over 90 member representatives, it resulted in the formation of the Labels and Precautionary Information Committee of the Association. This committee continues as the group longest active in this endeavor. One of its earliest concerns was the compilation of a manual on precautionary labeling practices for chemicals. First issued in March 1945 and revised on six subsequent occasions, Manual L-1 of the MCA LAPI Committee has become a widely recognized text on this subject.

INTRODUCTION TO PRECAUTIONARY LABELING OF HAZARDOUS CHEMICALS

Many products present no hazard in normal handling and storage. For these products, no precautionary statements are necessary on the label. The development of new chemical products, and the introduction of chemical processes into ever-widening fields, have accentuated the need for furnishing appropriate information in those cases where there are hazards requiring special precautions. Precautionary information should, as far as is practicable, reach every person using, handling, or storing hazardous substances.

The most practical means of disseminating this information has been found to be by precautionary labels, affixed to containers of hazardous substances, bearing appropriate precautionary statements expressed as simply and briefly as possible. Such label information, however, cannot take the place of the education of personnel regarding product hazards and the use of safety clothing and equipment. This education is, and must remain, the direct responsibility of their employers. The wording on precautionary labels cannot be expected to cover the complete information as to the properties of a material nor the complete details of its proper handling under all conditions. Such information may be found in the producers' technical bulletins, in the Manufacturing Chemists Association's Chemical Safety Data Sheets, or in other literature.

To achieve uniform and adequate labeling of hazardous substances, the Labels and Precautionary Information (LAPI) Committee of the Manufacturing Chemists Association offers Manual L-1 as a guide in preparing precautionary label texts.

The labeling of radioactive materials and explosives is a complex problem outside the scope of this Guide.

This Guide will be found extremely useful in the preparation of a precautionary text for any hazardous chemical even though the General Principles were designed originally for hazardous chemicals intended for industrial use. The precautionary texts developed with the aid of this Guide should be used in addition to, or in combination with, any specific wording required by law. Since individual statutes, regulations, or ordinances may require that particular information be included in a label, that certain information be displayed in a particular manner, or that a specific label be affixed to

a container, the use of this Guide will not necessarily insure compliance with such laws. The specific requirements of each such law, and the regulations issued thereunder, must be observed in order to insure compliance. Such laws include the Federal Food, Drug, and Cosmetic Act and the Federal Hazardous Substances Act and similar state and municipal legislation; the Federal Insecticide, Fungicide, and Rodenticide Act and similar state legislation; the U.S. Department of Transportation Hazardous Materials Regulations; and others.

DEFINITION OF TERMS USED IN PRECAUTIONARY LABELING

Antidote- *Specific therapeutic measures* that may or may not require the services of a physician.

Combustible Liquid - A liquid that has a flash point above 80°F to and including 150°F as determined by Tagliabue's Open-Cup Method.

Corrosive--A substance which in contact with living tissue causes destruction of the tissue by chemical action. This term shall not refer to action on inanimate surfaces.

Dust- Solid particles generated by handling, crushing, grinding, rapid impact, detonation, or decrepitation of organic or inorganic materials such as rock, ore, metal, coal, wood, grain, etc. Dusts can be dispersed in air but settle under the influence of gravity.

Extremely Flammable Liquid -A liquid that has a flash point of 20°F or less as determined by Tagliabue's Open-Cup Method.

First Aid - *General measures* that can be taken by the victim or other persons aimed principally at terminating the exposure.

Flammable Substance -A substance falling within any of the following categories:

1. A *Flammable Liquid* is one that has a flash point above 20°F to and including 80°F as determined by Tagliabue's Open-Cup Method.

2. A *Flammable Solid* is one, other than an explosive, that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard.

3. A *Flammable Gas* is a gas with either of the following properties: (a) at atmospheric temperature and pressure forms a flammable mixture with air when present at a concentration of 13 percent or less (by volume) or which forms a range of flammable mixtures with air wider than 12 percent regardless of the lower limit, or (b) projects a flame more than 18 inches beyond the ignition source with valve opened fully, or the flame flashes back and burns at the valve with any degree of valve opening, when tested in the Bureau of Explosives' Flame Projection Apparatus.

Fume—Solid particles generated by condensation from the gaseous state, generally after volatilization from molten metals, etc., and often accompanied by a chemical reaction such as oxidation. Fumes flocculate and sometimes coalesce.

Gas—A normally formless fluid that occupies the space of enclosure and which can be changed to the liquid or solid state by the effect of increased pressure or decreased temperature or both. A gas diffuses.

Hazardous Substance--A substance or mixture of substances that is toxic, highly toxic, an irritant, a corrosive, a strong oxidizer, a strong sensitizer, a combustible liquid, flammable, an extremely flammable liquid, dangerously reactive, or pressure-generating, ***provided*** such substance or mixture of substances may cause substantial personal injury or substantial illness during or as a direct result of any customary or reasonably foreseeable handling or use.

Highly Toxic Substance (Poison)--A substance falling within any of the following categories:

1. A substance that has a median lethal dose (LD_{50}) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 grams and 300 grams each.

2. A substance that has a median lethal dose (LD_{50}) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours or less with the bare skin of albino rabbits weighing between 2 kilograms and 3 kilograms each.

3. A substance that has a median lethal concentration (LC_{50}) in air of 200 parts per million by volume or less of gas or vapor or 2 milligrams per liter or less of mist, fume, or dust when administered by continuous inhalation for one hour or less to albino rats weighing between 200 grams and 300 grams each, ***provided*** such concentration is likely to be encountered by man when the substance is used in any reasonably foreseeable manner.

If available data on human experience with any substance in the above-named concentrations indicate results different from those obtained on animals, the human data shall take precedence in any classification of a substance as highly toxic.

Irritant—A substance, not a corrosive, which on immediate, prolonged, or repeated contact with normal living tissue will induce a local inflammatory reaction.

Median Lethal Dose or Concentration—The dose (LD_{50}) or concentration for a given period of time (LC_{50}) of a substance that is most likely to kill one-half of a group of animals within 14 days.

Mist--Suspended liquid droplets generated by condensation from the gaseous to the liquid state or by breaking up a liquid into a dispersed state such as by splashing, foaming, or atomizing.

Mixture--A physical commingling of two or more substances not involving a chemical reaction.

Poison- See **Highly Toxic Substance.**

Pressure-Generating Substance—A substance falling within any of the following categories:

1. A substance that must be protected from spontaneous polymerization by the addition of an inhibitor, or by refrigeration or other thermal control.

2. A substance that may decompose to release gas in its container.

3. A substance that comprises the contents of a self-pressurized container.

Pyroforic Substance--A substance that becomes self-igniting when exposed to normal atmospheric conditions.

Strong Oxidizer—A substance that yields oxygen readily to stimulate the combustion of organic matter.

Strong Sensitizer—A substance that available data on human experience show to be capable of inducing an allergic reaction in a substantial number of persons who come into contact with it.

Toxic Substance—A substance falling within any of the following categories:

1. A substance that has a median lethal dose (LD_{50}) of more than 50 milligrams per kilogram but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 grams and 300 grams each.

2. A substance that has a median lethal dose (LD_{50}) of more than 200 milligrams per kilogram but not more than 1000 milligrams

per kilogram of body weight when administered by continuous contact for 24 hours or less with the bare skin of albino rabbits weighing between 2 kilograms and 3 kilograms each.

3. A substance that has a median lethal concentration (LC_{50}) in air of more than 200 parts per million but not more than 2000 parts per million by volume of gas or vapor or more than 2 milligrams per liter but not more than 20 milligrams per liter of mist, fume, or dust when administered by continuous inhalation for one hour or less to albino rats weighing between 200 grams and 300 grams each, ***provided*** such concentration is likely to be encountered by man when the substance is used in any reasonably foreseeable manner.

If available data on human experience with any substance in the above-named concentrations indicate results different from those obtained on animals, the human data shall take precedence in any classification of a substance as toxic.

Vapor—The gaseous form of a substance that is normally in the solid or liquid state. A vapor diffuses.

GENERAL PRINCIPLES OF PRECAUTIONARY LABELING

The following General Principles serve as a guide in the preparation of precautionary labels for hazardous substances.

1. Each hazardous substance presents a distinct problem and must be treated individually in the light of its own characteristics. Conclusions regarding the hazards of a product cannot safely be drawn either from the properties of the materials from which it is formed or by analogies based upon chemical structure. Mixtures of two or more chemicals may have properties that vary in kind or degree from those of the individual components. Any precautionary label for mixtures should be based on the properties of the finished product. Impurities may contribute hazardous properties and should not be overlooked.

2. All statements on precautionary labels should be brief, accurate, and expressed in simple, easily understood terms.

3. Precautionary labeling should be used only when and to the extent necessary. The language should be practical, not based alone upon the inherent properties of a product, but directed toward the avoidance of hazards resulting from such use, handling, and storage as may be reasonably foreseeable. The use of precautionary labels for relatively harmless products, or the use of unnecessary words, may develop a disregard for precautionary texts and defeat their purpose as surely as will failure to give adequate notice of hazards.

4. On labels for different products, uniformity in language to indicate the same hazards and same degree of hazard is most desirable in order to gain greater understanding through standardization.

5. The following subject matter should be considered for inclusion on a precautionary label: *Name of Product*; *Signal Word* designating degree of hazard DANGER!, WARNING!, or CAUTION!; *Affirmative Statement of Hazards*; *Precautionary Measures* covering actions to be followed or avoided; *Instructions in Case of Contact or Exposure*, where advisable; *Antidotes and Notes to Physicians*, where advisable; *Instructions in Case of Fire, Spill, or Leak*, where advisable; and *Instructions for Container Handling and Storage*, where advisable.

6. Inclusion of the word POISON and the skull and crossbones on a label should be limited to those cases where the product is highly toxic according to the definition appearing on page 12, or where

such use is prescribed by law. When used, this legend should not take the place of the Signal Word.

7. A non-descriptive code designation or trade name should not be used as the only identification of a hazardous substance. If the complete chemical name is not shown, the label should clearly state the type of chemical, e.g., "corrosive acid," "lead compound."

8. Precautionary statements should be grouped together in a prominent location on the label and should be printed in easily legible type which is in contrast by typography, layout, or color with other printed matter on the label. The label should be affixed firmly to and in a conspicuous place on the container.

GENERAL INSTRUCTIONS FOR PREPARATION OF PRECAUTIONARY LABELS

In the preparation of a precautionary label, the compilation of all available relevant information on the product is a necessary first step. An adequate knowledge of the toxicity of the material (obtained from the literature or through laboratory tests) and data on physical and chemical properties, packaging, and methods of handling and use of the product are needed to make possible a description of the hazards. In the case of an established product, advantage should be taken of the experience of people involved in manufacturing, shipping, and using the material. All the General Principles should be kept in mind and the following information considered for inclusion on the label:

Name of Product--This is important information for the safety of handlers and users. It is preferable that the chemical name of the product be used. If the product is a mixture, those components which contribute substantially to the hazard should be identified. A non-descriptive code designation or trade name should not be used as the only identification of a hazardous chemical. If the complete chemical name is not shown, the label should at least clearly state the type of chemical, e.g., "corrosive acid," "lead compound." In any case, identification should be adequate to permit selection of proper treatment in case of exposure.

Signal Word—This word is intended to draw attention to the presence of hazard, and to indicate the degree of severity. In the order of diminishing severity of hazard, the Signal Words recommended are DANGER!, WARNING!, and CAUTION!

Degree of severity can be expressed only in relative terms. DANGER! is the strongest of the three words and should be used for those products presenting the most serious hazards. CAUTION! is recommended for those compounds presenting the least serious hazards. WARNING! is intermediate between the two.

Statement of Hazards- This statement should give notice of the hazards that are present in connection with the customary or reasonably foreseeable handling or use of the product. Examples are EXTREMELY FLAMMABLE and HARMFUL IF ABSORBED THROUGH SKIN.

Many chemical products will present more than one type of

hazard, in which case appropriate statements for each significant type should be included on the label. In general, the most serious hazard should be stated first.

While any compound may be hazardous if improperly used, it is impractical to cover every possible contingency on a label. Efforts should be directed toward giving notice of the significant hazards. A minor hazard may frequently be covered clearly and briefly by an appropriate precautionary statement alone. In some cases, the total hazard of a product, while justifying one or more Precautionary Measures, may be of such order as to require no Statement of Hazard on the label.

Precautionary Measures—These instructions are intended to supplement the Statement of Hazards by setting forth briefly measures to be taken to avoid injury or damage from stated hazards. Examples are "Keep away from heat, sparks, and open flame." and "Avoid breathing dust."

Precautionary Measures may be included for hazards not considered of sufficient importance to require mention in the Statement of Hazards.

Statements similar to "Do not take internally." are seldom necessary where the Precautionary Measure to be followed is obvious as, for example, when the product is labeled POISON or the Statement of Hazards contains the words MAY BE FATAL IF SWALLOWED. On the other hand, the instruction may be desirable if the name, appearance, use, or other attributes of the chemical are likely to result in its being taken orally through accident or mistaken identity.

Instructions in Case of Contact or Exposure—The primary purpose of precautionary labeling is to prevent injury or damage. However, Instructions in Case of Contact or Exposure may be included in those instances where the results of contact or exposure are severe and immediate treatment is highly desirable, and where simple remedial measures may be taken safely before medical assistance is available.

First aid instructions should be limited to recognized procedures based on simple methods and commonly available materials. Instructions for strictly medical treatment should be included when specifically required by law or indicated by special circumstances (see **Antidotes and Notes to Physicians** below). Some laws and regulations require the use of special or strictly defined antidotes on labels, or prescribe

specific ways in which these must be shown for certain hazardous substances.

Because of the serious and lasting effects that may result from eye injuries, a recommendation to get medical attention should accompany any specific instructions directed to treatment of the eyes.

In certain instances, simple remedial measures such as washing, or removal of clothing, may be included where they will serve to avoid serious injury following contact or exposure.

Antidotes and Notes to Physicians Specific therapeutic measures that can be taken before the physician arrives may be presented on a label under the heading "Antidote." Examples appear on page 62. Measures that can be taken only by a physician may be presented on a label under the heading "Note(s) to Physicians." Obviously, such information must be written by a physician for physicians. Examples appear on page 63.

Instructions in Case of Fire, Spill, or Leak—Accident instructions should be as simple and brief as possible and advise the use of suitable materials for control. Labels should provide persons who handle containers during shipment and storage with appropriate instructions for confining and extinguishing fires and for cleaning up spills or leaks. This information on precautionary labels, affixed to containers, will insure reference and provide opportunity to plan for emergencies that might occur during storage and use of the product. Applicable phrases may be selected from the statements on page 65.

Instructions for Container Handling and Storage—Care should always be exercised in handling and storing containers of hazardous chemicals, and in removing the contents. However, in some cases the properties of the product or the characteristics of the container may be such that specific instructions, such as those presented on page 67, may be included on the label.

SELECTION OF PRECAUTIONARY STATEMENTS

The effectiveness of precautionary labeling depends in large measure upon the extent to which there is uniformity of language, on labels of chemicals generally, to denote the same hazards and the same severity of hazard. Substantial differences in language for hazards that are similar in kind and degree can only create confusion. On the other hand, uniformity of language can lead to a better understanding of precautionary labeling by those to whom it is directed and by the public at large.

Complete uniformity of language is not feasible since the universe of chemicals includes too varied a range of hazardous properties and total uniformity could be achieved only by writing a specific label for every chemical and mixture of chemicals. On the other hand, the total hazards of the great majority of chemicals can be divided into a relatively few classes, such as set forth in Table I, and it is in describing these hazards that significant progress toward standardization of language can be made.

Table I represents a standardization of language, and is presented as a guide in the selection of precautionary statements for labels. It is a classification of chemicals on the basis of the hazardous properties that are most frequently encountered. Opposite each class of hazard are given a Signal Word, Statements of Hazard, Precautionary Measures, and, in most cases, Instructions in Case of Contact or Exposure and additional markings. All of these statements are considered to be the most appropriate for each of the particular classes of hazard, and are believed to be as concise and few in number as is consistent with a complete presentation of precautionary information.

It is important to bear in mind that hazardous chemicals frequently have properties that place them in more than one hazard class. In such cases, the precautionary label text will be the sum of the language in the individual classes. When the texts for different classes of hazard are combined, it may be necessary to eliminate some redundancies that occur in the Precautionary Measures or First Aid statements.

It must be emphasized that there are many hazardous properties of chemicals other than those dealt with in Table I and, therefore, there will be instances in which the label texts given in Table I will be inapplicable or insufficient. In such cases, suitable statements should be developed to fit the situation. In an effort to bring about uniformity of language, one should not lose sight of the fact that each hazardous substance must be considered individually in the light of its own characteristics and customary or reasonably foreseeable handling or use.

Examples of additional label statements that may be applicable in particular instances are given in the Label Statements Not Appearing in Table I section.

Some Statements of Hazard and Precautionary Measures in Table I contain words in parentheses. These words represent choices that are to be made according to the facts in a particular situation. It is not intended that the final wording should contain any parenthetical expressions.

It must also be recognized that the precautionary labeling detailed in Table I is directed primarily to the avoidance of injury from single, accidental exposures to a chemical. Some chemicals, however, produce cumulative effects from repeated exposures. When a knowledge of cumulative effects exists, a statement of that hazard together with suitable instructions for the avoidance of such injury should be included with the other label information recommended in Table I.

TABLE I—SELECTION OF PRECAUTIONARY STATEMENTS

	CLASS OF HAZARD	SIGNAL WORD	STATEMENTS OF HAZARD	PRECAUTIONARY MEASURES	INSTRUCTIONS IN CASE OF CONTACT OR EXPOSURE
INGESTION	Highly Toxic	DANGER!	MAY BE FATAL IF SWALLOWED	Wash thoroughly after handling.	☠ POISON ☠ Call a Physician FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. *Never give anything by mouth to an unconscious person.*
	Toxic	WARNING!	HARMFUL IF SWALLOWED	Wash thoroughly after handling.	FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Call a physician. *Never give anything by mouth to an unconscious person.*
ABSORPTION	Highly Toxic	DANGER!	MAY BE FATAL IF ABSORBED THROUGH SKIN	Do not get in eyes, on skin, on clothing. Wash thoroughly after handling.	☠ POISON ☠ Call a Physician FIRST AID: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)
	Toxic	WARNING!	HARMFUL IF ABSORBED THROUGH SKIN	Avoid contact with eyes, skin, and clothing. Wash thoroughly after handling.	FIRST AID: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician. Wash clothing before re-use. (Discard contaminated shoes.)
INHALATION	Highly Toxic	DANGER!	MAY BE FATAL IF INHALED	Do not breathe (dust, vapor, mist, gas). Keep container closed. Use only with adequate ventilation.	☠ POISON ☠ Call a Physician *FIRST AID* If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.
	Toxic	WARNING!	HARMFUL IF INHALED	Avoid breathing (dust, vapor, mist, gas). Keep container closed. Use with adequate ventilation.	FIRST AID: If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Call a physician.
	Strong Sensitizer, Lungs	WARNING!	MAY CAUSE ALLERGIC RESPIRATORY REACTION	Avoid breathing (dust, vapor, mist, gas). Keep container closed. Use with adequate ventilation.	
	Physiologically Inert Vapor or Gas	CAUTION!	(VAPOR) (GAS) REDUCES OXYGEN AVAILABLE FOR BREATHING	Keep container closed. Use with adequate ventilation. Do not enter storage areas unless adequately ventilated.	

NOTE 1. In addition to the use of POISON and skull and crossbones in the highly toxic classes shown above, certain laws may require this use in other specified instances.

NOTE 2. Examples of Antidote Statements; Examples of Notes to Physicians; Instructions in Case of Fire, Spill, or Leak; and Instructions for Container Handling and Storage are illustrated separately starting on Pages 62, 63, 65, and 67.

NOTE 3. Products may present a special or unique hazard not covered in this table. For example, some chemicals may react violently with water, may liberate extremely poisonous vapors under special conditions, etc. These special conditions must be covered in the precautionary label text. See Page 50 for examples.

NOTE 4. The First Aid instructions for Class of Hazard INGESTION are considered to be applicable in the vast majority of cases involving the ingestion of a poison. In all cases, a study of the particular product involved and the applicable laws may dictate either additional or completely different First Aid instructions.

(Continued)

TABLE I—SELECTION OF PRECAUTIONARY STATEMENTS

	CLASS OF HAZARD	SIGNAL WORD	STATEMENTS OF HAZARD	PRECAUTIONARY MEASURES	INSTRUCTIONS IN CASE OF CONTACT OR EXPOSURE
CONTACT	Corrosive, Eye	DANGER!	CAUSES (SEVERE) EYE BURNS	Do not get in eyes. Avoid breathing (dust, vapor, mist, gas). Keep container closed. Use with adequate ventilation. Wash thoroughly after handling.	FIRST AID: In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.
CONTACT	Corrosive, Eye and Skin	DANGER!	CAUSES (SEVERE) BURNS	Do not get in eyes, on skin, on clothing. Avoid breathing (dust, vapor, mist, gas). Keep container closed. Use with adequate ventilation. Wash thoroughly after handling.	FIRST AID: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician. Wash clothing before re-use. (Discard contaminated shoes.)
CONTACT	Irritant, Eye	WARNING!	CAUSES EYE IRRITATION	Avoid contact with eyes. Wash thoroughly after handling.	FIRST AID. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.
CONTACT	Irritant, Eye and Skin	WARNING!	CAUSES IRRITATION	Avoid contact with eyes, skin, and clothing. Wash thoroughly after handling.	FIRST AID. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician. Flush skin with water. (Wash clothing before re-use.)
CONTACT	Strong Sensitizer, Skin	WARNING!	MAY CAUSE ALLERGIC SKIN REACTION	Avoid prolonged or repeated contact with skin. Wash thoroughly after handling.	FIRST AID. In case of contact, immediately wash skin with soap and plenty of water.
FLAMMABILITY	Extremely Flammable Liquid	DANGER!	EXTREMELY FLAMMABLE	Keep away from heat, sparks, and open flame. Keep container closed. Use with adequate ventilation.	
FLAMMABILITY	Flammable Liquid	WARNING!	FLAMMABLE	Keep away from heat, sparks, and open flame. Keep container closed. Use with adequate ventilation.	
FLAMMABILITY	Flammable Solid	WARNING!	FLAMMABLE	Keep away from heat, sparks, and open flame.	(See page 65 for selection of appropriate fire-extinguishing statement.)
FLAMMABILITY	Flammable Gas	DANGER!	EXTREMELY FLAMMABLE (GAS) (LIQUID AND GAS) UNDER PRESSURE	Keep away from heat, sparks, and open flame. Use with adequate ventilation. Never drop cylinder. Keep cylinder out of sun and away from heat.	
FLAMMABILITY	Combustible Liquid	CAUTION!	COMBUSTIBLE	Keep away from heat and open flame.	
FLAMMABILITY	Pyroforic Substance	DANGER!	EXTREMELY FLAMMABLE CATCHES FIRE IF EXPOSED TO AIR	Keep away from heat, sparks, and open flame. Keep container closed.	
FLAMMABILITY	Strong Oxidizer	DANGER!	STRONG OXIDIZER CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE	Keep from contact with clothing and other combustible materials. Do not store near combustible materials. Store in tightly closed container.	Remove and wash contaminated clothing promptly.

NOTE 1. In addition to the use of POISON and skull and crossbones in the highly toxic classes shown above, certain laws may require this use in other specified instances.

NOTE 2. Examples of Antidote Statements; Examples of Notes to Physicians; Instructions in Case of Fire, Spill, or Leak; and Instructions for Container Handling and Storage are illustrated separately starting on Pages 62, 63, 65, and 67.

NOTE 3. Products may present a special or unique hazard not covered in this table. For example, some chemicals may react violently with water, may liberate extremely poisonous vapors under special conditions, etc. These special conditions must be covered in the precautionary label text. See Page 50 for examples.

NOTE 4. The First Aid instructions for Class of Hazard INGESTION are considered to be applicable in the vast majority of cases involving the ingestion of a poison. In all cases, a study of the particular product involved and the applicable laws may dictate either additional or completely different First Aid instructions.

LABELS FOR CHEMICALS WITH SINGLE OR MULTIPLE HAZARDS

This section is only a different form of Table I, but is included to illustrate the arrangement of the various elements of a precautionary label text. It sets forth the recommended labels for those chemicals that are determined to have only that specific hazard or hazards listed above each text. **Be certain to refer also to all footnotes to Table I to determine the need for additional label statements.**

An explanation of the application of the statement "Discard contaminated shoes." and of the use of the words in parentheses in these labels is as follows:

Shoes that are contaminated with a chemical can, in most cases, be decontaminated through suitable washing, airing or other means. Thus, they are rendered fit for reuse, and there is no need to include the instruction "Discard contaminated shoes." in the first-aid statement. However, there are certain chemicals such as acrylonitrile, ethylene oxide, and methyl bromide that are retained so tenaciously by leather that there is no satisfactory method of removing them within a reasonable period of time. These are also chemicals which produce very serious blisters and other damage when they are retained in contact with the skin. Additionally, there are other chemicals, such as aniline, which have extreme toxicity by skin absorption as well as an affinity for leather. In all of these cases, the consequences of error are so severe that it does not seem wise that an individual should take the risk of reusing shoes that have had such chemicals absorbed into them, even though some decontamination procedure has been attempted. In writing precautionary labels, one must make a judgment in this situation based on the physical and toxicological properties of the product in question. If the facts warrant, the parentheses should be removed from about the statement "Discard contaminated shoes." and the statement should be allowed to remain in the first-aid instructions.

In Precautionary Measures that warn against breathing of the chemical, the physical forms "dust, vapor, mist, gas" are placed in parentheses. It is intended that the parentheses and the inapplicable forms should be eliminated from the final label. The word "dust" alone should be used for solids that do not have significant vapor pressure. The words "dust and vapor" should be used with solids that have a significant vapor pressure. The word "vapor" should be used for all liquids, and the words "vapor or mist" should be used for those liquids whose reasonably foreseeable use is likely to result in the creation of mist. The word "gas" should be used for all gases.

The Statement of Hazard for corrosives includes the word SEVERE in parentheses. The action of a corrosive is described as CAUSES (SEVERE) BURNS. While all burns, in this sense, involve the destruction of tissue, they vary widely in degree of severity depending upon the chemical that produces them. For example, all things being equal, burns from strong acids and alkalies are more severe than those from weak acids and alkalies. It is considered desirable to give the person reading the label some notion of the degree of severity of the injury that can occur. Therefore, the word SEVERE is placed in parentheses in Table I to indicate that its applicability must be left as a matter of judgment. If the action of the corrosive is not rapid or extensive, the word may be omitted. Otherwise, the parentheses should be eliminated, and the word allowed to remain.

The Statement of Hazard for liquids that yield physiologically inert vapors should be VAPOR REDUCES OXYGEN AVAILABLE FOR BREATHING; for physiologically inert gases, it should be GAS REDUCES OXYGEN AVAILABLE FOR BREATHING.

Compressed gases should be described as LIQUID AND GAS UNDER PRESSURE when there is a liquid phase in the container, and as GAS UNDER PRESSURE when there is no liquid phase in the container. This description should be included as a Statement of Hazard together with other applicable statements.

Labels for Chemicals with Single Hazards

HAZARD:
Highly Toxic by Ingestion

DANGER! MAY BE FATAL IF SWALLOWED

Wash thoroughly after handling.



Call a Physician

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

HAZARD:
Highly Toxic by Inhalation

DANGER! MAY BE FATAL IF INHALED

Do not breathe (dust, mist, vapor, gas).*
Keep container closed.
Use only with adequate ventilation.



Call a Physician

FIRST AID: If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

** Select applicable word or words in parentheses.*

HAZARD:
Highly Toxic by Absorption

DANGER! MAY BE FATAL IF ABSORBED THROUGH SKIN

Do not get in eyes, on skin, on clothing.
Wash thoroughly after handling.



Call a Physician

FIRST AID: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

HAZARD:
Toxic by Ingestion

WARNING! HARMFUL IF SWALLOWED

Wash thoroughly after handling.

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Call a physician. Never give anything by mouth to an unconscious person.

HAZARD:
Toxic by Inhalation

WARNING! HARMFUL IF INHALED

Avoid breathing (dust, mist, vapor, gas).*
Keep container closed.
Use with adequate ventilation.

FIRST AID: If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Call a physician.

** Select applicable word or words in parentheses.*

HAZARD:

Toxic by Absorption

WARNING! HARMFUL IF ABSORBED THROUGH SKIN

Avoid contact with eyes, skin, and clothing.
Wash thoroughly after handling.

FIRST AID: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician. Wash clothing before re-use. (Discard contaminated shoes.)

HAZARD:

Corrosive, Eye

DANGER! CAUSES (SEVERE) EYE BURNS

Do not get in eyes.
Avoid breathing (dust, vapor, mist, gas).*
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.

FIRST AID: In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

** Select applicable word or words in parentheses.*

HAZARD:

Corrosive, Eye and Skin

DANGER! CAUSES (SEVERE) BURNS

Do not get in eyes, on skin, on clothing.
Avoid breathing (dust, vapor, mist, gas).*
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.

FIRST AID: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician. Wash clothing before re-use. (Discard contaminated shoes.)

** Select applicable word or words in parentheses.*

HAZARD:

Irritant, Eye

WARNING! CAUSES EYE IRRITATION

Avoid contact with eyes.
Wash thoroughly after handling.

FIRST AID: In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

HAZARD:

Irritant, Eye and Skin

WARNING! CAUSES IRRITATION

Avoid contact with eyes, skin, and clothing.
Wash thoroughly after handling.

FIRST AID: In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician. Flush skin with water. (Wash clothing before re-use.)

HAZARD:

Strong Sensitizer, Skin

WARNING! MAY CAUSE ALLERGIC SKIN REACTION

Avoid prolonged or repeated contact with skin.
Wash thoroughly after handling.

FIRST AID: In case of contact, immediately wash skin with soap and plenty of water.

HAZARD:
Strong Sensitizer, Lungs

WARNING! MAY CAUSE ALLERGIC RESPIRATORY REACTION

Avoid breathing (dust, mist, vapor, gas).*
Keep container closed.
Use with adequate ventilation.

** Select applicable word or words in parentheses.*

HAZARD:
Physiologically Inert Vapor or Gas

CAUTION! (VAPOR) (GAS) REDUCES OXYGEN AVAILABLE FOR BREATHING *

Keep container closed.
Use with adequate ventilation.
Do not enter storage areas unless adequately ventilated.

** Select applicable word or words in parentheses.*

HAZARD:
Extremely Flammable Liquid

DANGER! EXTREMELY FLAMMABLE

Keep away from heat, sparks, and open flame.
Keep container closed.
Use with adequate ventilation.

See Page 65 for selection of appropriate fire-extinguishing statement.

HAZARD:
Flammable Liquid

WARNING! FLAMMABLE

Keep away from heat, sparks, and open flame.
Keep container closed.
Use with adequate ventilation.

See Page 65 for selection of appropriate fire-extinguishing statement.

HAZARD:
Flammable Solid

WARNING! FLAMMABLE

Keep away from heat, sparks, and open flame.

See Page 65 for selection of appropriate fire-extinguishing statement.

HAZARD:
Flammable Gas

DANGER! EXTREMELY FLAMMABLE (GAS) (LIQUID AND GAS) UNDER PRESSURE *

Keep away from heat, sparks, and open flame.
Use with adequate ventilation.
Never drop cylinder.
Keep cylinder out of sun and away from heat.

** Select applicable word or words in parentheses.*

See Page 65 for selection of appropriate fire-extinguishing statement.

HAZARD:
Combustible Liquid

CAUTION! COMBUSTIBLE

Keep away from heat and open flame.

See Page 65 for selection of appropriate fire-extinguishing statement.

HAZARD:
Pyroforic Substance

DANGER! EXTREMELY FLAMMABLE CATCHES FIRE IF EXPOSED TO AIR

Keep away from heat, sparks, and open flame.
Keep container closed.

See Page 65 for selection of appropriate fire-extinguishing statement.

HAZARD:

Strong Oxidizer

DANGER! STRONG OXIDIZER
CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE

Keep from contact with clothing and other combustible materials.
Do not store near combustible materials.
Store in tightly closed container.
Remove and wash contaminated clothing promptly.

See Page 65 for selection of appropriate fire-extinguishing statement.

Labels for Chemicals with Multiple Hazards

When a chemical falls into two or more of the hazard classes enumerated in Table I, the precautionary label text will be the sum of all of the statements in the individual classes. **Be certain to refer to all footnotes to Table I to determine the need for additional label statements.**

Some condensation of this information along the following lines is indicated:

1. Only one Signal Word should be used and this should be the Signal Word corresponding to the class of greatest hazard.

2. In the toxicity classes, Statements of Hazard may be combined when the product is equally toxic by more than one route of exposure. Examples of such combinations are: MAY BE FATAL IF SWALLOWED OR INHALED or HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.

3. When the same Precautionary Measure is applicable to more than one class of hazard, it should not be repeated.

4. When more than one first-aid statement is required, the words FIRST AID and "Call a physician" need not be repeated provided the statements are grouped under a general heading of FIRST AID and the phrase "Call a physician" is positioned in such a way as to be clearly applicable to all first-aid statements. Similarly, the instruction "Never give anything by mouth to an unconscious person." may appear in more than one statement, and this need not be repeated if it is clearly applicable to all of the statements that would otherwise include it.

5. When a product presents hazards by both skin contact and absorption, only one first-aid statement should be used. In such cases, the first-aid statement used should be that applicable to the class of hazard in the following order of priority: Highly Toxic; Toxic; Corrosive, Eye and Skin; Irritant, Eye and Skin; Strong Sensitizer, Skin.

The labels given in this section represent most of the instances in which condensation of label language is desirable. The language for flammability class of hazard does not lend itself to condensation with the language for other classes of hazard. Therefore no example is given.

HAZARDS:
Highly Toxic by Ingestion
Highly Toxic by Inhalation

DANGER! MAY BE FATAL IF SWALLOWED OR INHALED

*Do not breathe (dust, vapor, mist, gas).**
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Ingestion
Highly Toxic by Absorption

DANGER! MAY BE FATAL IF SWALLOWED OR ABSORBED THROUGH SKIN

Do not get in eyes, on skin, on clothing.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

HAZARDS:
Highly Toxic by Ingestion
Toxic by Inhalation

DANGER! MAY BE FATAL IF SWALLOWED
HARMFUL IF INHALED

Avoid breathing (dust, vapor, mist, gas).*
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Ingestion
Toxic by Absorption

DANGER! MAY BE FATAL IF SWALLOWED
HARMFUL IF ABSORBED THROUGH SKIN

Avoid contact with eyes, skin, and clothing.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

HAZARDS:
Highly Toxic by Inhalation
Highly Toxic by Absorption

DANGER! MAY BE FATAL IF INHALED OR ABSORBED THROUGH SKIN

Do not breathe (dust, vapor, mist, gas).*
Do not get in eyes, on skin, on clothing.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

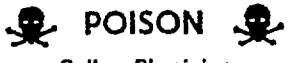
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Inhalation
Toxic by Ingestion

DANGER! MAY BE FATAL IF INHALED
HARMFUL IF SWALLOWED

Do not breathe (dust, vapor, mist, gas).*
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Inhalation
Toxic by Absorption

DANGER! MAY BE FATAL IF INHALED
HARMFUL IF ABSORBED THROUGH SKIN

Do not breathe (dust, vapor, mist, gas).*
Avoid contact with eyes, skin, and clothing.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Absorption
Toxic by Ingestion

DANGER! MAY BE FATAL IF ABSORBED THROUGH SKIN
HARMFUL IF SWALLOWED

Do not get in eyes, on skin, on clothing.
Wash thoroughly after handling.



Call a Physician

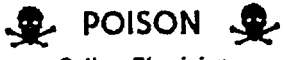
FIRST AID: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

HAZARDS:
Highly Toxic by Absorption
Toxic by Inhalation

DANGER! MAY BE FATAL IF ABSORBED THROUGH SKIN HARMFUL IF INHALED

Do not get in eyes, on skin, on clothing.
Avoid breathing (dust, vapor, mist, gas).*
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

** Select applicable word or words in parentheses.*

HAZARDS:
Toxic by Ingestion
Toxic by Inhalation

WARNING! HARMFUL IF SWALLOWED OR INHALED

Avoid breathing (dust, vapor, mist, gas).*
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Call a physician. Never give anything by mouth to an unconscious person.

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Call a physician.

** Select applicable word or words in parentheses.*

HAZARDS:
Toxic by Ingestion
Toxic by Absorption

WARNING! HARMFUL IF SWALLOWED OR ABSORBED THROUGH SKIN

Avoid contact with eyes, skin, and clothing.
Wash thoroughly after handling.

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Call a physician. Never give anything by mouth to an unconscious person.

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician. Wash clothing before re-use. (Discard contaminated shoes.)

HAZARDS:
Toxic by Inhalation
Toxic by Absorption

WARNING! HARMFUL IF INHALED OR ABSORBED THROUGH SKIN

Avoid breathing (dust, vapor, mist, gas).*
Avoid contact with eyes, skin, and clothing.
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.

FIRST AID: If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Call a physician.

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician. Wash clothing before re-use. (Discard contaminated shoes.)

** Select applicable word or words in parentheses.*

HAZARDS:
Strong Sensitizer, Skin
Strong Sensitizer, Lungs

WARNING! MAY CAUSE ALLERGIC SKIN OR RESPIRATORY REACTION

Avoid breathing (dust, vapor, mist, gas).*
Avoid prolonged or repeated contact with skin.
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.

FIRST AID: In case of contact, immediately wash skin with soap and plenty of water.

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Ingestion
Highly Toxic by Inhalation
Highly Toxic by Absorption

DANGER! MAY BE FATAL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN

Do not breathe (dust, vapor, mist, gas).*
Do not get in eyes, on skin, on clothing.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.
If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Ingestion
Highly Toxic by Inhalation
Toxic by Absorption

DANGER! MAY BE FATAL IF SWALLOWED OR INHALED HARMFUL IF ABSORBED THROUGH SKIN

Do not breathe (dust, vapor, mist, gas).*
Avoid contact with eyes, skin, and clothing.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.
If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Ingestion
Highly Toxic by Absorption
Toxic by Inhalation

DANGER! MAY BE FATAL IF SWALLOWED OR ABSORBED THROUGH SKIN
HARMFUL IF INHALED

Do not get in eyes, on skin, on clothing.
Avoid breathing (dust, vapor, mist, gas).*
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Ingestion
Toxic by Inhalation
Toxic by Absorption

DANGER! MAY BE FATAL IF SWALLOWED
HARMFUL IF INHALED OR ABSORBED THROUGH SKIN

Avoid breathing (dust, vapor, mist, gas).*
Avoid contact with eyes, skin, and clothing.
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Inhalation
Highly Toxic by Absorption
Toxic by Ingestion

DANGER! MAY BE FATAL IF INHALED OR ABSORBED THROUGH SKIN HARMFUL IF SWALLOWED

Do not breathe (dust, vapor, mist, gas).*
Do not get in eyes, on skin, on clothing.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

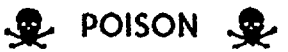
If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Inhalation
Toxic by Ingestion
Toxic by Absorption

DANGER! MAY BE FATAL IF INHALED HARMFUL IF SWALLOWED OR ABSORBED THROUGH SKIN

Do not breathe (dust, vapor, mist, gas).*
Avoid contact with eyes, skin, and clothing.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

** Select applicable word or words in parentheses.*

HAZARDS:
Highly Toxic by Absorption
Toxic by Ingestion
Toxic by Inhalation

DANGER! MAY BE FATAL IF ABSORBED THROUGH SKIN HARMFUL IF SWALLOWED OR INHALED

Do not get in eyes, on skin, on clothing.
Avoid breathing (dust, vapor, mist, gas).*
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.



Call a Physician

FIRST AID: In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. (Discard contaminated shoes.)

If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Never give anything by mouth to an unconscious person.

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen.

** Select applicable word or words in parentheses.*

HAZARDS:
Toxic by Ingestion
Toxic by Inhalation
Toxic by Absorption

WARNING! HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN

Avoid breathing (dust, vapor, mist, gas).*
Avoid contact with eyes, skin, and clothing.
Keep container closed.
Use with adequate ventilation.
Wash thoroughly after handling.

FIRST AID: If swallowed, induce vomiting by sticking finger down throat or by giving soapy or strong salty water to drink. Repeat until vomit is clear. Call a physician. Never give anything by mouth to an unconscious person.

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen. Call a physician.

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician. Wash clothing before re-use. (Discard contaminated shoes.)

** Select applicable word or words in parentheses.*

LABEL STATEMENTS NOT APPEARING IN TABLE I

The Statements of Hazard, Precautionary Measures, and other instructions suggested in Table I are intended to apply only to the common *classes* of hazards. No representation is made or intended that they are sufficiently informative to describe *all* of the hazardous properties a chemical may possess. Many chemicals possess uncommon hazards including some that may be specific for a particular chemical.

It is obviously impossible to suggest any standard or uniform language for describing hazards of this nature. However, the list of chemicals starting on page 52 (keyed to the statements starting on pages 57 and 58) will be helpful in informing persons writing precautionary labels of the existence of special conditions which may require unusual or highly specific language, and will aid these persons in understanding the proper application of the various statements.

The examples of specific statements shown in this section have been collected, and in some cases reworded slightly for overall consistency, from precautionary labeling texts appearing in the 1961 edition of Manual L-1 and in MCA Chemical Safety Data Sheets. It is not intended to imply that every chemical to which a particular statement may be applicable has been listed, or that a statement has been included for every possible special or specific situation.

Most of these statements are self explanatory, but a few of the distinctions between some of the statements and those shown in Table I merit additional explanation. For example, many chemicals are irritating if breathed, but frequently this presents no particularly serious hazard. The recommendation for use of a statement such as VAPOR EXTREMELY IRRITATING is usually made when the irritation is so intense it will temporarily immobilize or pain the person, so that even though no serious lasting harm may result, it is desirable to advise of this potential hazard before the container is opened.

The term HIGHLY VOLATILE is recommended as an additional Statement of Hazard for certain chemicals. Volatility, in and of itself, is not necessarily a hazard, but if there is a flammability or inhalation hazard it is considered important to point out the probability of an increase in this hazard due to the high volatility of the material.

In some cases where unusually severe hazards are present, an extra message such as EXTREMELY HAZARDOUS LIQUID AND VAPOR is desirable. For deciding this point, the exercise of good judgment based on an analysis of the facts with respect to a certain chemical—compared with data on similar chemicals which carry the same Statements of Hazard—may well justify adding an extra attention-getting statement.

The term RAPIDLY ABSORBED THROUGH SKIN is recommended as an additional Statement of Hazard for some products which are harmful by rapid skin absorption, but it would not be used as the sole Statement of Hazard. Again, the exercise of good judgment and observation in judging speed of absorption during the early stages of animal tests or from human experience from exposure will be helpful in deciding whether to add this statement to other Statements of Hazard, such as MAY BE FATAL IF ABSORBED THROUGH SKIN or HARMFUL IF ABSORBED THROUGH SKIN.

Many of the suggested additional Statements of Hazard will need supplemental precautionary measures or other instructions which do not appear in Table I or in the Instructions for Container Handling and Storage; Instructions in Case of Fire, Spill, or Leak; Antidotes; and Notes to Physicians sections of this manual. Examples of such precautionary measures and other instructions are included in this listing. Furthermore, there may be regulatory requirements for the use of the word POISON and the skull and crossbones symbol on the labels of certain chemicals that are not actually highly toxic as defined on page 12.

MCA publishes a number of safety bulletins for guidance in handling and using chemicals safely. Among these are Chemical Safety Data Sheets which give detailed information as to the safe handling of these chemicals. These are available at nominal cost from the Association headquarters. In addition, many chemical manufacturers and suppliers publish similar safety bulletins for the guidance of their customers which are provided on request.

Often there is not enough space on a container label to supply all the safety information adequate for the proper handling of a hazardous chemical. A suitable means of providing the necessary additional detailed instructions is through these various safety bulletins. In previous editions of the manual, many of the illustrative labels included a statement referring to the availability of further safety information, and this recommendation is retained here. Examples of such references are included in the following listing. Such label information, however, cannot take the place of the education of personnel regarding product hazards and the use of safety clothing and equipment. This education is, and must remain, the direct responsibility of their employers.

Chemicals with Key Numbers

	Statements of Hazard	Additional Statements
Acetaldehyde	31	41, 132, 133
Acetic Acid, Glacial		89, 132
Acetic Acid, 80%		132
Acetic Acid, 56%–70%		132
Acetic Acid, 28%		132
Acetic Anhydride		132
Acetone		41, 128, 132
Acetyl Chloride		64
Acetylene		132
Acrolein		132
Acrylonitrile		77, 132
Allyl Alcohol	3	79
Aluminum Chloride, Anhydrous		100, 102, 132
Ammonia, Anhydrous	11, 35	132
Ammonia, Aqua	9	102, 132
Ammonium Dichromate	20	39, 82, 132
Ammonium Hydroxide	9	102, 132
Amyl Acetate (Mixed Isomers)	38	41, 128
Aniline	3	132
Antimony Trichloride		132
Arsenic Trioxide		40, 132
Benzene (Benzol)		41, 129, 132
Benzidine Hydrochloride	2	82
Benzidine Sulfate	2	82
Benzoyl Peroxide	26	61, 62, 107, 130
Benzoyl Peroxide (Wet)	26	61, 62, 107, 108, 130
Benzyl Chloride (Stabilized)		132
Benzyl Chloride (Unstabilized)	34	90, 132
Beryllium Oxide Powder		92
Bromine	9	67, 70, 86, 132
Butadiene (Inhibited)	31	132, 133
Butyl Acetate (normal)	38	41, 128
Butyl Alcohol (normal or secondary)		41
Butyl Alcohol (tertiary)		41, 128
Butyl Chloride (normal)		41
Butyl Ether (normal)	31	41, 63, 128, 133
Butyllithium (normal) (In hydrocarbon solvents)		73, 99, 121, 130
Butyraldehyde (iso or normal)		132
Calcium Carbide		132
Calcium Cyanide	17	91, 122
Carbon Dioxide, Solid ("Dry Ice")	16, 37	66, 80, 93
Carbon Disulfide	8	97, 128, 132
Carbon Tetrachloride		79, 129, 132

	Statements of Hazard	Additional Statements
Caustic Potash		59, 73, 79, 124, 130
Caustic Soda		59, 73, 79, 124, 130
Chloral	6	84
Chlorinated Diphenyl (Mono, Di, or Tri)	38	41, 128
Chlorinated Diphenyl Oxide (Mono, Di, or Tri)	38	41, 128
Chlorinated Naphthalene (For Tri and Higher)	38	41, 128
Chlorine	35	110, 130
Chlorobenzene (Mono)		41, 128
Chloroform		79, 128, 132
Chlorophenol (Monochlorophenol) (ortho, meta, or para)	3	79
Chlorosulfonic Acid	7, 13	50, 64, 132
Chromium Trioxide (Chromic Acid)	21	82, 132
Cholinesterase Inhibitors	18	
Creosote Oil (Coal Tar Creosote)		41
Cresol (Cresylic Acid)	3	79, 132
Cyanides, Inorganic (Excluding Hydrocyanic Acid and Calcium Cyanide)	14	112, 130
Cyclohexane		41, 128, 132
Cyclohexanol		41, 128
Cyclohexanone		41, 128
Decaborane	32	47, 68, 130
Diborane	11	48, 69, 81, 130
Dichlorobenzene (ortho)		128, 132
Dichloroethylene		41, 79, 128
2,4-Dichlorophenol		79
Diethylamine		43, 132
Diethylenetriamine		41, 132
Dimethylamine, Anhydrous	9, 35	69, 85, 132
Dimethyl Sulfate	12	73, 130
2,4-Dinitrotoluene		125, 130
Dinitrotoluene (Oily)	3	125, 130
Dioxane (1,4-Diethylene Dioxide)	31	63, 128, 133
Ethyl Acetate		41, 128, 132
Ethyl Acrylate		132
Ethyl Chloride		132
Ethyl Ether	29, 31	41, 63, 128, 132
Ethylene Chlorohydrin (Anhydrous or 38%)		42
Ethylene Dichloride		79, 128, 132
Ethylene Oxide		132
Formaldehyde Solution		41, 132

	Statements of Hazard	Additional Statements
Hafnium Metal Powder (Min. 25% Water)	33	60, 71, 72, 101, 119, 126, 130
Hydrochloric Acid (Muriatic Acid)		132
Hydrocyanic Acid	36	67, 130
Hydrofluoric Acid, Aqueous	19	86, 130
Hydrogen Chloride, Anhydrous	11, 35	94, 132
Hydrogen Peroxide (27.5–52%)	29	46, 49, 51, 78, 95, 96, 113, 114, 132
Hydrogen Peroxide, High Strength (Over 52%)	23, 30	45, 52, 53, 78, 96, 98, 113, 114, 130
Hydrogen Sulfide	35	81, 120, 132
Isopropylamine		132
Isopropyl Ether	29, 31	41, 63, 128
Lead Monoxide (Litharge)		132
Lead Oxide (Red Lead)		132
Maleic Anhydride		132
Mercuric Chloride (Mercury Bichloride)		82
Methanol	1	129, 132
Methyl Acrylate		132
Methylamines, Anhydrous	9, 35	69, 85, 132
Methylamines, Aqueous Solutions		43, 132
Methyl Bromide	6, 22, 35, 36	75, 109, 130
Methyl Chloride		128, 132
Methylene Chloride	38	41, 128, 132
Methyl Ethyl Ketone		41, 128, 132
Methyl Methacrylate Monomer		41
Mixed Acid (Sulfuric and Nitric)	4, 5	132
Muriatic Acid (Hydrochloric Acid)		132
Naphthalene		132
Naphthylamine (alpha) (Containing beta-Naphthylamine)	2	82, 132
Naphthylamine (beta)	2	82, 132
Nitric Acid	4, 5	132
Nitroaniline (ortho, meta, or para)	3	132
Nitrobenzene	3, 36	130
Oleum (Fuming Sulfuric Acid)		64, 132
Paraformaldehyde		44, 132
Paraldehyde		54, 79
Pentaborane	32	47, 68, 130
Perchloric Acid	27	103, 109, 123, 132

	Statements of Hazard	Additional Statements
Perchloroethylene (Tetrachloroethylene)		79, 128, 132
Phenol	3	132
Phenylenediamine (meta or para)		44
Phosgene	6	67, 132
Phosphoric Acid		132
Phosphoric Anhydride (Phosphorus Pentoxide)		64, 73, 132
Phosphorus, White or Yellow (Wet)		55, 74, 132
Phosphorus Oxychloride	7	64, 132
Phosphorus Pentachloride		73
Phosphorus Pentasulfide	15	56, 100, 132
Phosphorus Pentoxide (Phosphoric Anhydride)		64, 73, 132
Phosphorus Trichloride	9, 24	65, 132
Phthalic Anhydride (Solid)		132
Potassium Dichromate	20	39, 82, 132
Potassium Hydroxide	1	59, 73, 79, 124, 130
Propylene		132
Pyridine		128
Sodium Chlorate		83, 104, 127, 132
Sodium Cyanide	14	112, 118, 130
Sodium Dichromate	20	39, 82, 132
Sodium Hydrosulfite	25	58, 106, 116
Sodium Hydroxide		59, 73, 79, 124, 130
Sodium Metal	28	57, 76, 88, 100, 115, 132
Sodium Orthosilicate		59, 73, 79
Sodium Sesquisilicate, Anhydrous		59, 73, 79
Sodium Sulfhydrate	14	111, 117
Sodium Sulfide (Containing 35% or more combined water)	14	111, 117
Styrene Monomer		128, 132
Sulfur		132
Sulfur Chloride		64, 132
Sulfur Dichloride		64, 132
Sulfur Dioxide	10	132
Sulfuric Acid		64, 132
Sulfuryl Chloride		64, 132
Tar Acids	3	79
Tetrachloroethane		67, 132
Tetrachloroethylene (Perchloroethylene)		79, 128, 132

	Statements of Hazard	Additional Statements
Thionyl Chloride		64, 132
Titanium Trichloride, Anhydrous		73, 87, 105, 131
Toluene (Toluol)		128, 132
Toluidine (ortho or meta)	3	132
Toluidine (para)	3	132
1, 1, 1-Trichloroethane	38	41, 128, 132
Tolylene Diisocyanate		132
Trichloroethylene		79, 128, 132
Trimethylamine, Anhydrous	9, 35	69, 85, 132
Trimethylcyclohexanol		41, 128
Vanadium Tetrachloride		73, 105, 131
Vinyl Acetate		41, 128, 132
Vinyl Chloride		41, 128, 132
Xylene (Xylol)		41
Xylidines	3	
Zirconium Metal Powder (Minimum 25% Water)	33	60, 71, 72, 101, 119, 126, 130

Statements of Hazard

1. MAY BE FATAL OR CAUSE BLINDNESS IF SWALLOWED
2. CANNOT BE MADE NON-POISONOUS
3. REPEATED ABSORPTION MAY RESULT IN BLADDER TUMORS
4. RAPIDLY ABSORBED THROUGH SKIN
5. MAY CAUSE NITROUS GAS POISONING
6. SPILLAGE MAY CAUSE FIRE OR LIBERATE DANGEROUS GAS
7. INHALATION MAY BE FATAL OR CAUSE DELAYED LUNG INJURY
8. HARMFUL IF INHALED AND MAY CAUSE DELAYED LUNG INJURY
9. HIGHLY VOLATILE
10. VAPOR EXTREMELY IRRITATING
11. EXTREMELY IRRITATING GAS AND LIQUID UNDER PRESSURE
12. GAS EXTREMELY IRRITATING
13. LUNG INJURY AND BURNS MAY BE DELAYED
14. CONTACT WITH WATER OR MOIST AIR LIBERATES IRRITATING GAS
15. CONTACT WITH ACID LIBERATES POISONOUS GAS
16. CONTACT WITH WATER OR ACID SLOWLY LIBERATES POISONOUS AND FLAMMABLE HYDROGEN SULFIDE GAS
17. LIBERATES HEAVY GAS WHICH MAY CAUSE SUFFOCATION
18. LIBERATES POISONOUS GAS
19. REPEATED INHALATION OR SKIN CONTACT MAY, WITHOUT SYMPTOMS, INCREASE SUSCEPTIBILITY
20. CAUSES SEVERE BURNS WHICH MAY NOT BE IMMEDIATELY PAINFUL OR VISIBLE
21. MAY CAUSE RASH OR EXTERNAL ULCERS
22. MAY CAUSE BURNS OR EXTERNAL ULCERS
23. LIQUID OR VAPOR CAUSES BURNS WHICH MAY BE DELAYED
24. CAUSES SEVERE BURNS—EFFECTS ON EYES MAY BE DELAYED
25. CONTACT WITH WATER MAY CAUSE FLASH FIRE
26. MAY IGNITE IF ALLOWED TO BECOME DAMP
27. HEAT, SHOCK, OR CONTACT WITH OTHER MATERIALS MAY CAUSE FIRE OR EXPLOSIVE DECOMPOSITION
28. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE OR EXPLOSION, ESPECIALLY IF HEATED
29. REACTS VIOLENTLY WITH WATER LIBERATING AND IGNITING HYDROGEN
30. MAY CAUSE EYE INJURY—EFFECTS MAY BE DELAYED
31. POWERFUL OXIDIZER
32. MAY FORM EXPLOSIVE PEROXIDES
33. FORMS SHOCK-SENSITIVE MIXTURES WITH CERTAIN OTHER MATERIALS
34. MAY EXPLODE IF WATER CONTENT IS 10% OR BELOW
35. CONTAMINATION MAY RESULT IN DANGEROUS PRESSURE
36. LIQUID AND GAS UNDER PRESSURE

36. EXTREMELY HAZARDOUS LIQUID AND VAPOR UNDER PRESSURE
37. EXTREMELY COLD (109°F. BELOW ZERO)
38. In some cases the total hazard of a product, while justifying one or more precautionary measures or other instructions, may be of such order as to require no statement of hazard.

Additional Statements

39. Avoid breathing dust or solution spray.
40. Avoid breathing dust or spray mist.
41. Avoid prolonged or repeated breathing of vapor.
42. Ordinary rubber protective clothing, including gloves, will not prevent skin absorption.
43. Avoid exposure to vapor.
44. Avoid breathing dust or vapor.
45. Wear goggles; neoprene, butyl rubber, or vinyl gloves; neoprene shoes or boots; and clean protective outer clothing.
46. Wear goggles; neoprene, butyl rubber, or vinyl gloves.
47. Keep from contact with oxidizing materials, highly oxygenated or halogenated solvents, organic compounds containing reducible functional groups, or aqueous ammonia.
48. Keep from contact with oxidizing materials.
49. Avoid contamination from any source including metals, dust, and organic materials. Such contamination may cause rapid decomposition, generation of large quantities of oxygen gas, and high pressures.
50. Keep from contact with clothing and other combustible materials to avoid fire.
51. Drying of this product on clothing or combustible materials may cause fire.
52. Keep from contamination from any source including metals, dust, and organic materials. Such contamination can cause rapid decomposition, generation of high pressures, or formation of explosive mixtures.
53. Spills on clothing or combustible materials will cause fire.
54. Solidifies at about 54°F. (12°C.) and may break container. Store in moderately warm place.
55. Contents packed under water and will ignite if water is removed.
56. Avoid friction or rough handling because of fire hazard.
57. Keep from any possible contact with water.
58. Use only dry, clean utensils in handling.
59. While making solutions, add slowly to surface to avoid violent spattering.
60. Keep wet in storage—dry powder may ignite by friction, static electricity, or heat.
61. Do not add to hot materials; do not grind or subject to frictional heat or shock—explosive decomposition may result.
62. Prevent contamination with readily oxidizable materials and polymerization accelerators.
63. Do not allow to evaporate to near dryness. Addition of water or appropriate reducing agents will lessen peroxide formation.

64. Do not allow water to get into container because of violent reaction.
65. Do not add water to contents while in a container because of violent reaction and possible flash fire.
66. Do not enter places where used or stored until adequately ventilated.
67. Use only with adequate ventilation and in closed systems.
68. Always wear a self-contained breathing apparatus or full-face air-line respirator when using this chemical.
69. Have available emergency self-contained breathing apparatus or full-face air-line respirator when using this chemical.
70. Have available emergency gas masks approved by U.S. Bureau of Mines for Bromine Service.
71. Do not attempt to loosen or remove material from container with any tool.
72. Wear goggles or face shield and fire-retardant clothing when handling.
73. Wear goggles or face shield, rubber gloves, and protective clothing when handling.
74. Wear heavy rubber gloves and goggles or face shield.
75. Do not wear ordinary rubber protective clothing, including gloves and boots.
76. Wear goggles and DRY gloves when handling.
77. Liquid penetrates leather shoes causing delayed burns.
78. Put nothing else in this container.
79. Do not take internally.
80. Do not taste.
81. This gas deadens the sense of smell. Do not depend on odor to detect presence of gas.
82. Use fresh clothing daily. Take hot shower after work using plenty of soap.
83. Clothing and vegetation contaminated with chlorate or its solutions are DANGEROUSLY FLAMMABLE. Remove clothing and wash thoroughly with water. Keep persons and animals off treated areas.
84. In case of inhalation or suspicion of inhalation, move patient at once to fresh air and call a physician. Keep patient absolutely quiet and start oxygen inhalation through suitable equipment.
85. Call a physician at once in case of burns, especially to eyes, nose, and throat or if patient is unconscious.
86. Flush eyes for at least 30 minutes.
87. In case of contact, immediately remove from skin with dry cloth followed by flushing with plenty of water for at least 15 minutes; for eyes, flush with plenty of water for at least 15 minutes; get medical attention. Remove contaminated clothing and wash before re-use.
88. Skin: Remove SODIUM and flush affected area with water.

89. Glacial Acetic Acid freezes at 62°F. forming hard lumps which may break carboy when moved. Store in area maintained above 62°F. If frozen, thaw by carefully moving carboy to warm area.
90. Keep dry and handle only in suitable equipment to prevent metallic contamination. Consult manufacturer.
91. Keep container tightly closed and away from water or acids.
92. Keep container tightly closed; flush container clean before discarding.
93. Do not put in stoppered or closed container.
94. Note: Suck-back into cylinder may cause explosion. Under no circumstances should the cylinder entry tube be inserted in a liquid or gas without a vacuum break or other protective apparatus in the line to prevent suck-back.
95. When empty, rinse thoroughly with clean water before discarding. (Do not use this statement on returnable drums.)
96. Store in original vented container.
97. Store in cool place.
98. Keep drum in upright position. Do not roll drum on side.
99. Handle under inert gas atmosphere in DRY equipment.
100. Keep container tightly closed.
101. Keep from freezing.
102. Loosen closure cautiously before opening.
103. Store separately from, and avoid contact with, dehydrating agents and other materials.
104. Keep away from fire.
105. Open container carefully and only in dry oxygen-free or inert atmosphere.
106. Store in cool dry place.
107. Store in a cool place in original container and protect from direct sunlight.
108. Keep container closed to prevent drying out.
109. Keep away from heat.
110. Do not heat cylinders.
111. Keep away from acids and heat.
112. Keep away from acids. Store in a dry place.
113. When empty, drain thoroughly. REPLACE BUNGS SECURELY. (Use this statement only on returnable drums.)
114. Never return unused HYDROGEN PEROXIDE to container. Dilute with plenty of water and discard.
115. Dispose of sodium by burning carefully in an open fire.
116. In case of fire, smother with Soda Ash, dry sand, or Carbon Dioxide. Dispose of by flushing away with a large volume of water under adequate ventilation.
117. Sweep up spillage. Do not flush to sewer which may contain acid.
118. Treat spillage with strong calcium hypochlorite solution and flush to sewer.
119. In case of spillage, keep wet and remove carefully.
120. In case of fire, stop flow of gas. Use dry chemical or carbon dioxide when necessary to gain access to valve.
121. Avoid spillage and contact with moisture or combustibles.

122. Clean up spillage immediately.
123. In case of spillage, flush with plenty of water and remove contaminated articles.
124. Flush area with water spray.
125. Fire or high temperatures may cause explosive decomposition if confined.
126. In case of fire, smother with dry sand, dry ground limestone, or dry powder type agents specially designed for metal powder fires. Do not use carbon tetrachloride, CO_2 extinguishers, or water.
127. Spillage may cause fire. Do not get on floor. Sweep up and remove immediately.
128. Avoid prolonged or repeated contact with skin.
129. POISON with skull and crossbones vignette.
130. DO NOT HANDLE OR USE UNTIL SAFETY PRECAUTIONS IN MCA CHEMICAL SAFETY DATA SHEET SD- HAVE BEEN READ AND UNDERSTOOD.
131. DO NOT HANDLE OR USE UNTIL SAFETY PRECAUTIONS RECOMMENDED BY THE MANUFACTURER HAVE BEEN READ AND UNDERSTOOD.
132. MCA CHEMICAL SAFETY DATA SHEET SD- . AVAILABLE.
133. Do not use air pressure to transfer.

In some cases, a minor hazard may be covered clearly and briefly by an appropriate precautionary statement.

Examples of these situations would include the use of a statement such as "Avoid prolonged or repeated contact with skin." as adequate to cover the minor hazard of skin defatting (which may result in chapping of the skin) such as is presented by some esters, ethers, ketones, or chlorinated hydrocarbon solvents. A statement such as "Avoid prolonged or repeated breathing of vapor." might also be adequate for those chemicals which do not present a significant vapor hazard but which may result in a temporary narcotic, soporific, or euphoric effect.

ANTIDOTE STATEMENTS

While it is generally true that specific antidotes are known for only very few chemicals and many of these can be administered only by a physician, there are some measures which may be used by laymen with benefit. The MCA Occupational Health Committee has provided the following specific examples of *some* of these. Others may be developed by the user of this manual for appropriate application to other chemicals.

1. For acid corrosive substances that are not toxic or highly toxic by ingestion: *Antidote.* If swallowed, do NOT induce vomiting. Give large quantities of water. Give at least one ounce of milk of magnesia or aluminum hydroxide gel in an equal amount of water. If these are not available, the whites of two or three eggs may be used. Never give anything by mouth to an unconscious person. Call a physician.

2. For alkaline corrosive substances that are not toxic or highly toxic by ingestion: *Antidote.* If swallowed, do NOT induce vomiting. Give large quantities of water. Give at least one ounce of vinegar in an equal amount of water. Never give anything by mouth to an unconscious person. Call a physician.

3. For cyanides and cyanide-like substances: *Antidote.* Always have on hand a cyanide first-aid kit. Break an amyl nitrite pearl in a cloth and hold lightly under nose for 15 seconds. Repeat 5 times at about 15-second intervals. Call a physician.

4. For hydrofluoric acid, anhydrous or aqueous: *Antidote.* Always have on hand a supply of magnesia paste (magnesium oxide and glycerin). In case of contact or suspicion of contact, immediately flush skin with large quantities of cold water until all acid is removed (3 to 4 hours or until medical attention is obtained), paying particular attention to skin under nails. If medical attention is delayed, apply magnesia paste. For eyes, immediately flush with cool water for 15 to 30 minutes. Prompt medical attention is absolutely necessary.

5. For soluble barium salts: *Antidote.* If swallowed, induce vomiting and then give one tablespoon of epsom salt in a glass of water. Never give anything by mouth to an unconscious person. Call a physician.

6. For cholinesterase-inhibiting compounds that are highly toxic: *Antidote.* Atropine is an antidote. Consult your physician about obtaining a supply of 1/100 grain (0.6 milligram) tablets for emergency use. If symptoms include blurred vision, stomach cramps or tightness in chest, don't wait for a physician but take two tablets at once. Do not take atropine unless symptoms of poisoning have occurred. Anyone who has been sick enough to have taken atropine must be seen by a physician as soon as possible.

NOTES TO PHYSICIANS

Physicians may not always be familiar with specific antidotes for given chemicals or with specific practices found useful by experts in the management of some poisonings.

It may, in certain cases, be desirable to acquaint the physician with an antidote or with a specific form of medical management through a Note to Physicians on the label. Some examples, as provided by the MCA Occupational Health Committee, are given below. The user of the manual may wish to discuss with his medical consultant the need for or appropriateness of a Note to Physicians in the labeling of his products. The Note to Physicians should be prepared by physicians.

1. For soluble arsenic compounds: *Note to Physicians.* If swallowed, give gastric lavage followed by saline cathartic. Force fluids. In all cases, give dimercaprol (BAL) in recommended dosages.

2. For cholinesterase-inhibiting compounds that are highly toxic: *Note to Physicians.* Warning symptoms include weakness, headache, tightness of chest, blurred vision, nonreactive pinpoint pupils, salivation, sweating, nausea, vomiting, diarrhea, and abdominal cramps. Give atropine intramuscularly or intravenously, depending on severity of poisoning, 2 to 4 milligrams (3 to 6 tablets, 1/100 grain each) every 15 minutes until fully atropinized as shown by dilated pupils, dry flushed skin and tachycardia. Twenty to thirty milligrams, or more, may be required during the first 24 hours. Never give opiates or phenothiazine tranquilizers. Clear chest by postural drainage. Artificial respiration or oxygen administration may be necessary. Observe patient continuously for at least 48 hours. Allow no further exposure to any cholinesterase inhibitor until cholinesterase regeneration has taken place as determined by blood tests.

3. For cyanides and cyanide-like substances: *Note to Physicians.* If patient has not responded to amyl nitrite, inject intravenously 10 milliliters of a 3 percent solution of sodium nitrite at a rate not greater than 2.5 to 5.0 milliliters per minute. Follow directly with 50 milliliters of a 25 percent solution of sodium thiosulfate at the same rate by the same route. Keep patient under observation. If signs of poisoning persist or reappear, repeat nitrite and thiosulfate injections one hour later in one-half the original doses.

4. For methemoglobin-inducing compounds: *Note to Physicians.* Absorption of this product into the body leads to the formation of methemoglobin which, in sufficient concentration, causes cyanosis. Since reversion of methemoglobin to hemoglobin occurs spontaneously after termination of exposure, moderate degrees of cyanosis need be treated only by supportive measures such as bed rest and oxygen inhalation. Thorough cleansing of the entire contaminated area of the body including scalp and nails is of utmost importance. If cyanosis is severe, intravenous injection of methylene blue, 1 milligram per kilogram of body weight, may be of value.

INSTRUCTIONS IN CASE OF FIRE, SPILL, OR LEAK

Accident instructions should be as simple and brief as possible and advise the use of suitable materials for control. Labels should provide persons who handle containers during shipment and storage with appropriate instructions.

For large fires, water is about the only practicable controlling or extinguishing agent, and is recommended in some form in almost all cases. In special cases where water would be ineffective or cause a dangerous reaction, the label statement should specifically exclude its use.

For small fires and where water may not be available, CO_2 (carbon dioxide) and dry-chemical fire extinguishers are generally recommended.

The amount of spillage or leak associated with handling containers is usually small. In view of this, the most convenient method for removing a liquid from the work area is to flush with copious quantities of water. Use of water as a spray rather than as a direct stream is effective in "knocking down" ignitable vapors.

In special cases where water would cause a dangerous reaction, the label statement should recommend an alternate method using generally available materials.

The following is a group of suitable phrases that may be used on labels of hazardous chemicals as steps to be taken in case of fire, spill, or leak. *Applicable phrases may be selected* from these statements or from others appearing in the special statements beginning on page 50. These may be used either as separate labels or as a part of the precautionary label text.

Fire-Extinguishing Statements

In case of fire, use water, dry chemical, or CO_2.
(Use for ignitable liquids that are water-soluble or dilutable and for solids, provided water and/or CO_2 are suitable for confining and extinguishing the flames.)

In case of fire, use water spray, foam, dry chemical, or CO_2.
(Use for ignitable liquids that are immiscible with water.)

In case of fire, do not use water. Use dry sand, salt, soda ash, or lime.
(Use for special cases where water would cause dangerous reaction.)

In case of fire, soak with water.
(Use for solids such as oxidizing agents, where water is effective and not dangerous.)

In case of fire, cover with water, sand, or earth.
(Use where water is effective but must be used properly to confine and control the fire.)

In case of fire, allow gas to burn if flow cannot be shut off immediately.
(Use for flammable gases.)

Spill or Leak Statements

Flush spill area with water spray.
(Use for most liquids.)

Soak up spill with sand or earth. Do not use water.
(Use where water would cause a dangerous reaction, or would create a further hazard.)

Flush away spill by flooding with water applied quickly to entire spill.
(Use for products that require proper use of much water to minimize irritating fumes that are given off when water contacts the product.)

Keep upwind of leak; evacuate enclosed places until gas has dispersed.
(Use for compressed gases.)

INSTRUCTIONS FOR CONTAINER HANDLING AND STORAGE

Care should always be exercised in handling and storing containers of hazardous chemicals and in removing the contents. The Chemical Packaging Committee of the Manufacturing Chemists Association has recommended the general precautions given below for handling and storing certain classes of containers. *Applicable phrases may be selected from these statements.* These may be used either as separate labels or as a part of the precautionary label text.

Metal Drums (For Liquids and Semi-Liquids)

Keep closure up to prevent leakage.

Keep drum out of sun and away from heat.

Relieve internal pressure when received and at least weekly thereafter by slowly loosening plug. Retighten immediately.

Drums should be grounded when being emptied.

Do not drop or slide across sharp projection.

Never use pressure to empty; drum is not a pressure vessel.

Keep lights, fire, and sparks away from drums.

Drum must not be washed out or used for other purposes.

Replace plug after each withdrawal and return with empty drum.

Do not expose drum to direct sunlight for long periods of time.

Glass Carboys

Before moving carboy be sure closure is securely fastened.

Avoid rough handling or dropping.

Loosen closure carefully.

Keep carboy out of sun and away from heat.

Never use pressure to empty; carboy is not a pressure vessel.

Completely drain carboy before returning.

Wooden Barrels (For Liquids and Semi-Liquids)

Keep barrel out of sun and away from heat.

Store with bilge bung up.

Never use pressure to empty.

Drain completely.

Keep barrel moist – shrinkage may cause leaks.

Cylinders

Keep cylinder out of sun and away from heat.

Never drop cylinders.

Always keep cylinders secured to prevent falling and/or movement.

Be sure connections are tight.

DOT Regulations prohibit refilling cylinder without permission of owner.

Have air-line respirator or self-contained oxygen respirator available for emergency.

Do not expose cylinder to direct sunlight for long periods of time.

Never apply direct heat to cylinders and/or fittings.

Always replace valve protection device before returning cylinders.

Plastic Containers With and Without Overpacks (For Liquids and Semi-Liquids)

Keep closure up to prevent leakage.

Keep container out of sun and away from heat.

Do not drop or slide across sharp projections.

Never use pressure to empty; container is not a pressure vessel.

Keep lights, fire, and sparks away from container.

Container must not be washed out or used for other purposes.

Replace closure after each withdrawal.

Thoroughly drain containers and tighten closure before returning.

Do not use container as dilution or mixing vessel.

Remove closure carefully to relieve possible internal pressure.

Fiber Drums

Protect from direct contact with water or excessive moisture.

Do not drop onto, or slide across sharp objects.

Do not store on side.

Avoid creasing and/or impacting of side walls.

Shipping Sacks

Protect from direct contact with water or excessive moisture.

Only those bags marked "May be used for open storage" should be so used. Never store on ground.

Keep out of sun and away from heat.

Do not drop or slide across sharp projections.

In case of puncture, use overslip bag and securely close.

Aerosol Containers

The term "aerosol container" is generally applied to a container which holds its contents under pressure and is equipped with a dispensing nozzle designed to release the container's contents through a very small orifice. This type of container requires more care in handling and storage than similar unpressurized containers and requires protection from elevated temperatures. When the contents are released as an aerosol or fine spray, there may be greater flammability or inhalation hazard than would be presented by the same product in other types of packaging and use.

The following is a recommended precautionary text for the pressure hazard presented by a metal aerosol container:

WARNING! CONTENTS UNDER PRESSURE

Do not puncture or incinerate container.

Do not expose to heat or store at temperatures above 120°F.

Appropriate modification of the above text or additional precautionary labeling may be needed to warn against hazards presented by the contents of an aerosol container after release.

SPECIAL PROBLEMS IN PRECAUTIONARY LABELING

Labels for Small Commercial Packages

Small containers may present a problem in that less space is available for labeling purposes. Careful and selective shortening of precautionary statements for such containers may be in order if necessary to permit legibility, or if the wording on labels for the chemical in industrial packages is not applicable. These may include, among others, hazardous substances in retail packages intended for the ultimate consumer; highly purified chemicals intended for research, education, testing, or control; and chemicals intended for professional use. Consideration should always be given to (1) the intended or reasonably foreseeable handling or use of the product, (2) the training and experience of the expected user, and (3) the extent to which the hazard is modified by the size or type of container.

The following principles are recommended for condensation of suggested label wording where necessary or advisable:

1. Retain the Signal Word.

2. Retain the Statement of Hazards, shortened if possible to a practical equivalent.

3. Consider omission of Precautionary Measures if they are clearly indicated or implied from the Statement of Hazards or can be clearly indicated or implied by revising the Statement of Hazards.

4. Consider omission of wording relating to hazards that may be less serious because of the particular characteristics of the package, the nature of the use, and the training and experience of the user.

Care should be taken to see that labels prepared in accordance with the above principles include all information required by law.

Labels for Samples

In general, the label for samples of a product should bear the same precautionary information that is on the commercial label, with the exception of possible differences in container instructions. If the product is not in commercial production, the label for samples should be prepared in accordance with the General Principles and instructions given earlier.

Labels for New Products for Investigational Use

Chemical, physical, and toxicological data should be obtained on any product before it is distributed, so that the hazardous properties, if any, can be described on the label. However, it may occasionally be necessary to make delivery of a new product for investigational use before all of these data are obtained. For example, the quantity available may be too small for the necessary tests, or the product may have to be delivered to investigators for the purpose of obtaining the desired information. These deliveries should be made to qualified investigators only, and should be labeled as adequately as possible with the information available. To cover such cases (and such cases only), the following illustration is suggested for preparing labels to be used during the period of investigation.

(NAME OR DESCRIPTION OF PRODUCT)

FOR INVESTIGATIONAL USE ONLY

SIGNAL WORD!

STATEMENT(S) OF KNOWN HAZARD(S)

Appropriate precautionary measures.

Appropriate instructions in case of contact or exposure.

IMPORTANT! The chemical, physical, and toxicological properties of this product have not been fully investigated, and its handling or use may (be hazardous) (present additional hazards).

Exercise due care.

(NAME AND ADDRESS OF SOURCE)

Notes

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